Title
Learning in Practice: Exploring the Use of Plan-Do-Study-Act Cycles to Support Professional Learning

Permalink
https://escholarship.org/uc/item/3mn1j51b

Author
Lozano, Maritza

Publication Date
2017

Peer reviewed|Thesis/dissertation
Learning in Practice:
Exploring the Use of Plan-Do-Study-Act Cycles
to Support Professional Learning

A dissertation submitted in partial satisfaction of the requirements for the degree Doctor of Philosophy in Education

by

Maritza Lozano

2017
ABSTRACT OF THE DISSERTATION

Learning in Practice:
Exploring the Use of Plan-Do-Study-Act Cycles
to Support Professional Learning

by

Maritza Lozano
Doctor of Philosophy in Education
University of California, Los Angeles, 2017
Professor Kimberley Gomez, Chair

The current dissertation is an examination of the micro and macro-level processes teachers engage through the course of professional learning. In this research I sought to understand the ways in which teachers used Plan-Do-Study-Act cycles as a tool to support their learning in the context of a school-wide literacy improvement effort. In this three-study dissertation, I draw on data collected over the course of two academic years, beginning in 2013. I approach this research from a participatory design lens to investigate teachers’ collaborative learning opportunities in practice-driven design work and examine the use of PDSA cycles as a tool for improvement. I explore the use PDSAs to support the iterative refinement of instructional practices in the context of localized design work.
I begin the dissertation with an examination of a group of science teachers who sought to improve science literacy over the course of the 2013-2014 school year. In the second study I investigate the use of PDSAs through the documentation practices of a group of second and third grade dual language teachers over the 2014-2015 school year. In my third investigation I return to the science team, this time with a focused examination on teacher learning for two of the science teachers. Here my goal was to understand how PDSAs contributed, or constrained, their broader conceptions of science learning.
The dissertation of Maritza Lozano is approved.

Louis M. Gomez

Lindsay Clare Matsumura

William A. Sandoval

Kimberley Gomez, Committee Chair

University of California, Los Angeles

2017
A mis padres María y José

por su amor y su apoyo

por brindarme luz en momentos de obscuridad

por siempre creer en mí
# TABLE OF CONTENTS

ABSTRACT OF THE DISSERTATION .............................................................................. ii

TABLE OF CONTENTS ............................................................................................... v

LIST OF FIGURES ...................................................................................................... vi

LIST OF TABLES ......................................................................................................... vii

AGRADECIMIENTOS ............................................................................................... ix

PREFACE .................................................................................................................... xii

VITA ............................................................................................................................ xv

PROBLEM OF PRACTICE ........................................................................................ 1

LITERATURE REVIEW ............................................................................................ 3

METHODOLOGY ....................................................................................................... 15

INQUIRY I ............................................................................................................... 18

INQUIRY II ............................................................................................................. 72

INQUIRY III ........................................................................................................... 104

CONCLUSION ......................................................................................................... 138

APPENDIX ............................................................................................................. 146

REFERENCES ........................................................................................................ 149
LIST OF FIGURES

Figure 1. The Plan-Do-Study-Act Cycle .................................................................20

Figure 2. The Interconnected Model of Professional Growth (IMPG) ..........................24

Figure 3. Science Team Driver Diagram .................................................................29

Figure 4. Three-Day Instructional Sequence ............................................................46

Figure 5. PDSA Tree (2013-2014) .........................................................................52

Figure 6. Annotation Coach Handout ....................................................................118

Figure 7. PLP – PDSA Work ................................................................................125

Figure 8. PLP – Data Analysis Work .....................................................................126

Figure 9. Mapping Measures for PDSAs ...............................................................126
LIST OF TABLES

Table 1. The Interconnected Model of Professional Growth (IMPG) Domains and Evidence …25
Table 2. Common Assessment Score Data (2012-2013).................................................................27
Table 3. 2013-2014 School Year Timeline of Activities............................................................30
Table 4. Queries to Support Teachers’ Use of PDSA Cycles.........................................................31
Table 5. The Underlying Cognitive Processes of PDSAs...............................................................41
Table 6. Time Spent on Assessment Discussions During Full-Day Meetings..............................47
Table 7. Common Assessment Score Data (2012-2014)...............................................................69
Table 8. Leonor’s Student Lab Report Samples..........................................................................133
Table 9. Frank’s Student Lab Report Samples............................................................................134
AGRADECIMIENTOS

The words contained within these pages represent the culmination of a journey that began long ago. I would not be here today if it weren’t for my parents. Four decades ago, my parents moved to Los Angeles to pursue their own dream of creating new life opportunities for themselves and their family. Just as it was then, today these dreams are made possible with the love and support of family, friends, colleagues, and mentors. I want to thank all of you for your encouragement and seeing it through the end of this journey.

I thank my committee members: Kimberley Gomez, Louis Gomez, Bill Sandoval, and Lindsay Clare Matsumura. I thank you for your guidance in my development as a scholar and for challenging me to think deeply about the future directions of this work. Your support, questions, and feedback have been invaluable. I want to give a special thanks to Kimberley Gomez. I am forever grateful for your mentoring and advisement throughout this journey, from Pittsburgh back to Los Angeles. Your belief in me helped me to believe in myself.

Thank you to the Pitt Crew, Benjamin Cooper and Nicole Mancevice, my academic siblings. We began this journey together in Pittsburgh and ended it in Los Angeles. I am forever grateful for you. I am forever grateful to you Sarah Mejia and Janet Garcia for teaching me to listen and be a mentor. Your eagerness and willingness to learn kept me going.

Thank you to Urban Schoolers, friends, and colleagues Michelle Smith, Elexia Reyes-McGovern, Ursula Aldana, Danny Cortez Martinez, Elizabeth Montaño, Mel Bertrand, Cliff Lee, Karla Perez-Mendoza, Rigo Marquez, Mary Martinez-Wenzl, and Jenn Ayscue. You welcomed me, sharing in conversation, scholarship, and writing retreats. Rebecca Neri, thank you for your friendship. Making medicine with you has helped me to remember that self-care matters for healing our families and communities.
Thank you Katherine C. Rodela, Maneka D. Brooks, and Maribel Santiago. I am forever grateful for your friendship and our many conversations about life and academia. Your help in carving out time to write was crucial to getting this done. Maneka, I thank you and Carlos for welcoming me into your home and giving me the space and time I needed to focus on my own work.

Thank you Sandy Chang and Julie Park Haubner for encouraging me to keep going, reminding me to not lose sight of the goal.

***

Thank you, Cesar Alvarado, for beginning this journey with me. When we first started, we had no idea what it would bring. We both took a chance. Although we end this journey with much changed from where we started, I am forever grateful for you, your family, the years you spent as my compañero, and our friendship. We are family.

Thank you for your unconditional friendship, Adrian Bowen. You never let me stay away too long and I thank you for reeling me in. Growing up you taught me to not take life too seriously, to express joy, and to dance in public! Those are lessons I continue to live each day.

Doy gracias a mi comadre Elida Lozano Cossio. You have always had an uncanny way of reaching out when I needed your friendship the most. I am forever grateful for your support, for bringing me into your family, and for entrusting me to be Junior’s madrina.

Gracias a Liz Soto and Cristina Serna for sharing the trials and tribulations of what it means to take care of us while supporting our families and pursuing degrees. You two have been with me through every step of the way and have supported me in unimaginable ways.

Thank you to my friends, Betty and Martin Siwy for sharing your family, and your miles, to bring me home when I was away in Pittsburgh. To Lily Chow, Kim Paulson, Gabriela

x
Ramirez, Manal Badawy, and Angélica Machado, your work with students in our schools inspires me to keep pushing forward.

To the school leaders and teachers that opened their doors to make this work possible, I thank you for your trust and your willingness to share your practice with me.

***

Doy gracias a mi familia. Agradezco en especial a mis padres, María y José Lozano, que con gran sacrificio y esfuerzo lograron que mis sueños se convirtieran en realidad. Siempre me apoyaron y me animaron a seguir adelante. Cuando elegí este camino, nunca imaginé que al llegar al final me faltaría uno de ustedes. Este logro en especial lo dedico a ti papi.

To my brothers Junior and Pablo, you were my first true friends and playmates. I thank you for keeping me grounded. You always reminded me that life is more than scholarship and academics, and that there are many alternatives to doing life. Thank you for your patience and unconditional love.

To Jon, you weathered the storm and saw this journey through the end. I am grateful for your support and your patience. You cheered me on and believed in me when I doubted my ability to finish.

And to Adeline, my sobrina. May you grow, spread your wings, and soar to new heights knowing that you are loved beyond belief. I will always love and support you.
Writing is personal. It involves deep engagement with thought processes and careful attention to purpose and audience. The teaching of writing is also personal. As a classroom teacher, and a teacher of writing, I sought to help my students communicate and be prepared for whatever was to come. If I could help them understand how to read others’ writing, examine the author’s craft, and have ownership of their writing, they could craft their own pieces. I hoped these were life lessons they might carry with them. I didn’t worry about my students’ writing ability when they left my class. I was confident that in that short year we had spent together, there had been growth that could never be taken away. Did I expect all my students to want to become writers and authors? No, but I did expect that they had developed the confidence in themselves and their ability to learn and to write that would serve them well as they continued through school.

When I left the classroom to coach teachers and, later, work with schools in the area of literacy, it was my passion for writing that gave me the energy to move forward. I learned that teaching writing, perhaps even more so than reading, was challenging for many of the teachers and coaches in my local district. I was fortunate in that I had the support of other teachers to improve my practice as a teacher of writing. I sought to support others as well.

As an out-of-classroom literacy support provider, I developed a keen eye for the teaching of writing. I would walk into classrooms all of the time and search out the writing on the wall. By looking at the work that was posted on the board, I could tell, immediately, what type of writing instruction was happening in that classroom. I often asked myself the questions why, what, and how - Why is there such variability in writing instruction - use of writing as a tool for learning - across classrooms and schools? What is the difference between these groups of
teachers that could help explain the variability in classrooms? How can I help teachers improve instructional practices so that conceptions of literacy teaching include the use of writing as a tool to help students engage in thinking, learning, communicating understanding, and expression?

In my work as a practitioner, I observed that the degree to which coaches and teachers used writing as a tool for learning - task complexity, looking at student work, shared expectations for writing - was largely contingent upon writing self-efficacy beliefs and writing attitude. Initially, I equated teachers’ ability to integrate and teach writing with a teacher’s identity as writer. I believed that if I could help teachers uncover, that is, identify and name past positive/negative experiences with writing, they could identify a sort of turning point (McAdams, 1993) that might help explain the source of comfort or aversion to the teaching of writing. For example, those with recognized positive experiences, and presumably strong identities as writers, could draw on these experiences as resources in their continued work to engage students in writing. Conversely, those with negative experiences, and aversion to writing, could use this knowledge as a source of empowerment for themselves and a resource for teaching - avoiding the reproduction of experiences that would recreate and perpetuate the issue of underachievement in writing for students.

I have come to understand that, at least initially, beliefs matter less than actions in practice. Nonetheless, in retrospect I understand that my early attempts to improve students’ learning experiences with the use of writing as a tool for learning were designed to create an experience of cognitive dissonance for teachers that would function as a catalyst for change in instructional practice.

At this point in my graduate program and career I have become much more interested in the role that professional learning can play on teachers' ability and capacity to change
instructional practice. My interest stems from the work I have done with a team of secondary science teachers over the past three years on the problem of improving student science learning for high school students. Through this work teachers have changed instructional practice and adopted a set of instructional routines that integrate literacy practice with science learning. While most of the work has focused on reading (annotation), writing-to-learn has become a more prominent goal. Teachers have limited their work with the use of writing to having students articulate claims and evidence from articles read and the construction of summaries based on reading. Teachers have expressed a need to understand how to support their students' ability to construct lab reports in ways that represent learning.

If ultimately the thing I care about is that students have access to a high-quality education, one in which they are expected to engage in complex writing tasks, then what I care about is that teachers change their practices in the teaching of writing. When teachers take up new instructional practices and experience, first hand, how such changes affect student writing, thereby yielding evidence of how such practices impact student learning, it primes teachers for the possibility of a change in beliefs to occur.
VITA

EDUCATION

2005 M.A., Education: Reading, K-12
California State University, Los Angeles

1997 B.A., Spanish Literary Studies
Occidental College

RESEARCH EXPERIENCE

2016-2017 Research Coordinator, UCLA
Los Angeles School Improvement Network
PLs: Louis M. Gomez, Pedro Noguera

2014-2016 Graduate Student Researcher, UCLA CRESST
Center for Standards and Assessment Implementation (CSAI)
Project Director: Joan Herman

Formative Assessment Lessons: English Language Arts and Science
Project Director: Joan Herman

Colorado Assessment Literacy Program
Project Directors: Margaret Heritage, Joan Herman

2011-2016 Research Associate/Research Coordinator, UCLA
School-University Collaboration to Support Professional Learning
PLs: Louis Gomez, Karen Hunter Quartz

Intensive Language Support for Credit Recovery in Biology
PLs: Louis Gomez, Kimberley Gomez

2011-2013 Research Consultant, Carnegie Foundation for the Advancement of Teaching
Language and Literacy Supports, Community College Pathways Project
Project Director: Kimberley Gomez

2010-2011 Field Research Assistant, Strategic Education Research Partnership (SERP)
Word Generation: Middle School Literacy Development Using Academic Language
PI: Catherine Snow

2009-2011 Graduate Student Researcher, Learning Research and Development Center (LRDC), University of Pittsburgh
Collaborative, Technology-Enhanced Lesson Planning as an Organizational Routine for Continuous, School-Wide Instructional Improvement
PIs: Mary Kay Stein, Louis Gomez, Kimberley Gomez, and Jennifer L. Russell

RELEVANT PROFESSIONAL EXPERIENCE

2014-2015  Student Educator, Hammer Museum
2013-2015  English Language Arts Consultant, Institute for Learning - University of Pittsburgh
2011      Resident Selector, Pittsburgh Public Schools - The New Teacher Project
2005-2009  Literacy Content Expert, Los Angeles Unified School District
2005-2007  AB466 Reading Institute Instructor, Sacramento County Office of Education
2002-2005  Instructional Literacy Coach, Los Angeles Unified School District
2003-2004  Fieldwork Supervisor, California State University Dominguez Hills

SELECTED PUBLICATIONS


AWARDS AND HONORS

2016-2017  UCLA Department Fellowship
2012 & 2013 UCLA Graduate Summer Mentor Fellowship
2011-2013  University Council for Educational Administration (UCEA) Barbara L. Jackson Scholar Award
2011-2013  MacArthur Foundation Emerging Scholar of Digital Media and Learning
2010-2013  University of Pittsburgh K. Leroy Irvis Doctoral Fellowship Award
2002      Earthwatch Fellowship Award
2001      Los Angeles Educational Partnership (LAEP) Excellence Award
Problem of Practice

Science learning has been a major focus of reform initiatives. While policymakers, researchers, and educators alike have employed a variety of strategies and tactics in an attempt to address the struggles with science learning, the stark reality is that little, if any, progress has been made to improve literacy outcomes, broadly, and science learning outcomes, specifically, in our nation’s schools (Graham & Hebert, 2010; Graham & Perin, 2007; Lee & Spratley, 2010; Moje, 2007; Oakes, Welner, Yonezawa, & Allen, 2005; Shanahan & Shanahan, 2008; 2012; Snow, 2002; Snow & Biancarosa, 2003).

Science provides a prime context in which literacy practices are required for learning. Reading and writing are tools that are used throughout the process of learning science. Science learning is largely comprised of conducting investigations, engaging inquiry processes, and documenting developing scientific understandings. For example, the process of scientific inquiry is principled by the design of questions, the development of hypotheses, the conduct of investigations to test conjectures, gathering, analyzing, and evaluating data, and drawing conclusions based on findings, and integrating what has been learned to previous understandings of scientific concepts (Schwarz & Gwekwerere, 2007; Schwarz & White, 2005). Inherent in each of these skills are a series of underlying literacy practices that contribute to science learning. Scientific inquiry and science learning, then, depend on myriad literacy practices. For example, the ability to read texts and engage in observations to learn about natural phenomena and to acquire knowledge about concepts, processes, and procedures is crucial for learning. Science, as practice, depends on the ability to make claims, support claims with evidence, revise warrants, analyze data, draw conclusions on the basis of evidence, and develop arguments on the basis of what is learned. For struggling readers and writers, science provides an authentic context of
inquiry where moving forward in learning requires increased ability to read and write (Pearson, Moje, & Greenleaf, 2010). Learning in science depends on the ability to carry out scientific practices, processes of inquiry, and literacy practices.

Despite science being a prime context for the meaningful integration of literacy, science teachers frequently underutilize reading and writing as part of a comprehensive approach to teaching and learning. Research suggests that teachers are unprepared to meaningfully integrate literacy as part of subject matter learning (Applebee & Langer, 2011; Kiuhara, Graham, & Hawken, 2009; Weiss et al., 2003). The challenge for teachers is to design reading and writing activities that are authentic and meaningful to the process of scientific inquiry and learning science (Cervetti & Pearson, 2012).

Recently, the advent of the Next Generation Science Standards (NGSS; NGSS Lead States, 2013) and the Common Core State Standards (CCSS; National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010) has shifted our attention to the prominence of literacy within science. In science, literacy (reading, writing, listening, and discussion) is arguably the vehicle through which inquiry and problem-based learning occurs. Science literacy itself has been widely defined (Feinstein, 2011; Glynn & Muth, 1994; Yore, Bisanz, & Hand, 2003), and approaches to scientific literacy highly contested (Keys, 1999; Pearson et al., 2010). Previous approaches designed to support science teacher learning fall short in preparing teachers to meet the new challenges of science learning. These challenges are further complicated by the changing expectations outlined in the new NGSS (NGSS Lead States, 2013) and CCSS (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010). The issue is perhaps more pronounced at the secondary level, where teachers, who typically have deep content knowledge, receive limited pre-service or in-
service support for developing pedagogical approaches to support science learning through literacy.

**Literature Review**

In this section I present the literature that is relevant to my dissertation work. I begin with a description of the current state of science achievement to situate my research and illustrate the significance and pervasiveness of the issue. Next, I provide an overview of the literature that discusses literacy-focused approaches that are considered important for the improvement of science learning. I transition from these broad descriptions and move into the heart of my literature review. Here, the literature review is divided into two major sections. First, I concentrate on building a case for teacher learning as a viable means for improving students’ science learning. I focus on describing an approach that can be used to support teacher learning in secondary science classrooms - Plan-Do-Study-Act cycles. Next, I use the literature related to learning within an organization to extend the case and describe expansion and sustenance of teacher learning efforts. Taken together, the two literature review sections highlight key considerations in developing systemic approaches to improve, and sustain, student learning and achievement.

**The Current State of Science Learning**

Much has been written about the role of science learning and its ability to impart the thinking and communication skills and ideals embodied by a civically engaged society (cf. Feinstein, 2011; O’Neill & Polman, 2004). Engagement in science learning in our nation’s schools affords students the opportunity to develop the scientific literacy practices that support civic participation. Science learning, for example, is an important part of high school course taking requirements. In 2009 alone, 96% of high school graduates completed a course in Biology.
and 30% of students completed courses in Biology, Chemistry, and Physics (Planty, Hussar, Snyder, Kena, KewalRamani, Kemp, Bianco, & Dinkes, 2009). While these figures are promising, they only reflect students who ultimately graduate high school. Research studies show that increases in science course graduation requirements alone have had no effect on science achievement (Buddin & Croft, 2014; Dalton, Ingels, Downing, & Bozick, 2007). Furthermore, research also suggests that raising science course requirements has had a deleterious effect on high school graduation rates of African-American and Latino students (Plunk, Tate, Bierut, & Grucza, 2014). Additionally, research has shown that failure to pass just one academic course in high school significantly reduces a student’s likelihood to graduate to 64% (Silver, Saunders, & Zarate, 2008).

The previous research suggests that science learning is challenging for many students - and it is African-American, Latino, and English Language Learners (ELLs), youth whose educational experiences are further complicated with histories of academic underachievement, trauma, and lower socioeconomic status who fare far worse. Research findings focused on large-scale assessments reveal disparities in academic achievement (Hemphill & Vanneman, 2011; Reardon, Valentino, Kalogrides, Shores, & Greenberg, 2013; Reardon, Robinson-Cimpian, & Weathers, 2015; Sparks, 2012). According to Kelly and colleagues (2013), in comparison to white and Asian peers, African American, Latino, and ELLs perform lower on measures of science and reading achievement.

**Literacy-Focused Approaches to Improve Science Learning**

Research related to science learning and adolescent literacy over the past two decades...
highlight a number of issues related to the academic underachievement of African American, Latino, and English Language Learners. Studies of adolescent literacy point to reading comprehension as a primary barrier to academic achievement for minority youth (Snow, 2002; Snow & Biancarosa, 2003). When it comes to learning science, literacy difficulties are intensified by the academic language (Schwendimann, 2011), literacy, and discourse practices of the discipline. Research suggests that factors that contribute to difficulties in science learning involve the ways of engaging with science (Duschl, Schweingruber, & Shouse, 2007). For example, the literature details three literacy-based approaches to teach science: argumentation, reading-to-learn, and writing-to-learn. Each approach broadly outlines a range of practices that should be explicitly used to teach science and, in so doing, support students’ access to science learning opportunities.

The first approach prioritizes argumentation as a means to support students’ learning of science language and discourse of science (Cavagnetto, 2010; Tippet, 2009). From this perspective, students are explicitly taught argumentation or explanation construction. The linguistic and scientific practices they are expected to use and emulate as they engage in opportunities to learn science are explained and detailed as part of classroom instruction (Chin & Osborne, 2010a, 2010b; Duschl & Osborne, 2002; Erduran & Jiménez-Aleixandre, 2007; Erduran, Simon, & Osborne, 2004; Lemke, 1990; Roseberry, Warren, & Conant, 1992; Warren, Roseberry, & Conant, 1991). Approaches to teaching argumentation in classroom contexts vary in terms of the degree of scaffolds, strategies, pedagogical approaches such as modeling, and topics of inquiry that teachers present to students. In one study of 13 science teachers, McKneill and Krajcik (2008) observed teachers as they introduced the concept of scientific explanation to their students. McKneill and Krajcik found that students who were in classrooms where teachers
who provided students with a rationale for scientific explanations during an introductory lesson, that is, making clear the need to provide evidence to support claims, were more successful in constructing scientific explanations than those whose teachers did not. Researchers also found that an examination of teacher practices alone was insufficient. Teaching practices must be considered in conjunction with other instructional practices to determine their effectiveness.

A second perspective emphasizes instruction of reading-to-learn approaches to learn science (Gomez & Gomez, 2007; Gomez, Herman, & Gomez, 2007; Herman, Gomez, Gomez, Williams, & Perkins, 2008; Herman & Wardrip, 2012; Sherer, Gomez, Herman, Gomez, White, & Williams, 2008; Yore & Shymansky, 1991; Zywica & Gomez, 2008). In contrast to reading instruction in the early grades, with a focus on decoding and meaning-making, a reading-to-learn emphasis shifts focus to learning from text (Fang, 2008). As students progress in their studies K-12, increasing text complexity and discipline-specific content and practices demand that students be well-versed in their ability to use diverse strategies and skills to make sense of text (Goldman & Snow, 2015; Lee & Spratley, 2010; Shanahan & Shanahan, 2008; 2012;). Reading-to-learn approaches support students engage in inquiry-based activities, access information in science texts, and use textual evidence to support claims and explanations. While some of the research in this area appears to privilege explorations of strategies for reading comprehension improvement over science learning (McNamara et al., 2006; Radcliffe et al., 2008), there is increasing attention to the role of literacy and science as mutually reinforcing and beneficial (Pearson et al., 2010). Greenleaf and colleagues (2011) offer one example of such a study. Their research investigated teachers’ instructional practices and students’ achievement in both science and literacy after teachers participated in ten days of professional development in Reading Apprenticeship, a reading-to-learn approach that focuses on comprehension strategy and
metacognitive routine work to learn science. Findings suggested that students who received explicit instruction in Reading Apprenticeship outperformed those who did not on English language arts, reading comprehension and biology assessment measures.

A third, though less prominent, perspective highlights instructional writing approaches to learn science (Hand, Lawrence, & Yore, 1999; Hand & Prain, 2011; Hildebrand, 1998; Keys, 1999; Rivard & Straw, 2000). Although the literature at the intersection of adolescent literacy and learning has highlighted writing as an important literacy practice, it has largely been limited to discussion of its role in the improvement of reading (Graham & Hebert, 2010). In the research specific to science learning, one particularly informative area of exploration has been in the use of writing-to-learn tasks to support learners to build conceptual knowledge and develop scientific literacy (Bereiter & Scardamalia, 1987; Halliday & Martin, 1993; Hand & Prain, 2011; Keys, 1999; Prain & Hand, 1996). Proponents of this approach posit that through engagement of writing-to-learn tasks, learners are supported in constructing scientific understandings and their ability to use everyday language in the process of developing scientific language.

These literacy-focused approaches have been used as part of prior research efforts that have sought to develop and support specific practices in work with science practitioners to improve science learning. A number of the studies that adopt literacy-focused approaches to improve science learning emphasize working with practitioners to support the implementation of a specific instructional practice and/or strategy. These investigations center on the degree to which teachers adhere to practices or strategies and examine whether these, in turn, support students’ science learning. While these research efforts have shown promise, less is known about the sustainability of those efforts in practice over time. To this end, rather than focus on the specific practice, attention to the ways in which teachers discipline pedagogy and instructional
practice is needed. In addition, we need to shift towards the examination of methods that best support teacher learning that is embedded in practice and tightly coupled to student learning.

**Teacher Learning to Improve Practice**

Teaching is a complex activity. It is mired with non-routine practices and, as such, requires a highly specialized set of skills that connect content knowledge with pedagogical prowess (Ball & Cohen, 1999; Ball & Forzani, 2009). Given its complexity, there is a substantial body of literature dedicated to the study of teaching. A review of the literature on teaching, broadly, is beyond the scope of this dissertation. Here, I specifically focus this discussion in the research on teacher learning. Often discussed in teacher education and professional development research, teacher learning is considered in the context of programmatic efforts to support formal preparation for teaching and continued on-the-job performance. In the field of teacher education learning is discussed in terms of the knowledge base required to effectively undertake the task of teaching.

Here, teacher learning is generally characterized by knowledge of content, pedagogy, assessment, and diverse learners (Darling-Hammond, 2006; Grossman & McDonald, 2008; Kilpatrick & Quinn, 2009). The professional development literature describes the essential conditions to maximize teacher learning. According to these works, effective professional development includes continuous focused opportunities to engage in practice-based inquiry with trusted colleagues, is anchored in records of practice, and is motivated by genuine interest in educational problem solving (Ball & Cohen, 1999; Borko, 2004; Feiman-Nesmer, 2001).

While prior work in teacher education and professional development espouse the need to tightly couple teacher learning to practice (Ball, Sleep, Boerst, & Bass, 2009), existing efforts highlight disconnects between what and how pre-service and professional teachers learn. Current
research suggests that the vast majority of teacher education and professional development occurs far removed from practice effectively deeming it inconsequential. Novice and experienced teachers alike are provided with learning opportunities that focus on methods or strategies aimed to help them improve their work with students yet these situations are limited in that they are essentially separate from the act of teaching (Ball & Cohen, 1999; Ball & Forzani, 2009).

**Learning in Practice**

Enhancing teachers’ ability to design, adapt, and refine effective instructional practices that tightly couples teacher learning to practice (Ball et al., 2009) is essential for teacher learning (Lampert, 2010). Nonetheless, there are limited examples in the literature that provide scalable models of professional learning (Borko, 2004). One potentially productive strand of research has been work that locates teacher learning in the ability to use records of practice to refine and improve teaching (Ball & Cohen, 1999; Lieberman & Mace, 2008; Little, 2001). Research in this area has typically explored the use of records of practice through examining student work (Kazemi & Franke, 2004; Little, Gearhart, Curry, & Kafka, 2003), instructional episodes in video clubs (Kisa & Stein, 2015; Sherin & Han, 2004; Sherin & van Es, 2009), and artifact collection and analysis over an extended period of time (Ball & Bass, 2003). The literature suggests that records of practice support teacher learning when these artifacts and other evidence are used as anchors for professional development over a period of time.

Anchoring discussions about teaching in records of practice, like student artifacts and videos of instructional episodes, support reflection and analysis. For example, Kazemi & Franke (2004) observed teachers engaged in monthly discussions of student work and found that teacher learning was evident on the basis of change in the quality of teachers’ discussions of student
work and participation in meetings. The quality of discussions was marked by a shift in teachers’ ability to move from students’ thinking towards treatment of students’ thinking in connection with instruction and pedagogy. Similarly, Kisa and Stein (2015) found that teachers involved in observation of instructional video episodes attended to both student thinking and pedagogy. Research also suggests that records of practice support teachers’ ability to recognize the interdependence of student thinking and pedagogical action. Yet, less is known about what teachers actually do with the information they glean from records of practice and the degree to which such knowledge is sustained.

Situating learning in practice is a cornerstone of teacher learning (Putnam & Borko, 2000). Teacher learning happens in the context of instruction - when a teacher can quickly implement an idea and test its utility in supporting student learning. I conceptualize teacher learning as improvement in teachers’ ability to identify discontinuities in student learning, problem-solve, and take swift and appropriate pedagogical action in the midst of teaching. Contexts that actively involve teachers in activities that enlist them in goal setting, data collection, evidence-based study and reflection, greatly support learning. While the importance of documenting these activities is an essential component of teacher learning, it is equally important to understand the theories that underpin these pedagogical adjustments. Records of practice are an important and useful way to capture evidence of practice grounded in theories of change and projections of student learning. Such records can be used iteratively to track and refine practice rapidly (Ball et al., 2009). When used to link learning over time, these records can represent an accrual of learning.

Recently, drawing on efforts in healthcare improvement, educators have begun to use Plan Do Study Act (PDSA) cycles to learn from their practice, while squarely situated in day-to-
day practice. PDSA cycles are a tool to keep records of practice. They have four phases: Plan, Do, Study, and Act. During the Plan phase, teachers create a plan and make predictions of what their intended plan will accomplish. In the next step, the Do phase, teachers test the plan by putting their ideas into action and documenting what occurred. Following the Do phase is the Study portion of the PDSA cycle. Here teachers summarize the results of their test and document learning. The last step of the PDSA is the Act phase. During the Act phase, educators use what they learned to inform future action.

Educators can use PDSAs to learn fast, fail fast, and improve quickly (Bryk, Gomez, Grunow, & LeMahieu, 2015). While PDSA cycles are an iterative design strategy traditionally used to support sustained improvement efforts across a range of fields, from manufacturing to healthcare (Berwick, 2003; Bryk, Gomez, & Grunow, 2011; Langley, Moen, Nolan, Nolan, Norman, & Provost, 2009), they are a useful tool for supporting situated and “integrated problem-solving research” (Bransford, Brown, & Cocking, 1999). Recent applications in education have demonstrated the value of PDSAs in supporting disciplined inquiry and accelerated learning (Bryk et al., 2015; Gomez, Gomez, Rodela, Horton, Cunningham, & Ambrocio, 2015).

Arguably, because they are situated in practice, and tightly coupled to pedagogical adjustments, in practice, PDSA cycles, when used effectively, allow teachers to not only intuitively sense what is or is not working in the classroom, but to use the evidence collected to inform design changes and quickly adapt their practice. Thought seemingly akin to lesson study cycles (Lewis, Perry, Murata, 2006), PDSAs stand apart in their emphasis of rapidly testing minute instructional refinements, linking data collection predictions to change ideas and student learning outcomes, and rapid succession of iterative design cycles. The speed and degree to
which teachers learn what works in the classroom is largely contingent upon the quality of data they collect and use formatively. PDSAs enable teachers to quickly test and track refinement and implementation of instructional changes and align improved instructional practices to student learning (Bryk et al., 2011). They are a promising strategy to foster teacher learning driven by teacher inquiry (Ball & Cohen, 1999), to document progress in practice coupled to student learning and theories of change (Borko, 2004) continuously over time (Lieberman, 1995), and to promote evidence-based instructional refinement (Feiman-Nesmer, 2001).

In the previous discussion, I situated the focus of the dissertation research, in the teacher learning literature, in general, and more specifically in research on literacy-focused, teacher professional development to support science teaching and learning that is situated in, and tightly coupled to, practice. I described the value of building records of teacher practice over extended periods to support teacher learning, and highlighted the meager literature on what teachers do with the information they have derived from records of practice and the degree to which such knowledge is sustained. Next, I will describe the central role of participatory design activities and design research efforts.

**Situating Improvement in Participatory Design**

In the dissertation research, I am guided by principles of participatory design research (PDR). While work within a PDR framework spans a range of research efforts, there are basic undergirding tenets that reflect a main body of research. According to Trigg and Clement (2000), PDR considers every participant, regardless of their position within an organization, as an expert and partner essential for design and innovation. In this way, it is the *frontline workers* (Langley et al., 2009), those who experience the problem of practice, who are key in identifying solutions and designing innovations. Within a PDR framework, systems are conceptualized “as networks
of people, practices, and technology embedded in particular organizational contexts” (Trigg & Clement, 2000). Who better than those within the system to work to identify root causes that contribute to a particular problem of practice and then work to engineering solutions within a localized context?

The importance of working in collaboration with members of the organization is an essential idea that runs across a PDR framework. Within a PDR approach, researchers working in collaboration with practitioners reveal important conceptions of whose knowledge is valued (Schuler & Namioka, 1993), who is essential to the design of activities, tools, and routines to solve a particular problem of practice (Harrison & Zappen, 2003; Magnussen et al., 2003), and who stands to learn from the collaboration [careful process of shared inquiry and reflection] (Gutiérrez & Jurow, 2014; Gutiérrez & Penuel, 2014; Teeters, Jurow, & Shea, 201). In this way, too, a PDR approach responds to traditional approaches to research in which researchers engage with the researched in hegemonic ways (Shrader, Williams, Lachance-Whitcomb, Finn, Walker, & Gomez, 1999). PDR flips the script on traditional research approaches and “reflects a commitment to issues of culture, race, power, and equity in the study of learning and teaching” (Bang & Vossoughi, 2014, p. 416).

PDR is a fruitful framework to anchor studies of change in learning and teaching. Because PDR has often been used in the context of innovating and designing for real problems of practice, in partnership with frontline experts, it supports examination of epistemologies through careful study of evolving theories of change. In this work, I adopt a participatory design lens to examine changes in learning and practice over time. Specifically, a PDR lens allows me to analyze learning of both of individual teachers, teacher teams, and also to examine how their engagement in collaborative design-based efforts support learning across an organization.
Collaborative Design-Based Research Partnerships

A hallmark of design-based research is its inclusion of practitioners as partners in the design and iterative refinement of educational innovations (Bell, 2004; Bell, Hoadley, & Linn, 2004; Brown, 1992; Cobb et al, 2003; Gomez et al., 2015). Co-design partnerships have been described in the literature as essential to solving the problem of scalability, yet, less is understood about the conditions under which partners learn in the process of iterative design, what they learn, or how they learn it. The extent to which practitioners are involved in the process of co-design varies (Penuel, Fishman, Yamaguchi, & Gallagher, 2007). Nonetheless, these studies suggest that positioning teachers as key decision-makers in the process of innovation, design, and iteration contributes to learning (Edelson, 2002). In this respect, design partnerships involving teachers offer a prime opportunity to examine iterative design cycles as potential learning sources (Lewis et al., 2006).

Design partnership arrangements have great potential to foster teacher learning when partnership goals are closely connected to teachers’ current experiences. In their current form, design partnerships generally privilege the role of the researcher. For instance, it is typical for research team members interested in testing the usability of an innovation to initiate partnerships (Shear, Bell, & Linn, 2004). Because teachers’ time is a commodity, design involvement is usually limited to phases of refinement. In this capacity, teachers have described their role in the design partnership work as one of providing feedback (Penuel, Roschelle, & Schechtman, 2007). Thus, although practitioners are design partners in these settings, the conditions under which teachers engage in design remain separate from teachers’ day-to-day work. The present work is guided by current efforts that adopt improvement science principles and tools to accelerate learning and move practice, and involve participatory collaborative design. The work seeks to
push the field of design-based research partnership work to consider on-the-ground design efforts motivated by practitioners seeking to design and adapt educational innovations to solve critical problems of practice. I seek to contribute to studies that examine learning affordances in teachers’ educational design work situated in practice-driven inquiry contexts.

**Dissertation Inquiries**

The current dissertation investigation seeks to contribute to a body of research that focuses on the viability and sustainability of efforts to improve learning and achievement. In this dissertation, my goal is to examine the process in which learning within an organization is developed, modified, and sustained over time. I adopt a participatory design lens to investigate teachers’ collaborative learning opportunities in practice-driven design work and examine the use of PDSA cycles as a tool to support teacher learning. Because the research site’s scope of work is tied to achieving school-wide literacy improvement, literacy-focused approaches are quite relevant to the collection of studies. My research seeks to highlight the nature in which improvement is undertaken and routinized, and ultimately woven into the fabric of the work and processes in an organization. I explore the use of improvement science tools, like PDSAs, to support the iterative refinement of instructional innovations and advance teacher learning in the context of localized design work.

**Methodology**

Learning is a social endeavor. Earlier I argued that teacher learning is more likely to occur, and be sustained, in the context of teacher’s work and activity. When teachers enact instructional practices, testing out new ideas in an effort to improve student learning, it is in their interactions with students that they are able to gauge whether they are making progress in supporting their goals. Similarly, in an organization, it is in the interactions that occur between
individual actors in the context of daily work practice that learning is likely to occur. In both of these instances, routines, like PDSA cycles, organize daily work activities (Feldman & Pentland, 2003; Sherer & Spillane, 2011) and are used to bring greater specificity to otherwise uncertain work (DiMaggio & Powell, Rowan, Raudenbush, & Cheong, 1993; Scott & Davis, 2007).

In this section, I first provide an overarching description of the research design approach that guides this set of inquiries. I follow by describing the research context, the participants in the study, and my role as a researcher and participant observer.

**Research Approach**

In this collection of studies I adopt a sociocognitive (Vygotsky, 1978; Wertsch, 1985) and situated (Brown, Collins, & Duguid, 1989; Greeno, 2006; Greeno & Engeström, 2014) perspective. Guided by a socio-cognitive approach I will both attend to cognition in individuals and also examine cognition in the context of people’s interactions with each other and with tools, or routines, to support learning within the context of a community of practice (Lave & Wenger, 1991). My work is situated in that learning occurs in the context of practice and action (Suchman, 1995).

**Research Context**

The present investigation is an extension of ongoing partnership work between the University and a local K-12 school. As a graduate student researcher, I have worked on several research projects with the secondary science team since the summer of 2012. As part of my work I have engaged teachers in professional development focused on literacy strategies, have been involved in collaborative planning of instruction, co-developed instructional materials, have supported data analysis and use, have co-taught lessons, conducted classroom and team meeting observations, and have engaged in reflective conversations, with teachers, individually, and in
groups, around teaching, instructional routine development, and implementation. Because I have, in particular, worked in this manner with teachers in the science team, these experiences have provided a convenient sample of teacher participants to work with in this research context.

**Research Site**

Research was conducted at a public K-12 school located in the heart of a large metropolitan West Coast city. The school is one of six located on a large campus designated as a learning complex. Approximately 1000 students attend the K-12 school with 44% of the student population classified as English learners. Eighty-one percent of the students were also classified as economically disadvantaged. The school is unique in its designation as a pilot school and its status as a partnership school. Due to the school’s unique status, teachers exercise high degrees of autonomy and, though they must adhere to *certain* district policies, are free to use alternative curricula. At the same time, because there is a great deal of autonomy, teachers also have various additional responsibilities at the school site. Finally, due to its partnership status, teachers and students regularly participate and engage in educational research with partnering university faculty.
**Inquiry I. Teacher Learning in Context: Improving Practice**

**Abstract:** The present work documents a collaborative design effort to study teacher learning in the context of practice. Using the context of design rooted in an authentic problem of practice, researchers worked with a team of science practitioners to support learning and make progress on a problem of practice. In this collaboration, PDSAs were used as a tool to mediate teacher learning towards meeting a goal to increase student literacy achievement. PDSA implementation improved teacher learning, supported teachers’ capacity to better align and refine instructional practice with student learning, and progressively hone in on a set of practices that allow them to rapidly improve their teaching.

**Keywords:** design-based research, partnerships, teacher learning, student learning, improvement science

*Teachers learn best by studying, doing, and reflecting; by collaborating with other teachers; by looking closely at students and their work; and by sharing what they see*  
*(Darling-Hammond, 1998).*

Enhancing teachers’ ability to design, adapt, and refine effective instructional practices is essential for teacher learning (Lampert, 2010). While prior work in teacher education and professional learning espouses the need to tightly couple teacher learning to practice, there are limited examples of scalable professional learning models (Borko, 2004). One potentially productive strand of research has been the work that locates teacher learning in records of practice (Ball & Cohen, 1999). Many studies explore records of practice in the context of looking at student work (Kazemi & Franke, 2004), examining instructional episodes in video clubs (Sherin & van Es, 2009), or in-depth analysis of artifacts collected over the course of
extended periods of time to understand teaching in practice (Ball & Bass, 2003). The work presented here builds on current research that explores teacher learning in the context of design (Gomez, Gomez, Rodela, Horton, Cunningham, & Ambrocio, 2015) and extends earlier conceptions of records of practice (Ball & Cohen, 1999; Ball & Forzani, 2009). The present study explore the use of improvement science tools that support the iterative refinement of instructional innovations to advance teacher learning in the context of localized design work.

Situating learning in practice is a cornerstone of teacher learning (Putnam & Borko, 2000). Teacher learning happens in the context of instruction - when a teacher can implement an idea quickly and test its utility in supporting student learning. I conceptualize teacher learning as improvement in teachers’ ability to identify discontinuities in student learning, problem-solve, and take swift and appropriate pedagogical action in the midst of teaching. Environments that actively involve teachers in activities that enlist them in goal setting, data collection, evidence-based study and reflection, greatly support learning. The importance of documenting these activities is an essential component of teacher learning. These records of practice are a way to capture evidence of practice grounded in projections of student learning. Such records can be used iteratively to track and refine practice rapidly. When used to link learning over time, these records can represent an accrual of learning.

I suggest that one way educators can learn from their practice is by using PDSA cycles as tool to record practice. Educators can use PDSAs as a tool to make predictions about the implementation of a desired change idea before they test it. When teachers compare their predictions to the outcome of their PDSA, they can use this comparison to learn how they might adjust their practice in light of the results. In a PDSA cycles, educators complete a series of four phases: Plan, Do, Study, and Act (see Figure 1). During the Plan phase, teachers create a plan
and make predictions of what their intended plan will accomplish. In the next step, the Do phase, teachers test the plan by putting their ideas into action and documenting what occurred.

Following the Do phase is the Study portion of the PDSA cycle. Here teachers summarize the results of their test and document learning. The last step of the PDSA is the Act phase. During the Act phase, educators use what they learned to inform future action.

Figure 1. The Plan-Do-Study-Act Cycle

The power in PDSAs lies in the completion of consecutive cycles where learning in one cycle informs the planning, enactment, and reflection phase in the subsequent cycle. Through the accrual of learning, educators can make steady progress on a problem of practice.

Educators can use PDSAs to learn fast, fail fast, and improve quickly (Bryk et al., 2015). While PDSA cycles are an iterative design strategy traditionally used to support sustained improvement efforts across a range of fields, from manufacturing to healthcare (Berwick, 2003; Bryk, Gomez, & Grunow, 2011; Langley et al., 2009), they are a useful tool for supporting
“integrated problem-solving research” (Bransford, et al., 1999). Recent applications in education have demonstrated the value of PDSAs in supporting disciplined inquiry and accelerated learning (Bryk, Gomez, Grunow, & LeMahieu, 2015; Gomez et al., 2015). PDSA cycles, when used effectively, are a tool that allow teachers to not only intuitively sense what is or is not working in the classroom, but to use the evidence collected to inform design changes and quickly adapt their practice. Seemingly akin to lesson study cycles (Lewis, Perry, Murata, 2006), PDSAs stand apart in their emphasis of rapidly testing minute instructional refinements, linking data collection predictions to change ideas and student learning outcomes, and rapid succession of iterative design cycles. The speed and degree to which teachers learn what works in the classroom is largely contingent upon the quality of data they collect and use formatively. PDSAs are a tool that enables teachers to quickly test and track refinement and implementation of instructional changes and align improved instructional practices to student learning (Bryk, Gomez, & Grunow, 2011). PDSA cycles are a promising strategy to foster teacher learning, document progress in practice coupled to student learning, and promote evidence-based instructional refinement.

A hallmark of design-based research is its inclusion of practitioners as partners in the design and iterative refinement of educational innovations (Bell, 2004; Bell, Hoadley, & Linn, 2004; Brown, 1992; Cobb et al, 2003; Gomez et al., 2015). Co-design partnerships have been described in the literature as essential to solving the problem of scalability, yet less is understood about the conditions under which partners learn in the process of iterative design, what they learn, or how they learn it. The extent to which practitioners are involved in the process of co-design varies (Penuel, Fishman, Yamaguchi, & Gallagher, 2007). Nonetheless, these studies suggest that positioning teachers as key decision-makers in the process of innovation, design,
and iteration contributes to learning (Edelson, 2002). In this respect, design partnerships involving teachers offer a prime opportunity to examine iterative design cycles as potential learning sources (Lewis, Perry, Murata, 2006).

Design partnership arrangements have great potential to foster teacher learning when partnership goals are closely connected to teachers’ current experiences. In their current form, design partnerships generally privilege the role of the researcher. For instance, it is typical for research team members interested in testing the usability of an innovation to initiate partnerships (Shear, Bell, & Linn, 2004). Because teachers’ time is a commodity, design involvement is usually limited to phases of refinement. In this capacity, teachers have described their role in the design partnership work as one of providing feedback (Penuel, Roschelle, & Schechtman, 2007). Thus, although practitioners are design partners in these settings, the conditions under which teachers engage in design remain separate from teachers’ day-to-day work. In this work, I am guided by current efforts that adopt improvement science principles and tools to accelerate learning and move practice. The work contributes to expanded design research efforts (Bang & Vossoughi, 2015; Fishman, Penuel, Allen, Cheng, & Sabelli, 2013; Gutierrez, Engeström, & Sannino, 2016; Gutierrez & Jurow, 2016) that consider on-the-ground design efforts motivated by practitioners seeking to design and adapt educational innovations to solve critical problems of practice. I seek to contribute to studies that examine learning affordances in teachers’ educational design work situated in practice-driven inquiry contexts.

The present study investigates teachers’ learning opportunities in practice-driven design work and examines the use of PDSA cycles as a mediating tool to support teacher learning through experimentation. I present a case example of a collaborative group of secondary science teachers who were interested in learning how to integrate literacy strategies to improve their
students’ science and literacy achievement. In this case, teacher learning was made possible when it was tightly coupled to practice (Cochran-Smith & Lytle, 1999; Desimone, 2009), involved iterative refinement of instructional strategies (Feiman-Nesmer, 2001) and was grounded in documented (Ball & Cohen, 1999; Borko, 2004) and evidence-based design (Gomez et al., 2015). The present study differs from previous design-based research partnership studies in that it was a team of three secondary science teachers experiencing a critical problem of practice that initiated the design partnership. Teachers acted as design partners throughout every phase of the project. PDSA cycles were a cornerstone of the design work, involving teachers in successive cycles of inquiry and, in turn, serving as the records of practice that supported teacher inquiry and learning. I describe results from the first year of design partnership work, illustrating how teacher learning was supported and sustained through the use of PDSA cycles over the course of an academic school year.

**Theoretical Framework**

In this study, I define teacher learning as changes in practice over time. I use Clarke and Hollingsworth’s (2002) Interconnected Model of Professional Growth (IMPG) to analyze teachers learning over the academic school year (see Figure 2).
Figure 2. The Interconnected Model of Professional Growth (IMPG). Source: Clarke & Hollingsworth, 2002.

The model operationalizes teacher learning as growth when changes across any of the following four domains occur: personal, practice, consequence, and external (see Table 1). According to the model, change is fostered by the mediating processes of enactment and reflection (p. 953). The resulting changes can occur in any of the domains and, most often, a change in one domain is associated with concurrent changes in another. The model aligns especially well with the use of PDSA cycles. In the case of PDSAs, teachers’ experimentation is guided by an articulated theory of change. Key to these cycles of experimentation are the continuous mediating processes of prediction, enactment, and reflection. It is through these actions that teachers can assess the quality of their experimentation and make determinations about how what they have just done meshes with their previous understanding of their practice, their students, etc. The IMPG highlights the importance of experimentation through enactment and reflection as mediating processes for growth and learning.
Table 1

The Interconnected Model of Professional Growth (IMPG) Domains and Evidence

<table>
<thead>
<tr>
<th>Domain</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal</td>
<td>Teacher’s knowledge, attitudes, and beliefs</td>
</tr>
<tr>
<td>Practice</td>
<td>Professional experimentation</td>
</tr>
<tr>
<td>Consequence</td>
<td>Salient outcomes</td>
</tr>
<tr>
<td>External</td>
<td>Sources of information, stimulus, or support</td>
</tr>
</tbody>
</table>

Study Design and Methodology

The current study explores teacher learning in the process of collaborative design work. I examine the use of PDSAs as a tool to record experimentation and practice and a method through which teachers are prompted/supported to undertake the processes of enactment and reflection, carefully tracking their work and documenting how this supported student learning. It was in the maintenance of these records of instructional practice that teachers learned and subsequently made progress in their own learning and students’ learning in science classrooms. The aim of this collaborative design effort was to support teacher use and implementation of PDSAs as a design tool to improve literacy instructional routines.

The following research questions guided the study:

1. Do teachers perceive plan-do-study-act (PDSA) cycles as helpful in supporting their learning about supporting literacy in science? If so, in what ways do teachers perceive PDSAs as helpful to their learning?

2. What is the role of PDSAs in framing the ways teachers collaborate and in supporting collaboration?

3. Did, and if so, how did PDSAs support teachers’ learning about supporting literacy in science?
To address the research questions, I analyzed teachers’ PDSA documentation (online PDSA trackers), PDSA classroom observation field notes, professional learning meeting agendas, artifacts, and field notes, and structured teacher interview transcripts.

I present examples of PDSAs, how they aligned with teachers’ goal to improve literacy, and the results of student learning outcomes as a proxy for teacher learning. I first describe the context of the study and offer relevant background information that supported this work. Next, I discuss how PDSAs were an essential tool in this iterative collaboration, mediating disciplined inquiry in connection with the theoretical underpinnings that guided the design. I then report findings and discuss conclusions and implications.

Study Context

At the beginning of the 2013-2014 school year, a local school’s secondary science team (n=3) requested assistance from UCLA researchers in identifying discipline-specific goals and establishing a process for meeting the school’s aim of increased school wide literacy achievement. During a collaborative planning meeting, the teachers decided to focus their efforts on improving students’ ability to reference text in science learning. Teachers used student data from 2012 and 2013 administrations of departmental common integrated learning assessments (ILAs) developed by the National Center for Research on Evaluation, Standards, and Student Testing (CRESST). The assessments consisted of two parts: a reading comprehension portion where students read three connected texts about a specific science topic and a related writing component that, among other things, measured students’ ability to reference text to support claims on a four-point scale (Silver, Hansen, Herman, Silk, & Greenleaf, 2011). Reference to text is a measure of students’ ability to support statements and claims in a written essay. Here, reference to text can take the form of quotations, paraphrases, citations, or other references to the
information and ideas in the texts students read as part of the assessment. The four-point scale rates students in their ability to reference text. A score of 1 indicates that a student makes little or no accurate or detailed references to support their written essays. A score of 2 indicates that students use some accurate and detailed references to support their written essays. A score of 3 indicates use of accurate and detailed references while a score of 4 means that students use well-chosen references to support their arguments. Students in grades 7 through 12 consistently demonstrated an inability to reference text and use it as evidence to support the claims they made in the written portion of the assessment. In Table 2 below, the majority of students consistently received a score of 1, indicating their inability to use references to support their arguments in writing. Given the important role of claims and evidence in science and literacy, teachers decided that they wanted to make progress in their learning to understand the kinds of instructional practices that would allow them to support students’ referencing ability in science (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010; NGSS Lead States, 2013).

Table 2

*Common Assessment Score Data (2012 - 2013)*

<table>
<thead>
<tr>
<th>Reference to text scores</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students with a score of 1</td>
<td>68%</td>
<td>63%</td>
</tr>
<tr>
<td>n=217</td>
<td></td>
<td>n=223</td>
</tr>
<tr>
<td>Students with a score of 2</td>
<td>22%</td>
<td>30%</td>
</tr>
<tr>
<td>n=70</td>
<td></td>
<td>n=107</td>
</tr>
<tr>
<td>Students with a score of 3</td>
<td>8%</td>
<td>6%</td>
</tr>
<tr>
<td>n=26</td>
<td></td>
<td>n=22</td>
</tr>
<tr>
<td>Students with a score of 4</td>
<td>2%</td>
<td>0.5%</td>
</tr>
<tr>
<td>n=6</td>
<td></td>
<td>n=2</td>
</tr>
<tr>
<td>Total number of students</td>
<td>319</td>
<td>354</td>
</tr>
</tbody>
</table>
The collaborative team decided to establish a set of common instructional literacy routines that were tightly coupled to effectiveness in improving student learning. The design team’s work was particularly well suited to an improvement approach where PDSA cycles could serve as a primary tool to situate practice and expedite learning.

Participants

The work reported here draws on documentation of three science teachers’ PDSA cycle use. Ms. Rodarte, Ms. Bravo, and Mr. Córdova taught courses in grades 7-12 at a K-12 school located in a large metropolitan west coast city. Approximately 1000 students attended the school, with 44% of the student population classified as English learners. Eighty-one percent of the students were also classified as economically disadvantaged. All three teachers worked with the research team, comprised of two university faculty members, one graduate student researcher, and one post-baccalaureate research assistant. The role of researchers in this setting ranged between support provider, data collector, instructional coach, team member, and improvement advisor. All participants were collaborative partners in the design work.

Engagement in disciplined inquiry

In the literature on improvement, the following three questions are at the heart of any concerted effort: (1) What specifically are we trying to accomplish? (2) What change might we introduce? and (3) How will we know that a change is an improvement?

The first collaborative team task was the formulation of a theory of change that directly related to the team’s aim. Teachers used 2013 common assessment data to develop a departmental aim that aligned with a school wide literacy focus: By the end of March 2014, 70% of students will score level 2 or better (on a four-point scale) on the CRESST assessment. Aim specification was followed by the creation of a set of change ideas that link the aim to the
theoretical underpinnings that guided the design work. Teachers elected to work on language as a primary driver of the problem of practice (reference to text). Generated change ideas related to the conceptual supports that were important to solving the problem of practice (see Figure 3).

Figure 3. Science Team Driver Diagram

During the first year of PDSA implementation, change ideas targeted improvement in A. Argument Recognition and B. Argument use in discussion. Instructional literacy routines that incorporated reading-to-learn tools like annotation, double-entry journals, and summary writing (Gomez & Gomez, 2007) were instructional supports that underwent iterative refinement as part of the PDSA work.

Equally important to this work was teachers’ ability to specify a set of measures that would serve as evidence of student learning in relation to the change ideas they were testing. This set of measures would support them to quickly gauge whether a change idea was indeed an improvement. Because the intention of this work was to progressively refine a set of instructional
practices, the team decided to begin with one teacher and progress to include the entire science team (see Table 3 for a timeline and description of activities).

Table 3

2013 - 2014 School Year Timeline of Activities

<table>
<thead>
<tr>
<th>Month</th>
<th>Activities</th>
<th>PDSA</th>
<th>Researcher Roles</th>
</tr>
</thead>
<tbody>
<tr>
<td>September</td>
<td>1. Biology teacher works with partners to design and test annotation routine.</td>
<td>5</td>
<td>- Design partners in the development and refinement of the annotation routine</td>
</tr>
<tr>
<td></td>
<td>2. Full-day planning meeting to support teachers’ use improvement science tools</td>
<td></td>
<td>- Facilitate portions of the full-day planning meeting to support development</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>of theory of change and aim statement, brainstorming measures, including</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>PDSA use</td>
</tr>
<tr>
<td>October -</td>
<td>1. Teachers use PDSA cycles to test and refine the annotation routine in their</td>
<td>45</td>
<td>- Support teachers to implement PDSAs</td>
</tr>
<tr>
<td>December</td>
<td>classrooms</td>
<td></td>
<td>- Provide instructional support in lesson design and text selection</td>
</tr>
<tr>
<td></td>
<td>2. Teachers introduce other reading-to-learn tools and use PDSAs to refine</td>
<td></td>
<td>- Observe PDSAs</td>
</tr>
<tr>
<td></td>
<td>their use</td>
<td></td>
<td>- Think partners</td>
</tr>
<tr>
<td></td>
<td>3. Teachers design and administer mid-year assessment to measure students’</td>
<td></td>
<td>- Support refinement of mid-year goals</td>
</tr>
<tr>
<td></td>
<td>progress towards overarching aim (assessment measures students’ ability to</td>
<td></td>
<td>- Participate in full-day planning meeting</td>
</tr>
<tr>
<td></td>
<td>identify claims and evidence in text)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>January</td>
<td>1. Teachers use mid-year assessment data from December and PDSA cycle</td>
<td>6</td>
<td>- Support teachers to implement PDSAs</td>
</tr>
<tr>
<td></td>
<td>information to discuss future change ideas.</td>
<td></td>
<td>- Observe PDSAs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Think partners</td>
</tr>
<tr>
<td>February</td>
<td>1. Teachers develop a 3-day instructional sequence that reflects their</td>
<td>8</td>
<td>- Support teachers to implement PDSAs</td>
</tr>
<tr>
<td></td>
<td>learning to date based on their PDSAs.</td>
<td></td>
<td>- Observe PDSAs</td>
</tr>
<tr>
<td></td>
<td>2. Teachers focus PDSA cycles on refining aspects of day one in their three -</td>
<td></td>
<td>- Think partners</td>
</tr>
<tr>
<td></td>
<td>day instructional sequence.</td>
<td></td>
<td>- Participate in full-day planning meeting</td>
</tr>
<tr>
<td>March</td>
<td>1. Teachers implement last series of PDSA cycles.</td>
<td>10</td>
<td>- Support teachers to implement PDSAs</td>
</tr>
<tr>
<td></td>
<td>2. Teachers make preparations to administer CRESST ILA (common</td>
<td></td>
<td>- Observe PDSAs</td>
</tr>
<tr>
<td></td>
<td>performance-based assessment)</td>
<td></td>
<td>- Think partners</td>
</tr>
<tr>
<td>April - June</td>
<td>1. Teachers administer CRESST ILA (common performance-based assessment)</td>
<td>0</td>
<td>- Participate in full-day planning meeting</td>
</tr>
<tr>
<td></td>
<td>2. Teachers prepare and present PDSA work to the staff</td>
<td></td>
<td>- Prepare a review of routines and measures</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Interview teachers</td>
</tr>
</tbody>
</table>

As shown in Table 3 above, Ms. Bravo, the biology teacher, was first involved in the design of an annotation routine that would be used to discipline initial PDSAs. Ms. Bravo had
some familiarity with PDSAs when the remaining science team members were introduced to the tool in late September. The PDSA protocol included public sharing and critique in the planning phase. Ms. Bravo shared her experience with the design of the routine and discussed her planned use of PDSAs to test new ideas, learn quickly, and improve expeditiously, a cornerstone of PDSA cycle work. During this planning meeting, university design partners shared a paper-based tracking tool that had been used in previous PDSA work. The teachers were accustomed to collaborating and documenting their professional learning work online and requested an online version. One of the design partners agreed to formulate a similar tool that would be readily available online. The online PDSA tracker included information about the team’s theory of change, documented the measures that they had decided to use to document student progress on referencing text, and, individual teacher trackers that were also accessible by the entire design team. Using the PDSA tracker provided teachers with a common tool to document their tests and change and align their change ideas with their theory of change. The PDSA tracker also provided teachers with an embedded set of queries that corresponded with each phase of the PDSAs (see Table 4). Guided by this process, teachers specified a change idea, linked the change idea to the theory of change in their driver diagram, made predictions about student learning, recorded observations, and documented their learning.

Table 4

Queries to support teachers’ use of PDSA cycles

<table>
<thead>
<tr>
<th>PDSA</th>
<th>Guiding Queries</th>
</tr>
</thead>
</table>
| Plan | 1. What are you going change? What is the goal of the change (i.e., what is being tested?)  
2. What do you think might happen as a result of the change? (Predictions)  
3. Tasks/tools required to set up the test of change (Who? By when?) |
| Do   | 1. What happened during the test? (surprises, challenges, etc.) |
| Study| 1. Record your results. How do results compare to your predictions? |
| Act  | 1. Record learning: What modifications will you make for the next test cycle for this change idea?  
2. Backburner items: Potential change ideas to test in the future. |
Data sources

The teachers and I were interested in understanding how to use PDSAs as a tool to learn and improve student learning. In the process, I was interested, in my research, in examining what teachers’ learned about how to improve practice through practice. Overall, teachers completed 78 PDSA cycles during the 2013-2014 school year. Of these, 50 PDSAs were completed in the fall semester and 28 in the spring semester. In total, I examined 53 PDSA tracker entries and the field notes for 33 classroom PDSA observations. I focused the analysis of teacher learning on teachers’ use of PDSA cycles. Several data sources supported this analysis: online PDSA trackers, field notes and other artifacts that illustrated changes in teachers’ patterns of instruction, teacher interviews. I also used students’ CRESST ILA scores as a lens to illustrate how, in the course of one year, teachers’ ability to learn quickly resulted in their ability to meet their overarching aim – improving student learning.

First, I examined teachers’ use of PDSAs by focusing on the number of cycles teachers conducted, identifying the conceptual supports that their change ideas were linked to, and studying the continuity between cycles. Next, I used teacher interviews to help me understand teachers’ perceptions of the use and limitations of PDSA cycles to support teacher learning and student learning. After that, I studied the degree to which documented PDSA cycles contributed to changes in teachers’ instruction. To gauge the degree to which practice had changed, I used field notes and artifact analyses. I identified points of congruence between documented changes in the PDSA trackers and teachers’ patterns of instruction. Finally, I conducted a Wilcoxon signed ranks test to examine differences in 2013 and 2014 CRESST ILA student reference to text scores (n = 60).

Data Analysis
Documenting teacher’s experimentation. To understand teachers’ engagement and use of PDSAs as a tool for experimentation, documentation of practice, and learning, my first step was to analyze the online PDSA tracker entries completed by each teacher to create a PDSA Tree (Health Quality & Safety Commission, 2015; Ko Awatea, 2015). The PDSA Tree is a visual representation tool that helped me organize the PDSA cycles conducted over the academic school year. The visual representation of the PDSA cycles helped me to analyze and understand three things: 1) each teacher’s individual PDSA development and progress towards the group aim; 2) the target areas where the team collectively concentrated its learning and experimentation efforts as they worked to meet the group aim; and 3) the connections between teacher’s individual PDSA cycles where one teacher’s learning may have influenced another teacher’s experimentation focus during future PDSA cycles.

Analyzing teacher’s perceptions of PDSA cycles in supporting learning. My first step was to analyze the transcripts of the interviews conducted with the science teachers at the end of the academic school year. Beginning the analysis here served a dual purpose. First, it helped me to understand teachers’ perceptions of the use and utility of PDSAs in support of their professional learning practice. Second, it also helped me understand any perceived limitations of the work. Understanding this information was important to the data analysis process because I used these findings to guide my analysis of teacher learning using documentation in the online PDSA trackers and classroom observation field notes during PDSAs.

I first read the transcripts, noting general themes. I then reread the transcripts, this time using In Vivo coding as the first cycle coding method (Saldaña, 2016). I selected In Vivo coding because I thought it was best suited to gaining insight into the ways that teachers described their work with, and understanding of, PDSAs. I used a spreadsheet to organize and keep track of the
codes for each teacher. I had a second coder also read the transcripts and conduct In Vivo coding for reliability purposes. The second coder also kept track of the codes using a copy of the same spreadsheet. After conducting the first cycle coding, we both reviewed the codes together and discussed any areas of incongruence. In total, we were in agreement with the codes 99 instances. There were 5 instances where we were incongruent in our coding. Next, I went back through the coded interviews and clustered the coded sequences together across teachers and organized these in a table. Here, I read through the clusters, documented the overlapping codes and sequences, and used a third table column to document my initial impressions and analyses for each cluster. After that, I used the memo’s third column of analysis, documenting the salient In Vivo codes and sequences across teachers along with my analyses to recode the interviews. This time I applied concept codes to the clusters (Saldaña, 2016) and, in turn, used these to conduct a third cycle of analysis where I used axial coding to consider the relationships between the In Vivo and concept codes, what claims I might be able to make from the data, and considered where, in the data, I might find evidence to warrant these claims.

Analyzing if, and what, teachers’ learned during PDSAs. To understand if teachers learned, what they learned, and how they learned it, I began the analysis by reading all PDSA tracker documentation and classroom observation field notes, by teacher, in chronological date and time sequence. Theoretically, I was guided in this analysis by Clarke and Hollingsworth’s (2002) Interconnected Model of Professional Growth (IMPG). Here, I focused on identifying evidence of learning through enactment and reflection of experimentation in the PDSA process.

2 There were instances where I observed a teacher conduct a PDSA but the teacher did not document the PDSA in their tracker. I analyzed the field notes in the sequence in which they occurred. There were also PDSAs for online PDSA tracker entries by the teacher and classroom observation field notes were collected. In those cases, I first read the teacher documentation and then read the corresponding observation field notes, noting any evidence of what the teacher documented in their tracker as important.
The model’s domain categories (changes in teachers’ instructional practice that are informed by professional experimentation; changes in teachers’ personal knowledge, beliefs, and attitudes; consideration of salient outcomes, or the results that teacher’s value; examination of possible external sources of information or change stimuli; and the change environment in which professional learning is situated) also oriented my attention to the places where I might expect to find evidence of learning over the course of the year as well as consider what might have contributed to those changes.

To prepare for the initial analysis, I printed out all of the PDSA tracker entries and classroom observation field notes and organized the data by teacher. First, I read and coded the tracker entries and field notes focusing on what changes the teachers hoped to accomplish during the PDSA cycle in relation to what they actually did and the types of things they recorded as important. After I coded each teacher’s set of entries and classroom observation field notes, I went back and recoded the entries, and entered them into a spreadsheet where I documented the data source (tracker or observation), the changes that were made as part of the PDSA cycle, emergent codes and themes, predictions and results, and documented analytic notes and examples. Here I sought to identify patterns and variation in the instantiations for each teacher. I documented the frequency with which these occurred as well as whether they were documented by the teacher or the researcher. After this, I printed out the spreadsheet and used it to guide me as I recoded the data for a third time in preparation for the final analysis.

In the final analysis, I reviewed all of the coded categories and instantiations by each teacher, this time with a goal of refining categories and understanding if and how these changed from fall to spring over the course of the academic year. As I did this, I wrote analytic summaries of each teacher for each coded category, cycling back to previous teachers if I discovered a new
phenomenon in the data, making sure that I had not missed it in previous analyses. I summarized the results for each coded category by teacher, along with the frequency of occurrence in the data. Finally, I used Clarke and Hollingsworth’s IMPG to help me visualize and organize the relationships between the coded categories, the theoretical model, and the categories themselves.

*Understanding the role of PDSAs in framing and supporting teacher collaboration.* In total, there were five designated full-day science team teacher meetings held throughout the school year. The goal of these meetings was to provide teachers with protected time for professional learning and support teachers’ inquiry work. I analyzed full-day meeting agendas \( n = 5 \), meeting field notes \( n = 5 \), and meeting artifacts to identify the amount of time that teachers spent working on PDSA-related work during these meetings and the content of the meetings themselves to understand how teachers collaborated together.

These data sources provided insight into teachers’ joint professional learning work. Having access to this information allowed me to understand the prominence of teachers’ PDSA work in terms of how much time was spent on PDSA-related activities. In addition, the variety of data sources also afforded me insight into both teachers’ perceptions of the PDSA work as well as the quality of the work teachers were doing.

**Findings**

Study findings suggest that frequent engagement in PDSAs supports to anchor teachers’ professional learning experiences by providing a structured way to undertake improvement on a problem of practice. The findings also suggest that the conditions in which teachers use PDSAs matter. When teachers engaged in successive PDSAs over a one to two-day period, data suggests that they experienced rapid incremental growth and consequential learning. Furthermore, study findings also suggest that regular PDSA engagement to improved teachers’ ability to align their
instruction to match the learning goals for their students. In addition, teachers also developed additional pedagogical strategies that they could use to support students’ make progress towards science learning goals. In this section, I organize the findings by research question.

RQ1: What are teachers’ perceptions about the utility of PDSAs?

Broadly speaking, teachers perceived that PDSAs were helpful in supporting their professional practice. Teachers’ perceived that the use of PDSAs as a method of inquiry: structured and organized their professional learning practice, fostered accelerated growth in their instructional teaching practice, and supported intradepartmental consistency. In what follows, I offer details about each finding and supporting examples from the data.

**PDSAs organize teacher learning**

All three science teachers described and offered examples of the ways in which PDSAs helped to structure what they were doing in the classroom helping them to take informed action in support of student learning. All teachers reported that they had changed the ways that they taught and planned. In particular, all three teachers discussed the importance of using data to set goals in varied time increments and also attributed structure and organization to their teaching and learning to the use of PDSAs.

*It’s a cycle.* Each of the teachers described PDSAs as a cycle or a stage that helped them to keep track of their goals and implementation of particular strategies in relation to student learning. Teachers described how PDSAs supported their ability to assess how their instruction impacted student learning and enabled them to quickly make changes to their instruction in subsequent teaching. The goal-setting and reflection elements of PDSAs were important aspects of the process. Learning from PDSAs is a continuous process that is designed to help them meet their goals. Because it is iterative and dependent on how closely goals align with outcomes, it is
a process that can be repeated indefinitely. Mr. Córdova describes the process in the following way:

...these changes can occur... either... within the minute or within whatever time period you want to look at. So, for example, you noticed during your class that your lesson was going a certain way during one period, the following period would be changed based on those observations that you made upon the prior period.

Ms. Bravo explained:

But it’s a cycle so you can revise and you can go back so the whole point is that you... always look up your... strategies that you’re using and keep track of what’s working and what’s not working so you can... make changes.

And Ms. Rodarte noted:

We’ll go ahead and keep track of how by doing these little changes, improve or not improve, you know our teaching and their learning.

All teachers discussed how engaging in PDSA cycles helped them to keep track of these “little changes” they were making in relation to how students were doing. In the quotes above, teachers described the cyclical nature of PDSAs, highlighting how keeping track of this information helped them take action and revise their teaching. Teachers also talked about evaluating student results in relation to their goals and predictions, and using their observations to make changes in teaching for the benefit of student learning. At base, these reflections suggest that teachers found that PDSAs supported their ability to place students at the ‘center’ of instruction.

Teachers reported that PDSAs were key in supporting their individual and collective learning. PDSAs helped them to becoming more reflective practitioners and discussed this process of reflection as occurring in two ways: self-reflection and reflection with others.

Self-Reflection. Teachers shared a common understanding of the ways in which PDSAs helped them become more reflective practitioners. All teachers discussed the utility of PDSAs in helping them gain a deeper understanding of how their teaching impacted student learning.
Teachers reported that they were able to pinpoint what wasn’t working and make adjustments to their teaching quickly, often between one class period to the following class period. For example, Ms. Bravo was piloting an evaluation process at the school site while she was engaged in this study. She discussed the ways that PDSAs supported her teaching in the context of teacher evaluation. The teacher evaluation process required her to engage in deeply reflective activities throughout the year. The evaluation process required her to provide extensive documentation of her learning process throughout the year, including written narrative reflections. According to Ms. Bravo, the PDSAs supported her ability to keep track of what she was doing and focus on how she was using data to evaluate her practice in relation to what she expected students to learn.

“It’s just thinking about what you’re doing and how it impacts your teaching and student learning. It just makes you kind of stop and just not go go go. So, I mean, this year I was getting evaluated so, like, PDSA really helped me because a big part of the teacher evaluation was reflecting on your practice and, pretty much, this was, you know, right along what I was doing already so it really helped me with it, with the teacher eval as well where I had to look at, okay, this is what I’m doing, this is what I’m going to do, and this is what’s happening with the data I’m obtaining and how it’s impacting my students. So, again, it supports reflecting... and evaluation, too... so it was helpful.”

By engaging in the process of reflection, teachers gained a novel level of self-awareness. This self-awareness supported the ways in which teachers began to align their student learning goals with their instruction over the course of the school year. In adopting a macroscopic lens on their pedagogical practice, teachers were able to differentiate and evaluate the degree to which they coordinated the different aspects of their instruction (texts, materials, routines, strategies, etc.), and how these were coupled to their goals. Teachers gained a deeper understanding of the texts they selected, how well these aligned to their learning goals, and the degree to which they actually supported students to reach their learning goals. Teachers reported that they have developed new methods to keep track of data regularly and have tapped into other resources that support students to build confidence and meet their learning goals.
Reflection with others. When teachers used PDSAs to improve their practice, they had to develop an understanding of the detailed work that PDSAs would help them accomplish within the context of a larger problem of practice. While this level of understanding may have been obscured by the work of learning to engage in PDSAs, in the beginning, teachers began to develop a bidirectional understanding of how their work fit within the scope of their “ultimate aim”. Over time, teachers in this setting learned to work their way through the problem of practice, developing additional instructional routines. The learning they undertook, individually and collectively, was continuous. Findings suggest that PDSAs supported this learning because they required teachers to develop intentional measures of student learning in concurrence with the documentation of a process that included goal-setting, enactment, reflection, and making adjustments to subsequent actions that moved teaching and student learning closer to the goal. With each PDSA, teachers had the expectation that they would get closer to reaching their goal. As one teacher describes it, PDSAs were helpful in supporting expanded interpretations of data.

In this particular case, Mr. Córdova likened the process of teacher reflection to student reflection:

Yeah... you have to be reflective with the PDSA cycles. It’s... kind of hard to have a conversation with yourself, and not have someone... I mean, it's good to self-reflect, but at the same time, it's good to reflect with others because sometimes your ideas may be just too, I don't want to call it narrow-minded, but just one-directional, that it doesn't give you an option to expand other possibilities. So, the reflection piece I think for ourselves and I think it also goes back into the classroom. It just, you know, feeds on our students, you know, because we reflect ... they’re reflecting as well, and they are able to see differences in their, in their understanding of content.

An important benefit of engaging with PDSA cycles, which are comprised of distinct, yet interdependent, components: plan-do-study-act - is that they provided teachers with a concrete iterative process that helped the teachers to both keep track of their goals and to take informed action using measures to gauge the degree to which these actions got them closer to their goal(s). These distinct, but interdependent, components are reflective of key processes for learning that
are also represented in the Clarke & Hollingsworth (2002) Interconnected Model of Professional Growth. Table 5 below details the underlying cognitive processes that undergird PDSA cycles.

Table 5

*The Underlying Cognitive Processes of PDSAs*

<table>
<thead>
<tr>
<th>Domain</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plan</td>
<td>Goal-setting, guided by a theory of change</td>
</tr>
<tr>
<td>Do</td>
<td>Learning by doing, enactment, experimentation</td>
</tr>
<tr>
<td>Study</td>
<td>Reflection, learning</td>
</tr>
<tr>
<td>Act</td>
<td>Praxis, informed committed action</td>
</tr>
</tbody>
</table>

If we map these processes to Clarke and Hollingsworth’s theoretical model (see Figure X), we can envision that planning in a PDSA cycle requires some sort of stimulus. The stimulus can take the form of information from an outside source, like a knowledgeable other or curricula (External Domain). Similarly, the processes of enactment and reflection from a previous PDSA cycle (Domain of Consequence or Personal Domain) can also be used to inform planning.

Planning and goal setting involve careful attention to, and clarity about, the preciseness about the objective of professional experimentation in the Domain of Practice. Questions that are helpful to guide this process in PDSAs include: What will the teacher try? How is that different from what was done before? What predictions does the teacher have about what might happen? When teachers are clear about this, they then carry out the plan in the ‘do’ part of the PDSA. Here, they are involved in the process of *enactment*, a key component of the Clarke & Hollingsworth model. It is through enactment that reflection, in turn, can occur. During the study portion of the PDSA, teachers can *reflect* on the outcomes in relation to the predictions and use what they learn to inform future action, or *enactment*.

*PDSAs fostered accelerated growth in teaching practice*
PDSAs were a method that supported accelerated teacher learning in two ways. First, engaging in the approach harnessed the diverse perspectives and incremental learning of the team to support individual growth. Second, it provided teachers with a method that they could use within the context of a finite time sequence to gauge the effectiveness of a specific teaching practice in meeting their goals for student learning.

The benefit of diverse perspectives. All three teachers also discussed how collaborating with others in their department in relation to PDSAs helped them think about their challenges from diverse perspectives, expanding the possibilities for action. Ms. Rodarte described PDSAs as operating within the frame of a team effort, stating that the “team will actually have “different tests and different ways”, or approaches, to doing the work. Because the team conducted PDSA concurrently, guided by a shared theory of change, what they were learning supported them both as individuals seeking to improve their teaching practice and as a team seeking to improve their collective understanding as they worked together to meet a broader departmental aim.

The importance of diversity in teaching perspectives was echoed by the other teachers. Mr. Córdova described engagement in PDSAs in the context of reflection with others, highlighting it as a way in which they could see beyond a single “option to expand other possibilities.” He elaborates on his response, discussing the integral role that support plays in conducting PDSA work. For Mr. Córdova, having the benefit of a ‘knowledgeable other’ to support the team in engaging a new process for teacher learning was pivotal to the utility of PDSAs.

I agree... the level of support has been what's sort of driving this. Because, I think that you know, if I were to run a PDSA on my own without the kind of support that I'm getting from you, or from my colleagues, or from anyone that is knowledgeable within the PDSA world, I wouldn’t have been able to, you know, carry it through because you don’t have anybody to... to depend on, you know what I mean. But, because we have this sort of system here, this structure, and there’s, like a sense of responsibility, even though it’s not
right out front, hey, you’re responsible for this, you need to have this. It’s still understood that we kind of all depend on each others’ information to carry PDSAs out.

Linking practice to learning. All three teachers talked about the ways in which PDSAs helped them to not just link pedagogical practice with student learning, but do so in a way that helped them to quickly gauge the degree to which their instruction aligned with, and contributed to, student learning. PDSAs supported teachers’ ability to improve pedagogical practice, regularly reflecting on how the texts, materials, and learning tasks aligned with their goals for student learning. Ms. Rodarte discusses it in the following way:

...by grading the PDSA cycles on the annotations we were able to, you know, see the changes immediately. I think I had an opportunity to see how many students did actually find or identify the claim, and how many the evidence, and [it] gave me a quick look. The other thing... sometimes when I chose the articles, you know, I find that, okay, the purpose of these articles is different than the purpose of my lesson. So, [it] was like a big eye opener and you can definitely make the texts work towards what you want to teach but that makes me, as a teacher, to be more aware of choosing the right thing for the purpose of my lesson. I can always go around and make it work, but there were definitely articles that were more suitable for what I wanted to teach or the concept that I wanted to teach. So, it kind of like, keeps me not only track of myself, or how I plan the lessons. Also, I was able to see some sort of, like a general idea of how many students understand and how many, they didn’t.

In essence, PDSAs help teachers to ‘slow down’ and ‘narrow’ their instructional focus in an effort to learn quickly and have a big impact on student learning. On the surface, slowing down and narrowing your focus might seem to stand in direct contradiction to learning quickly to overcome complex challenges. Teaching is a complex activity. Improving know-how requires attention to the minute processes that comprise teaching and learning as described by the teacher in the excerpt above.

PDSAs support teachers in parsing out the challenges involved in big inquiries. Big inquiries must be parsed into smaller questions, questions that are small enough to locate in the moment-to-moment interactions in the context of daily classroom instruction. The iterative
nature of PDSAs make it possible to weave together a tapestry of teacher and student learning, an accumulation of knowledge that quickly chips away at the barriers that make progress on complex challenges so difficult. In the following excerpt, Ms. Bravo describes how using PDSAs has supported her ability to more quickly address student challenges.

*I've been able to, like, be able to reteach the concepts the students don't understand way quicker than I used to do. Because... some of the things that we implemented were the use of plickers and the exit slips so, again, it goes back to structures. Just be more aware of the things you are using in class and how it impacts the students, and get quicker feedback, I think, for me, for... my teaching practice, and for the student understanding.*

PDSAs are one method that works because they require that teachers develop quick and easy methods or processes to measure student learning progress. The goal, here, is to immediately gauge whether a planned instructional change yields the desired student learning results.

Teachers reported that PDSAs provided them with the opportunity to consider “a lot more tools to focus on our [their] goals.”

**PDSAs support intradepartmental consistency**

Teachers reported that using PDSAs to support their work brought about consistency in method, or approach, to addressing departmental challenges, consistency in teaching, and consistency in expectation and evaluation of students’ science learning.

*Consistency in method.* Teachers described the ways in which PDSAs brought an organizational structure to the departmental approach to doing work.

...there really hasn’t been a way how to do it, like a know-how on what to do first. It was, kind of like, [there was] no template for us, until this new PDSA sort of came along, then we had a template...” (Mr. Rodarte)

*I think it helped us organize ourselves better, cause like we all had our goals that we want. Like I had my, my vision for my kids but it’s just that... I think it improved communication in our department as well ‘cause now we, we were dealing with the same language like saying, ‘Oh, PDSA.’ You know, like, we’re working on the same thing and it’s like a common thing for us as well. Just like we were talking about the same structures for students for next year, like vocabulary, you know. Seems like now we’re on
the same page so we can use the common tools as a department to meet... our goals.”
(Ms. Bravo)

Consistency in teaching practice. Over the school year, the intradepartmental consistency was apparent in the ways in which teachers shared and co-constructed learning. During the interviews, teachers provided examples of the ways in which they were able to focus their teaching to, in turn, create a structure for teaching that worked for them individually, but at the same time addressed the needs for consistency within the department.

... what is necessary, I think, is consistency. In other words... what I mean by that is if kids have a certain structure with her [Ms. Bravo] then I can carry that forward in my own classrooms because... she’s 9th grade and I’m 10th grade, so these kids will be a little bit more in tune with what they’re supposed to be writing about... and more reflection happens and I’m also looking at it at... the macroscopic level of, like there is a lot of consistency that's happening throughout the departments that helps, uh, the PDSA cycles happen with much more ease. You know, because we’re all focusing, for example, on reference with support of text, it just helps facilitate, you know, the school as a whole.
(Mr. Córdova)

Ms. Bravo emphasized the importance of carrying what works forward. In her response she stated:

... the whole point is to find strategies that will work for our students, that will help them. So if we’re finding things that are working then to me it wouldn’t make sense that we’re not using those strategies that were finding not being successful with the kids you know like, so I think it will be good to just have... just go over um the strategies that have worked so we can continue to bring them back.

PDSAs were helpful in establishing continuity from grade to grade within science classrooms. Using PDSAs to develop a shared annotation routine that focused on discussing claims and evidence, beginning in middle school, carried through the secondary grades. PDSAs were helpful in establishing consistency in teaching practice, creating structures that supported student learning. For example, in February, the teachers worked together to create a three-day instructional sequence that was circulated for revisions before formal adoption (Figure 4). Some examples of this continuity are reflected in the shared instructional cycle below, including shared
reading and writing routines (annotation, summary writing), the use of organizers (triple-entry journals), and learning tasks embedded within the lab report structure.

![SEQUENCE OF EVENTS](image)

**Figure 4.** Three-day instructional sequence.

The instructional sequence itself represents the dramatic change in instruction that was evident in teachers’ classrooms due, in large part, to the learning that took place over the first half of the school year. Classroom observations over the school year corroborated the integration of literacy routines into daily practice.

*Consistency in students’ science learning expectations.* Because teachers were focused on aligning their routines and instructional practices, PDSAs also supported teachers in thinking carefully about what they expected students to learn and what they expected students to be able to do to show that they had indeed learned. Over the course of the year, teachers refined their own understanding of annotation, specifically considering what they wanted students to annotate for.

For example, at the beginning of the school year, PDSA tracker entries and classroom observation field notes show that teachers focused students’ annotations on main idea and
supporting details. As time went on, and teachers became more comfortable with the routine, they shifted the focus of annotation from main ideas and supporting details to claims and evidence. This shift was more in line with the teachers’ departmental aim - to get their students to recognize and use claims and evidence to support argumentation. It also suggests a shift in teachers’ understanding of students’ science learning expectations.

During teachers’ full-day departmental meetings, teachers also spent time discussing assessment and evaluation of annotation, summarization, and laboratory notebooks. As teachers gained more experience with PDSAs, refined their instructional routines, and grew more comfortable with the integration and assessment of literacy-focused practices in their own classrooms, an important shift was seen in meeting agendas, which increasingly reflected the departmental need to establish continuity in expectations across the department (see Table 6 below).

Table 6

Time Spent on Assessment Discussions During Full-Day Meetings

<table>
<thead>
<tr>
<th>Meeting</th>
<th>Time and Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>September 20, 2013</td>
<td>Using measurement to inform instructional processes (1 hour)</td>
</tr>
<tr>
<td>November 19, 2013</td>
<td>Alignment of exit questions to readings (1 hour)</td>
</tr>
<tr>
<td></td>
<td>Exit Question Development (2.25 hours)</td>
</tr>
<tr>
<td>January 23, 2013</td>
<td>Annotation/Summarization Rubric (1 hour)</td>
</tr>
<tr>
<td></td>
<td>Laboratory Notebook Rubric (1.5 hours)</td>
</tr>
<tr>
<td>February 28, 2014</td>
<td>Analyzing data: How will last year’s CRESST assessment shape our next PDSA cycle? (3 hours)</td>
</tr>
<tr>
<td>April 1, 2014</td>
<td>Analyzing data: How will last year’s CRESST assessment shape our next PDSA cycle? (2 hours)</td>
</tr>
</tbody>
</table>

As one teacher describes it,
If your students are successful that’s because... what you’re doing with them is, important... and what you’re doing in terms of a PDSA cycles, is right. So, I for example, have become a little bit more structured, you know, in terms of what I’m going to do, not on a daily basis, per se, but like on a consistent level.

**Research Question 2: How do PDSAs support teacher collaboration?**

*Structure.* PDSAs supported teacher collaboration by providing a structure that teachers could use to organize their own professional learning practice to meet their goals as a department. In doing so, teachers were better equipped to establish intradepartmental consistency (described above) in terms of the instructional routines they developed and refined through collective PDSA implementation during the academic school year.

*Interrogating practices.* Furthermore, PDSAs provided teachers with the opportunities to interrogate new literacy-focused practices, experimenting with different pedagogical moves to learn how to make these routines accessible to all students. The data suggests that teachers’ engagement in the PDSA process not only supported establishing intradepartmental consistency through collaboration. In essence, because science teachers were working to improve their own ability to support students’ argumentation practices, the process gave rise to opportunities for collaboration with colleagues in other departments. The literacy-focused school-wide charge for improvement encouraged all grade levels and departments to have active improvement agendas that centered on literacy. All departments were actively involved in addressing literacy challenges that they had identified as barriers to their students’ learning and achievement outcomes. As a routine for supporting literate interactions with text, the process of annotation was relatively new to science teachers, but was common practice for their English and social studies/history colleagues who regularly engaged their students in reading texts, identifying claims, and using evidence to support those claims in discussion and in writing. As science teachers began to shift their annotation focus from identifying main ideas and supporting details
to identifying claims and evidence in the science readings, the teachers required support and clarification about what constituted a claims and evidence for that claim in the science text. By the end of the year, at least one teacher discussed the importance of PDSA work in helping establish stronger connections between science learning and broader disciplinary learning. In this case, the teacher discussed the importance of focusing on claims and evidence with students because it was also a key to student engagement in other core subjects. Similarly, another teacher discussed the importance of supporting students’ ability to improve reading and writing.

*Inter-departmental collaboration to support to intra-departmental change.* The science team regularly collaborated with the special education department. Because the school followed a full-inclusion model, special education students were part of every science teachers’ classrooms. In addition, one special education teacher regularly pushed in to science teachers’ classrooms with her students, supporting teachers with modifications and accommodations. Although this was a common form of collaboration for the science team, it didn’t involve other departments, per se, as much as it involved a single teacher. In January, however, this shifted. During the science team’s full-day department meeting, the work focused on supporting the team to better understand claims and evidence. I highlight this meeting, here, because the meeting represents an example of cross-departmental collaboration resulting in intra-departmental learning.

The science lead teacher collaborated with the English department to prepare for this full-day meeting. His primary concern was that the meeting content, and tasks, supported the science team in refining their understanding of annotating for claims and evidence. At this point, it was important for the department to have this learning opportunity. They were in the midst of supporting students’ movement from annotating for main ideas and supporting details to claims
and evidence. Science teachers began to shift away from the use of main ideas and supporting
details because they believed it was better aligned the expectations detailed in the Next
Generation Science Standards NGSS; NGSS Lead States, 2013) and the Common Core State
Standards (CCSS; National Governors Association Center for Best Practices, Council of Chief
State School Officers, 2010). What was evident from the PDSA tracker entries and classroom
observation field notes was that teachers were struggling to distinguish claims and evidence from
main ideas and supporting details. It was a crucial step in establishing consistency across the
department because it had direct implications for the kind of work they needed students to do.

During the meeting, the lead teacher presented the definition of an argument and
evidence. He referenced and made available two resources that he used to support his
understanding of these definitions. In the meeting, teachers first discussed claims and considered
how to identify them in the text. Then, they read and annotated two articles and discussed their
annotations for claim and evidence after each article. The task surfaced the difficulty teachers,
themselves, can face when identifying claims and evidence in text. Teachers struggled with
identifying the claim of the first article and were uncertain about their annotations, leading to a
discussion about how important it is to provide students with more opportunities to discuss their
annotations. The lead teacher reiterated that it was through having multiple opportunities to read
and write that students would enhance their ability to use arguments.

**Research Question 3: Did, and if so, how did PDSAs support teachers’ learning?**

Teachers’ use of PDSA cycles supported learning anchored in a shared problem of
practice through their work towards achieving an overarching aim. At the same time, teachers’
individual use of PDSA cycles illustrates a trajectory of teacher learning that was simultaneously
individual and collective. Study findings suggest that teacher learning was accelerated and
sustained when teachers engaged in continuous, and consecutive, PDSA cycles around a problem of practice. The study findings suggest that the more teachers engaged in PDSA cycles, the more they learned. That is, frequency had a lot to do with how much progress teachers were able to make. Similarly, the degree to which individual teacher’s learned also contributed to the collective learning of the team.

*How many PDSAs?*

Within a single school year, the three teachers conducted 78 PDSAs. The majority of PDSA cycles (n = 50) were conducted between September and December with the remaining PDSAs conducted during the spring semester - between January and March (n = 28). During this time, teachers met regularly to discuss and share their learning progress. When teachers experienced great success with their PDSA design work, they reported it to others who then used the group’s collective knowledge to inform future iterations of their own PDSAs and design work. Teachers’ engagement in PDSA cycles suggests that teachers were learning a tremendous amount about aligning instructional practice to student learning. Teacher growth in their ability to connect specific aspects of the instructional literacy routine to measures of student learning was also documented in the PDSA tracker entries and classroom observation field notes.

In Figure 5 below, I have represented PDSA cycles in a PDSA tree. Here, I highlight the number of PDSA cycles teachers conducted as well as possible connections between individual teacher’s cycles. Using the PDSA tree, I was able to examine the specific content of each teacher’s learning journey, in general, and more specifically, I was able to see the connections from one teacher’s PDSA cycle to another.
For example, Mr. Córdova, the chemistry teacher in this team, conducted the majority of cycles (n = 38) and implemented tests related to several change ideas: annotation, reading entry journals, and lab writing. By contrast, Ms. Rodarte, the middle school teacher, and Ms. Bravo, the biology teacher, limited their PDSA cycles to focus on annotation. Nonetheless, because all teachers regularly interacted in meetings throughout the year, they regularly discussed PDSAs, sharing the results of their work. Thus, although teachers were not necessarily conducting PDSA cycles for every change they introduced, they were consistently, during the school year, appropriating each others’ ideas and leveraging the group’s collective knowledge to make changes to their instructional practice.
Incremental learning and consequential outcomes

A major finding from this study is understanding the conditions in which teachers experienced accelerated growth in their pedagogical learning when they conducted PDSA cycles. The data suggests that when teachers conducted consecutive PDSA cycles, from day to day and/or from period to period, they were more likely to experience consequential learning. Teachers were more readily able to see and apply the learning from one PDSA cycle to the next. Teachers used what they learned to make subsequent changes in their experimentation plans. This was a common finding across all three science teachers. The data suggests that the frequency of PDSA cycles completed was related to evidence of teachers’ differential learning experiences. For example, findings suggest that Ms. Rodarte, the middle school science teacher who had the least number of PDSA cycle iterations documented and observed, experienced one cycle of incremental learning during the school year. Furthermore, this cycle of incremental learning was observed during the second half of the school year, towards the end of February.

In the following example, Ms. Rodarte conducted two back-to-back PDSA cycles on February 19. During the first cycle, she provided students with an example of a claim and modeled her thought process as she selected the claim. Before she identified the claim, she provided students with the opportunity to share what they had identified as a claim. In doing so, the teacher also probed the students for their reasoning. Ms. Rodarte had not previously engaged in probing students for their reasoning in the way she was doing during this lesson. Before she provided students with her own version she acknowledges student responses stating, "This is very interesting!" Ms. Rodarte subsequently moves to tell students what the claim is and offers her own reasoning, “This is actually the claim. I'm going to tell you why [my emphasis]." The teacher continued to model other tasks throughout the lesson in a similar fashion, each time
providing students with opportunities to practice before moving on to the next step. These were new ways of modeling annotation for Ms. Rodarte. In the second PDSA cycle of the day, the teacher continued to guide students in the same manner. Here, she shifted her approach by providing additional examples. Ms. Rodarte modeled her thought process with these additional examples to make sure students were better prepared to offer their own reasoning. She used what she had learned in the previous PDSA from probing students’ reasoning to change her modeling approach to include more examples in the second iteration. While Ms. Rodarte did not document these two PDSA cycles in the tracker, observation field notes indicate that she refined her teaching practice when she conducted subsequent PDSA cycles.

During PDSA classroom observations teachers typically shared their insights verbally with the researcher. Debriefing would often occur towards the end of the teaching period or between periods, depending on the schedule. During these conversations, teachers would share how they thought the PDSA cycle went and why. The researcher offered insights, based on the observation and field notes and together they would discuss possible change ideas for future PDSA cycles. The idea that conducting consecutive PDSA cycles supported teachers’ accelerated growth was also present in the case of both high school science teachers.

In Mr. Córdova’s case, the chemistry teacher, incremental learning was evident across five separate PDSA sequences: October 14 to October 15, October 25 to October 25, October 31 to October 31, November 5 to November 5, and March 3 to March 4. In each of these cycles, the teacher made specific changes based on something he learned in the previous cycle. For example, on October 14, student performance met the teacher's goals. He reflected on this and implemented the same routine in the next period and received equal results. In the remaining cycles (October 25, October 31, November 5, March 3), the teacher or students struggled with
specific task components. In these cases, the teacher responded to these findings by making changes in an effort to achieve more desirable results. Mr. Córdova's changes were successful in bringing about positive outcomes in 3 of the 4 cycle sequences. During the cycle in which he was unsuccessful, on November 5, his goal was to build in prereading activities to support students’ ability to annotate for main idea and evidence, and understand how evidence is used to support the main idea. Mr. Córdova recorded the following in the PDSA tracker.

*Period 1 students will be tested on evidence finding ability and disagreement finding ability. I will give them more time to annotate (annotation for homework). The activities prior to the reading will help them understand the reading. Also, lesson needs to emphasize purpose of cycle at the end of the activity-how supporting evidence supports main idea.*

After the PDSA cycle he documented the outcome of the PDSA cycle.

*Students were not able to finish the reading on time. Students were not able to have a discussion on annotation selections. Students were able to answer plicker quiz question.*

Here he highlights that students did not complete the activities he had planned for the allotted time period. In the Study section of the PDSA tracker, Mr. Córdova references his results in comparison to his prediction. In his comments, he indicates that while he is happy with the overall results, he is not satisfied with his inability to formatively assess students as they engage in the annotation task. He writes:

*Although the results of the plicker quiz were great, (76% of the students were able to answer the correct choice), I was not happy about letting them take the annotation assignment home. I cannot see what kind of effect this has on their annotation.*

Mr. Córdova then reflects on the instructional choices he made during the enactment of the cycle and records his ideas about it. He notes that the text was too lengthy for the students to complete in class given the amount of time he allotted to the activity. In the Act section of the PDSA tracker Mr. Córdova records the following:
Next period, 3, will be doing the same activity; however, I will shorten the reading assignment, ask a different plicker question because I feel students are sharing ideas between periods, and allow time for discussion of the reading.

He identifies three things he will change during the next PDSA cycle: a) shorten the reading assignment, b) ask a different plicker question, and c) provide time for discussion during the next PDSA cycle. Nonetheless, during the second PDSA cycle that day the teacher again ran out of time. During this iteration, however, he ran out of time because he scheduled the annotation task towards the end of the class period.

Period 3 scores were lower than expected. Students scored at 59% for their plicker quiz. Students were allowed to figure out for themselves what the main idea and supporting evidence was. Some of the challenges that I have is that I keep on running out of time. I need to stop choosing annotations towards the end of the class because it prevents the conclusion of the annotation routine cycle. No stars were evident in the text.

In this entry, Mr. Córdova noted his disappointment about the cycle being unsuccessful. He locates his inability to complete the activities in continuing to place the annotation task “towards the end of the class” period. He makes this reference because he failed to implement something he had already learned during an earlier PDSA cycle (October 16). During that PDSA cycle Mr. Córdova recorded the following:

The time is still quite long, about 50 minutes. Students did not answer the questions at the end of the article. I think I need to introduce the activity earlier in the lesson, leaving the activity towards the end of the class should no longer be part of the [routine].

From this cycle, Mr. Córdova learned that it was better to complete annotation tasks at the beginning of the class period rather than at the end of the class period. Subsequently, he implements this change in the November 15 consecutive PDSA cycles. He records the following entries in the PDSA tracker.

Period 5 students will begin with the annotation routine and then follow the similar protocol above. The goal is for 50% of the students to score the annotation related plickers question correctly. In terms of the annotation document, I expect that only 50% of the class will be able to identify the main idea and supporting evidence. Not only am I
testing them on content comprehension, I am also testing them on recognizing main idea. (November 15, Period 5)

Period 6 students will begin with the annotation routine and then follow the similar protocol above (Cycle 14). The goal is for 50% of the students to obtain a perfect score on the plicker quiz. In the annotation document I expect that 50% of the kids will target the main idea and 50% of the kids to target the supporting evidence annotations 100% of the time. I will give them two quizzes: one on content and the other based on asking them what was the main idea that they read during the annotation routine. (November 15, Period 6)

The November 15 cycle was successful, largely because Mr. Córdova put into practice the incremental learning he had accrued through his participation in the PDSA process. In that instance, he began the class period with the annotation task and also implemented the learning from the November 5 PDSA cycle, resulting in a successful outcome.

Incremental learning was also evident in Ms. Bravo’s PDSA tracker documentation and observations. In her case, there were two examples where she appeared to immediately connect her learning from one PDSA cycle iteration to the next. For example, in the consecutive PDSA cycles that took place between September 20, 30, and October 1, the teacher recognized that it was much more difficult to have students consider what challenges they would make to the her annotated copy of the text while they were themselves engaged in the peer review process. For example, on September 20 Ms. Bravo’s new learning was that students needed time to go back to their own articles to mark areas of disagreement.

Once students get their article back I will ask them to go back and (*) the items that they disagreed with or had questions on their own article.

Then, between September 30 and October 1, she realized that the peer review process itself was taking too long and not resulting in rich discussions. Understanding that discussions about points of disagreement were her goal, Ms. Bravo first adjusted the annotation routine to instead include an opportunity for students to engage in the peer review process first and then reflect on their
own work. By October 1st, the teacher found that it was best to have students self-assess annotations and not engage in a peer review. Here, the teacher documents:

*This took very long because I waited for every single student to finish reading and doing their annotations.... It also took long to peer-review because I was projecting the master and needed to wait for every student to grade their peer's article. Discussion didn't go so well. It seemed students were over it by then. Not too many students placed (*) on their articles.*

She realized that when students did not have their own paper in front of them, it was much more difficult for students to express annotation disagreements. Ms. Bravo concluded that engaging in the peer review process was not sensible, as a classroom task, her main goal was to have students reflect on their own work and to engage in discussions about their own disagreements or questions. This prompted her to develop the following change idea in the next PDSA cycle iterations.

1. **Students will self-asses instead of peer-assess.**
   *Rationale: Based on the last cycles, I have noticed students are less likely to (*) the annotations they disagree with or have questions on.*

During the October 7 PDSA cycle, the teacher carried forward her learning and implemented the change ideas from October 1. At the end of the PDSA cycle, the teacher’s entry reflects her understanding of how the implemented change ideas aligned with her goals.

*I found that students were more engaged throughout the entire routine. As the students finished the annotations, I would hand them a paper with reading comprehension questions. Students were engaged and did not disrupt. I also found that at least 10/33 students drew a (*) next to annotations they disagreed with or had questions because they were doing this as they self assess their annotations. Students were also making references to the text when we were having discussion on what they disagreed on.*

With each PDSA cycle, Ms. Bravo was able to connect her learning from the PDSA cycles, implementing the changes to achieve the results she desired.
The data suggests that all three teachers benefitted the most from PDSAs when they engage in more than one per day or over two consecutive days. Furthermore, it was in these instances, as the data illustrates above, that teachers were able to also apply previous learning from their PDSA engagement, putting it all together to achieve the results they desired for their students. Because teachers were focused on improving pedagogical action, having the benefit of iterating pedagogically within the same lesson content appears to have supported teachers to cognitively engage learning. Teachers were not navigating new content while they were experimenting with pedagogical iterations. For this reason, teachers might have been better able to learn rapidly when they engaged in successive PDSAs.

Refining understanding of learning goals, practice, and assessment

A second major finding was that of PDSAs as a method to support teacher’s refinement of how to best align their instructional practice to help students meet lesson goals. Through the process of engaging in PDSA cycles, teachers became accustomed to the process of setting learning goals for their lessons, making predictions about student learning outcomes, thinking through the tasks, the materials, and the learning arrangements that would be most conducive to achieving these outcomes, and increasingly reflecting on how they would assess whether students were on-track to meet both the lesson goals and the overarching aim of the work. In essence, this work illustrates the ways that teachers connect their own day-to-day, period-to-period work with student learning. Teachers referenced the importance of intention and alignment in their work, specifically in relation to student results. However, over time, what became evident was that the types of things teachers 'intended' became increasingly sophisticated over time. The teacher for which this is most evident is the chemistry teacher (36 instances), followed by the biology teacher (12 instances), and then the middle school teacher (4 instances).
The chemistry teacher. When Mr. Córdova began implementing PDSAs during the fall semester, his primary concerns were about the ways in which he used the text instructionally including providing the right kinds of examples during discussion of the text annotations,

*I think careful thought must be in place before coming up with examples to support their understanding of the text*

determining the appropriate text length for learning the annotation process,

*The article was longer than necessary. I noticed that the kids were getting impatient in not finding the main idea right away; however, it served its purpose of them recognizing that main idea is not always found immediately in the beginning of an article.*

and giving consideration to the adequate amount of time that should be spent on the routine.

*This was another whole class activity and students are able to determine the main idea and supporting evidence with much more ease (with guidance questions as a support). Total time taken was about 45 minutes. Students are not improving in disagreements with teacher.*

Later that fall, there was an observable shift in Mr. Córdova’s concern. While he previously worried about the adequacy of the planning of the materials, his attention shifted towards how and when students engaged with the text. Here, Mr. Córdova learned that it was better for students to engage with the text at the beginning of a learning block, not at the end. He also began to attend to the ways in which he measured student progress to determine how well student performance matched his learning goals.

*The results match my goals and predictions; however, I still need to account for the many students who are not able to identify 100% of the evidence and 100% of the claims. It becomes difficult to track who in particular is not understanding how to find claims and evidence. At this point, I still see that there needs to be teacher intervention for identifying claims and evidence. (November 21, 2014)*

*If this data is reliable; maybe it is due to the fact that there are less students in the class compared to other classes; however, I need for the data to match the quiz results. I question if the day's questions (essential/enduring understandings) are aligned (November 22, 2014)*
In the fall he also began to develop a better sense of how to gauge and monitor students' in-the-moment progress.

_I think that the questions are becoming a bit more aligned now. I think that students need to practice a little more with comprehension type questions rather than content questions. Maybe they need both; however, I will not be able to determine if students are understanding the reading if they don't test on taking comprehension type questions. The changes that I will make next time will be: 1) to stick only to comprehension questions based on annotations; 2) have them double-underline and write the claim question before the beginning of the reading of the text; and 3) during the annotation, I am going to try to have students lead the annotation results discussion._

By the spring semester, Mr. Córdova focused on how to improve instructional alignment to learning goals and continued to experiment with better ways of measuring and monitoring students' progress.

_I don't know why they results were surprisingly good. Maybe I was able to direct the students attention to the enduring understanding a little better than the last class; or maybe the students were not being honest about making the mistakes they made. Even the plicker question asked that day that pertained to content; only 50% of the class was able to answer the question correctly. I don't think this is reliable data; and, more trials are necessary with this class._

Here, he expanded consideration of his assessment practices to include how best to measure how well students were understanding the content in addition to how they were engaging in the processes of learning.

By February, Mr. Córdova began to gather additional evidence of learning. He readily implemented and refined the three-day instructional sequence that was co-constructed by the science team. He provided students with opportunities to activate prior knowledge, document their initial ideas and understandings, and talk about them with other students. Here, the teacher monitored learning with regularity, checking in with students while they worked and offering
support when needed. The teacher's instruction became more structured and aligned in relation to students’ learning needs.

We performed a pre-writing activity, paraphrased and annotated text, and we discussed the material extensively. I noticed that there were a dominant number of students who were leading the classroom discussion. The change that I made here was that I focused on the students that I knew were going to perform lower than expected and I made sure they understood the content. Together, I taught them how to paraphrase and analyze text and charts. (March 28, 2014)

For example, when students struggled with paraphrasing claims and evidence from the text, the teacher responded to students' needs by modeling and guiding paraphrasing, shifting away from a strict orientation to annotation of claims and evidence.

The biology teacher. Like the chemistry teacher, Ms. Bravo began her PDSA cycle work with attention to text length and how long the routine was taking to complete. In early PDSA cycles (September 20), she reflects on the possibility of “shortening the length of the article” to improve the routine. Over time, the teacher also began to reflect on ways to improve student engagement with text. On October 1, Ms. Bravo is increasingly concerned with keeping students engaged in the annotation task.

2. I will give comprehension questions to the students that finish their annotations meanwhile we wait for the rest of the class to finish annotating the text (especially on long articles that are 3-4 pgs).

Rationale: Wide range of reading abilities leads to students that are finished annotating quickly to become bored, disruptive and unengaged and I believe that giving them questions to work on as they finish will keep them on task.

By the end of the school year, Ms. Bravo has shifted her attention to supporting students’ engagement in discussion. Here, the teacher reflects on the role that her annotations may have played in hindering student participation. She writes,

I was surprised to find that by not showing my annotations, it opened more of an opportunity for students to argue with each other as to why one sentence was the main
Instead of students disagreeing with the teacher, students were disagreeing with each other so there was higher participation.

Yet, here she seemingly fails to recognize the role that she has played in supporting students to reach this point. Participation has been a major focus for this teacher. Because she has consistently used discussion as a major part of her pedagogy, the teacher has modeled for students ways to challenge each other’s thinking and press for reasoning.

The middle school science teacher. Finally, there are 4 instances in the data where there is evidence that Ms. Rodarte reflects on her goals for the PDSA cycle in relation to student outcomes. In 3 of these instances, she considers the degree to which the texts she has selected and the questions she has developed align with the goals of the lesson.

Thinking about the essential questions, aren't they well chosen? Articles, do they have certain format in which some of the answers are very ambiguous?

These occurrences were reflected during the fall PDSA cycles. In the spring, there was evidence of one more instance in the classroom observation field notes. Here, Ms. Rodarte focused on the quality of discussion and the degree to which students engaged with the science content.

Increasing student participation

All participants refined their ability to engage and enhance students’ participation in classroom discussions. Through engagement in PDSA cycles, teachers refined their approaches to leading discussions and increasingly improved their ability to probe student thinking.

There was evidence that Ms. Rodarte refined her approach to increasing student participation in discussions (10 instances). During the fall semester, she used four strategies to increase participation: giving participation points (October 1), peer-to-peer discussion (October 29), using student's annotated texts to lead annotation review discussions (November 12 and 21), and peer review checks (December 3). Observation field note analyses show that discussions
were heavily teacher-centered and teacher-directed during the fall semester. For example, the two instances where Ms. Rodarte selected and used student's annotated texts to guide the annotation peer review process presented as natural opportunities for students themselves to explain their annotation rationales to peers. Instead, Ms. Rodarte used student annotations to guide the annotation review with the whole class. In contrast, during the second semester, she began using probing in increasing degrees of sophistication to promote participation during discussion. Based on the observation field notes during the second semester, it became clear that Ms. Rodarte regularly asked follow up questions that challenged students to provide justifications for their responses.

For example, on February 19, the teacher follows up student responses with probes: *Why do you think it’s a claim? What do you think? Why do you agree that the answer is this? Why does it answer the question? So, how do we know?* These probes stand in sharp contrast to the type of questioning sequences that were observed during the fall semester. At that time, Ms. Rodarte regularly asked close-ended questions where students would give yes-no responses. She did not follow up with probing questions but would typically confirm the response and move on.

Similarly, Mr. Córdova also focused a great deal on enhancing students’ participation during discussions. In total, there were 20 instances when the teacher discussed participation opportunities during PDSA tracker entries and field notes. Findings suggest that Mr. Córdova used two dominant approaches to in enhance student participation: disagreement with annotations \((n = 9)\) and providing reasoning to support responses during discussions \((n = 8)\). During the fall semester, the teacher stressed the importance of students disagreeing with his annotations 8 times. On October 25, Mr. Córdova reflects on his instruction and writes, “I would like to spend less time lecturing and more time on eliciting responses from students during
discussion.” Increasing student participation is an intentional focus during the following six PDSA cycles (October 29, October 29, October 31, October 31, November 1, and November 5). On October 29, the teacher first focuses on getting “students to find at least one disagreement annotation made in the article.” In the second PDSA cycle on October 29, Mr. Córdova plans “at least one annotation where students should find disagreement.” His “hope [is] that they are able to articulate why they disagree.” On October 31, he reflects on his practice and arrives at the conclusion that students need to have more opportunities to discuss with other students prior to engaging in whole group discussions.

As time progressed it became increasingly clear that the reason Mr. Córdova valued disagreements during discussion of annotations was that, in his view, it approximated the type of scientific discourse that scientists used. Participation in discussions was important for students’ scientific literacy development because it gave them the opportunities to practice making claims, supporting them with evidence, and providing the appropriate reasoning.

Mr. Córdova continues to read and pauses to ask students, “Does this answer the question - What can nanotubes do?” Students are in agreement that it does and the teacher proceeds to place a checkmark. He tells the students that at this point they should all have three check marks. One student raises his hand and says, “I have two check marks and a star.” Mr. Córdova is pleased that the student disagrees with his annotation. Mr. Córdova reads the text excerpt and explains his reasoning. The student disagrees with the second half of the annotated sentence and explains why he is in disagreement. Mr. Córdova is visibly pleased with student’s reasoning and proceeds to give the class a meta-level explanation of how the student’s reasoning supported his disagreement. Mr. Córdova proceeds to tell students that engaging in discussions like these is the kind of thing that scientists do. Scientists make claims and support them with evidence. (October 31, 2013)

By the spring semester, Mr. Córdova’s instruction emphasized students’ ability to support their claims with supporting evidence and appropriate reasoning. This was evident in the classroom observation field notes where the teacher challenged students to provide justifications for their responses (n = 4). Much less frequently, the teacher referenced the importance of working with
others to increase participation, once in the fall and another in the spring \((n = 2)\). Finally, during the teacher’s last PDSA cycle (March 28), he expressed the desire to disrupt discussion patterns that were dominated by the same group of students.

With respect to PDSA cycle activities, and increased student participation, the findings suggest that Ms. Bravo placed a great deal of effort in improving students’ participation in discussions \((n = 18)\). As the data suggests, she refined her ability to increase students’ participation over the course of the school year. There were two prominent strategies that the teacher employed to improve students’ participation: identifying points of disagreement \((n = 7)\) and probing for student reasoning \((n = 13)\). Ms. Bravo introduced the use of disagreements during annotation review during the second cycle of PDSA implementation (September 17). She is the one who first experimented with this practice and introduced it to Mr. Córdova and Ms. Rodarte. Like Mr. Córdova and Ms. Rodarte, it appears that this practice of disagreement was an important part of Ms. Bravo’s discussion process as it set the foundation for engaging questioning and reasoning practices. During the first month of PDSA implementation, between September 17 and October 8, Ms. Bravo focused explicitly on getting students to mark disagreements 6 times. By October 8, the teacher shifted her primary focus towards probing students’ reasoning for the remainder of the academic school year.

Ms. Bravo’s use of probes to press for student reasoning and thinking evolved over time. For example, on October 10 the teacher probes student reasoning by asking probing questions. Her probes include: *So, does it support the main idea? What do you mean by that?* Over time, she increases the types of questions she uses to probe students’ reasoning and begins to direct students to build on each other’s responses. For example, on November 12, Ms. Bravo continues to push students to provide reasoning for their disagreements and to build on each others’
contributions and justifications. She facilitates the discussion by asking students whether they agree or disagree with a previous student’s contribution and presses students to say why they are in agreement or not.

Over time, Ms. Bravo increases her ability to challenge students’ thinking. During the spring, observation field notes document additional ways that the teacher probes student thinking during discussion. On February 20, she continues to engage students in discussion but has expanded the probes she uses to press for student reasoning. Here, Ms. Bravo uses the following probes to challenge students to provide their reasoning:

- Is there anything that helps you answer the question?
- Why do you think this is the supporting sentence instead of the main idea?
- What do you agree with?
- Give us examples of what DNA can do.
- What do you think? Why?

Finally, on March 3, during discussion Ms. Bravo challenged students’ to explain why they believed something was the claim. She pushed other students to contribute to the idea, expressing agreement or disagreement, before giving her own opinion. She pushed students to reference other students’ remarks, making sure to explain why they did or did not agree. Ms. Bravo continued to facilitate these discussions, asking questions like, “What do you think about what ___ said?” She typically asked 3 students to build on another student’s contribution before moving on.

The above examples illustrate the importance of discussion participation for this group of science teachers. Because PDSA cycles were grounded in the aim of improving students' ability to reference text in support of claims, teachers valued students' ability to engage in discussions where they had to use text-based evidence to support their discussions. Furthermore, they
approximated a form of scientific discourse that teachers valued and wanted their students to successfully emulate in their own discussions.

**PDSAs effect on student outcomes**

Teachers began this learning journey in an effort to support their students’ ability to support written arguments, making claims and supporting them with evidence referenced in texts. In the first part of this paper, I presented the CRESST ILA data that teachers used as a baseline measure to develop an overarching aim for the school year. The teachers engaged in PDSAs, mapping changes to instruction on a shared theory of action. In this section, I present a brief statistical analysis of the CRESST ILA data for the 2013-2014 school year in comparison to data from previous years to determine whether there was a difference in students’ reference to text scores after implementation of PDSAs.

I conducted a Wilcoxon signed rank test on a subset of the data (n = 60) to determine whether there was a difference in students’ reference to text scores after PDSA implementation (Sawilowsky, 1990). Based on data from previous years (2012 and 2013), I hypothesized that assessment scores would remain the same without the use of PDSA cycles. While it might be common to expect growth in scores on the basis of students’ maturation, the CRESST ILAs are scored according to grade-level expectations, thus accounting for any expected growth. Thus, this was not a concern. Nonetheless, there were limitations in obtaining matched student data. For this reason, there were only 60 students that were paired for the Wilcoxon signed rank test. Results of the analysis indicated that there was a significant difference in students’ reference to text scores, z = -4.02, p < .000. The results indicate that students improved in their ability reference text on the CRESST ILAs after teachers implemented PDSA cycles to improve practice.
When teachers used disciplined inquiry to establish common routines to approach teaching tied to student learning and shared their learning with each other, they were better able to support students in making progress to meet their aim of improving students' ability to reference text. At the end of the 2013-2014 school year, 71% of students scored a level 2 or higher on the CRESST ILAs. This represents a large increase in student achievement from both the 2012 and 2013 data (see Table 7).

Table 7

*Common Assessment Score Data (2012 - 2014)*

<table>
<thead>
<tr>
<th>Reference to text scores</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students with a score of 1</td>
<td>68%</td>
<td>63%</td>
<td>29%</td>
</tr>
<tr>
<td>n=217</td>
<td>n=223</td>
<td>n=98</td>
<td></td>
</tr>
<tr>
<td>Students with a score of 2 or higher</td>
<td>32%</td>
<td>37%</td>
<td>71%</td>
</tr>
<tr>
<td>n=102</td>
<td>n=131</td>
<td>n=242</td>
<td></td>
</tr>
<tr>
<td>Total number of students</td>
<td>319</td>
<td>354</td>
<td>340</td>
</tr>
</tbody>
</table>

In this study, findings suggest that PDSAs support teachers to improve their instruction, aligning it to shared learning goals. In addition to providing teachers with a structure that they can use to engage in sustained inquiry, PDSAs are a tool that promotes intradepartamental consistency and coherence. Through their sustained work together over the course of a year, teachers documented and shared their learning. When teachers engaged in successive PDSAs, they experienced accelerated incremental learning that contributed to the design of enhanced instructional supports and routines to assist students’ learning. Furthermore, PDSAs are a tool that can be used to foster interdepartmental collaboration. When teachers engage in these cycles, they position themselves as learners. In this way, the seek resources and knowledgeable others, often leveraging the expertise of their colleagues.
Conclusion

The CRESST ILAs were used as a baseline measure to motivate sustained teacher inquiry. Because the work grew out of their goals for student learning with respect to supporting students in making reference to text, the data suggests that teachers were invested in developing a common set of practices and routines that would be instituted across the grade levels. In the first year of implementing PDSA cycles as a tool to discipline improvement efforts, teachers successfully established common routines to approach teaching and share their learning around a common goal. I argue that teachers’ ability to quickly improve and refine instructional routines was largely due to their ability to document their teaching practice in relation to student learning. Teachers increased their pedagogical knowledge and their ability to adapt practice quickly in ways that positively impacted student learning. Teachers developed ownership of the PDSA process as a tool for refining practice. As a result, science teachers designed an instructional set of routines for science teaching that was adopted by the entire science team and yielded remarkable gains in student learning.

Implications

This work has broad implications for understanding teacher learning efforts, informing design-based research partnerships concerned with scale and sustainability of innovations, and the design of professional learning environments and experiences. Study findings suggest that the use of PDSA cycles as tools offers opportunities to accelerate teacher learning and iteratively refine alignment between instructional practice to student learning. I argue that PDSAs serve as records of practice and that their continued use should be a integral component to support teacher learning that both improves and sustains instructional practice and student achievement (Stein & Matsumura, 2008). I further suggest that the use of PDSAs serves as a tool to regularize,
discipline, and structure teacher learning. When teachers are focused on making progress on a
shared problem, having a structure to support their professional learning work is essential.

PDSAs are a method that, when used with other improvement tools, can accomplish this. These
findings suggest that district and local school leaders may find great value in incorporating
PDSA cycles as a part of regular classroom practice as a useful tool towards meeting a goal to
increase student literacy achievement.
Inquiry II. Dual Language Teachers Working to Improve Reading Comprehension

Abstract: The present work builds on previous empirical research about the use of PDSA cycles as a tool to support a secondary science teacher team’s professional learning as they worked to improve an authentic problem of practice. In this article, I investigate one elementary school teacher team’s professional learning experience over the course of a one-year period. Between 2014 and 2015, this team of second-third grade dual language program teachers took up the use of PDSA cycles to support their professional learning as they worked to improve their students’ literacy. Using content analysis methods, I sought to understand the ways that teachers used PDSAs and how their use changed over the course of the year. Study findings suggest that PDSA implementation supported teacher learning, improving their capacity to better align and refine instructional practice with student learning, and progressively hone in on a set of practices that allowed them to iteratively improve their teaching.

Keywords: improvement science, teacher learning, student learning, literacy, dual language

Dual language bilingual programs are gaining increasing popularity in schools across the United States. Touted as programs that promote language proficiency in two languages, these programs provide students with opportunities to learn content in both their native language and English. Research suggests that students who participate in dual language instruction outperform their monolingual counterparts in measures of reading and math achievement (Thomas & Collier, 2010). With the growing emphasis on the importance of supporting students to become biliterate and bicultural (Orellana, 2015; Martinez, Hikida & Duran, 2015), these programs seem to be strong sites for supporting student learning. Because the programs are quite new, less than
15 years old, there is little empirical research about how to build, and sustain, good teaching and learning skills in these contexts. Further, there is little, if any, empirical information about how to document, and refine teaching and learning contexts to meet the dual-language learning needs of all students. In this study, I report on my findings from a yearlong investigation of one elementary school teacher team’s professional learning experience in documenting and refining their dual-language immersion pedagogical skills and their support for the learning context.

**Study Design and Methodology**

The present study builds on previous research findings that suggest PDSA cycles are a helpful tool to support teachers as they structure professional learning experiences to improve a shared problem of practice (see Lozano, Inquiry I). In this paper I explore how a team of second-third grade dual language program teachers used PDSAs to support and discipline their professional learning experience. My goal was to understand teachers' engagement and use of PDSAs over time. Specifically, I wanted to understand what they did, how they did it (or documented it), and what, if anything, they were able to improve. The following research questions guided the study:

1. What is the role of PDSAs in framing the ways teachers collaborate?

2. Did, and if so, how did PDSAs support teachers’ learning about improving their students’ literacy?

To address the research questions I drew on document analysis of teachers’ PDSA documentation over the course of the 2014-2015 academic school year. These documents include the team’s professional learning plan, professional learning meeting agendas and minutes, end-of-year presentation preparation materials, and supporting artifacts.

*Study Context*
During the 2014-2015 school year, the school leadership team set a focus on school-wide literacy improvement for a second year in a row. Because of the success that the secondary science team experienced during the 2013-2014 school year while using PDSAs, school leadership made the decision to implement/diffuse the use of PDSAs as a tool to support improvement school-wide. School leadership made several systematic changes to its organizational routines and structures in support of this effort. One major change the school made was a revision to the school’s Professional Learning Plan (PLP). The PLP is an annual process that teachers use to support their growth. As part of this process, teachers engage in cycles of inquiry around a shared problem, regularly documenting their progress. The evidence of this work is documented throughout the year and is submitted annually by each individual teacher. At the beginning of every school year, teachers are provided with a companion guidance document to support the PLP work. In 2014-2015, the language in the PLP guidance document was revised to include the language and structure of PDSAs. In addition, the process in the guidance document was heavily scaffolded and included examples designed to support teachers and teams engage in PDSAs. A complementary change was made to the content of weekly school-wide faculty meetings. The school leadership allotted a subset of these meetings to focus on professional learning and PDSA use. During these allotted meetings, school teams received explicit professional development to support PDSA implementation and were also provided with time to work collaboratively on this work in their school teams.

Participants

The present study draws on data collected over the 2014-2015 school year in the context of a larger multi-year collaborative effort between UCLA and a local K-12 school site. I draw on collaborative documentation of a team of six elementary school teachers who taught second and
third grade combination classrooms in a K-5 dual language program. Five of these teachers taught in Spanish-English dual language classrooms and the sixth teacher taught in a Korean-English dual language classroom. The school has an annual enrollment of approximately 1000 students in grades K-12 with 44% of the student population labeled as English learners. Eighty-one percent of the student population is also classified as economically disadvantaged.

There are 17 teachers comprising the dual-immersion program faculty. The faculty has been relatively stable with little turnover. One of the Spanish-English dual language classroom teachers went on leave at the end of the first semester and was replaced by another dual language classroom teacher. The new teacher joined the team in December. At that time, team members apprenticed her into the team’s ways of doing work by assigning her to a role on the team and including her in the instructional practices of the school, like mixing. Despite her new status, the teacher appears to have actively engaged in the team’s professional learning work, conducting PDSAs, building on her predecessor’s work, and contributing to the professional learning process.

The team had regularly scheduled meeting each week: Mondays after school and Wednesdays as part of the school-wide faculty meetings. Teachers also had time to work and meet with each other on Thursdays while their students were in Physical Education class, but my understanding is that this was less formalized and was not documented. Instead, teachers used this time to complete team projects, like book leveling, or checking in with each other to work on pending tasks related to other subject areas when needed. Teachers also received time to have 5 full-day team meetings. The team decided when they would schedule these meetings as the expectation was that they use this time to support their PLP-focused work and PDSAs. In the past, teachers received additional days to conduct Independent Reading Level (IRL) testing in
the fall and again in the spring. IRL measures are used to measure and track proficiency in dual language and literacy proficiency. During the 2014-2015 school year, teachers administered Spanish and English IRL assessments in October 2014 and again in May 2015. Students enrolled in the Korean and English dual language program were assessed only in English. Teachers decided to use 3 of the 5 team-meeting days for PLP/PDSA work. They used the remaining 2 release days to support their work in conducting IRL testing during the months of October and May. Here, teachers would have a substitute relieve them of their teaching duties while they assessed students.

During the 2014-2015 school year I was a graduate student researcher at the school site with the primary responsibility of supporting the work of improvement. One of my tasks was to support the team as they learned to use PDSAs in their professional learning and improvement work. My approach included checking in with the team lead at least once a month during the fall semester, and communicating primarily via email and, on occasion, by phone. At the onset of the collaboration, I envisioned my participation with the team to be similar to the work I had conducted with the science team (Lozano, Inquiry 1). However, my participation in full team meetings during the year was limited. I attended two team meetings in October, upon invitation, and was subsequently invited to lead a portion of their January full-day team meeting. The team primarily sought my support to help them think about assessment data analysis and measurement.

Data sources

I was interested in working with teachers to support their understanding and use of PDSAs as a tool to support them in their professional learning practice as they worked to improve students’ literacy. My goal was to build on the work from the previous year with the
secondary science team, and use that experience to work with teachers of different disciplinary subject matter, and a different grade level to engage with PDSAs. I did not have the same level of access to this team of teachers as the science team. I was a new person to this team of teachers as I had not worked with the elementary team in any capacity prior to this work. I made myself available to regular participate in their team meetings. When I was invited to attend, I enthusiastically offered my support in various forms. For example, I provided feedback during the meeting and asked beforehand what questions they had so that I might begin to think about ways that I could offer support. I also helped them translate one of the measures they used with their students. I drew on team meeting documents, including meeting minutes and agendas, PLP evidence document entries, linked artifacts, and meeting observation field notes for the meetings that I was invited to participate (3 meetings). In total, I analyzed documentation for 40 regular team meetings and documentation for 14 PLP-focused meetings throughout the school year for a total of 54 meetings.

I understood the limitations in only using data that was recorded by teachers in the context of their work and for the purpose of their professional learning practice in this study. I did not have interviews to draw on nor access to my own set of field notes for the meetings themselves because I was not a participant in the team’s work in the same way I had experienced during my previous year at the school site. Nonetheless, I did have a set of experiences to draw on to help me conduct a deep analysis of the existing data in addition to having rich knowledge of the research setting. I viewed these as complementary experiences that I could draw on in the context of the present study. In addition, I drew on the findings detailed in the first inquiry (Lozano, Inquiry I), including the use of coding categories to guide data analysis in the present study.
To conduct this analysis, first, I examined the documents to understand the degree to which operations and professional learning figured into the team’s regular work activities. Second, I used the content of the documents to help me understand the scope of work activities and shared work tasks teachers in the team took up in the context of professional learning and PDSA engagement. After that, I examined the documents to understand how the learning from each PDSA cycle connected to subsequent changes in teachers’ practice and the degree to which teachers developed a set of shared routines and practices to support their students’ literacy improvement. I drew on findings from the previous study to support my analyses in this study.

Data Analysis

Analyzing what teachers documented. To understand teachers’ engagement and use of PDSAs as a tool for experimentation, documentation of practice, and learning, my first step was to understand what teachers typically documented. As a first step, I read through a total of 54 meeting entries. These entries were recorded in the professional learning plan document and the meeting minutes for the 2014-2015 school year as they were organized by the team. My goal with this first read was two-fold. First, I wanted to understand the team’s work trajectory over the course of the school year and how they took up PDSAs to support their professional growth. Here, teachers kept track of their meeting notes by adding the most recent entry to the beginning of the document. Because I was trying to understand the team’s trajectory of work for the 2014-2015 school year, I found it very difficult to put together a chronological timeline when I read the documents in this way. As a next step, I printed all the meeting entries and read through them in the order in which they happened, by date. This gave me a sense of the chronological sequence in which team activities occurred, allowing me to weave together a history of events to understand, first, the team’s work for the year, and second, their engagement in PDSAs. I read
through each of the documents, separately, parsing the document sections according to meeting
dates and recording these dates in a spreadsheet. My next step was to read through the team's
meeting minutes and determine which, if any, of those meetings made reference to PDSA or PLP
work. I recorded these findings in the spreadsheet and then repeated the process with the PLP
document. Upon completion, I compared overlapping meeting date documentation between the
team meeting document and the PLP document. My purpose in comparing overlapping dates was
to determine whether these overlaps were in the documentation as well.

Of the 54 meeting documentation entries I analyzed I found four instances where the
dates in the team meeting and PLP documents overlapped. I examined these entries to see if the
documented content was the same. I found that there was only one instance (May 4), from these
four overlapping meeting dates, where the same information was documented.

Analyzing the role of PDSAs in professional learning. To understand the role of PDSAs
in the context of the team’s professional learning, I read the team meeting document and the PLP
documents in their entirety. As I read the documents, I often moved between documents as
needed, in order to follow the chronological order, according to the date and time in which things
occurred. As I read through the entries, I marked sections of the document that directly
referenced PLP or PDSA work, offered insight into teachers’ work processes, evidence of
teachers’ reflections and concerns, instructional actions, and collaborative learning practices.
I conducted a second chronological read of the documents in their entirety. During this second
read, I referenced the coding scheme I developed as part of the previous study and proceeded to

---

3 When teachers met for full-day team meetings, there were typically extensive notes, spanning
several pages, in the PLP document. On those same days, the ongoing team meeting document
typically had a corresponding entry, though much shorter, with a meeting start time in the late
afternoon. In those cases, I read in chronological order by date and time, to get a sense of the
work unfolded throughout the day.
code the documents. I used a combination of In Vivo and process coding as first cycle coding method (Saldaña, 2016). I used these coding methods concurrently because I thought they worked well to help me capture teachers’ insights through their documented work and the processes that they used to actually get the work done. I used a spreadsheet to organize and keep track of the codes by meeting date and data source (team meeting document or PLP meeting document). I also documented what I considered salient text excerpts – those that exemplified a particular type of learning or change in practice – along with analytic memos about what I was seeing. I printed the spreadsheet out and used it to review the text excerpts, codes, and analytic memos along with the coded documents. I reviewed the clustered coded sequences together with the memos in the spreadsheet and revisited the document entries as needed. As I did this, I refined the coding categories and proceeded to document all the clustered code sequences, along with the dates in a separate document, a second time to prepare for the final analysis.

In the final analysis, I reread the documentation of all the instantiations of the clustered code categories. My goal here was to understand the nuanced ways in which the code categories were expressed. As I did this, I reorganized clustered sequences within existing code categories, generating new subcode categories. I wrote analytic summaries of the final coded categories along with the frequency of occurrence in the data. I returned to the coding categories from previous empirical work (Lozano, Inquiry I) and used these to guide my examination of the relationships between the codes in the analytic summaries as I understood them in the final analysis. I found that there were examples in the data that corroborated previous findings and that there were new categories that surfaced through my analyses.

Findings

**RQ1: What is the role of PDSAs in framing the ways teachers collaborate?**
PDSAs are a helpful tool that can be successfully used to support teachers’ collaboration around a shared problem of practice and engage in yearlong professional learning process. In the present study, findings suggest that PDSAs were a natural complement to existing shared processes the team regularly used to coordinate, distribute and complete work tasks. Specifically, there were two processes to which PDSAs were a natural complement in the course of professional learning: shared decision-making and distribution of labor. The data also corroborated past findings that suggest that teachers’ engagement in the PDSA process fosters collaboration with colleagues in other grade level teams and departments, successfully promoting interdepartmental collaboration. Next, I describe these findings, in turn, and use examples from the data to illustrate how the processes supported the team’s professional learning.

Building on shared decision-making processes. During the course of the school year, the teacher team met regularly to discuss various aspects of their work. Evident in the team’s documentation were the myriad ways that teachers worked together to prioritize team needs, reach consensus, and make commitments to teaching and learning in the dual-immersion program. At the beginning of the year, teachers devoted portions of three meetings (August 13, 25, and 27) to discuss and prioritize professional learning needs. For example, on August 13, teachers documented their ideas for PLP as follows:

**PLP Ideas:**
1. Time: devote 30 min. to the beginning of every meeting
2. Conferring - Comprehension of strategy (read aloud) during Strategy lesson in order to 15 Wed (How many for PLP-4? , 4 for projects)

I noticed that teachers documented their ideas, even when they were not fully formed (see item 2 above). In this excerpt, the team does not arrive at a decision, but does make sure to record ideas to revisit them at a later date. The topic was revisited again on August 25 and 27. For example,
on August 25 the team dedicated 10 minutes of their meeting time to follow up on the literacy work:

\[
\text{Literacy (10 min.) 4:00-4:10} \\
- \text{pass out copies of first week plans (T1)} \\
- \text{decision to start and complete week first three lessons in RW and WW launch}
\]

While PLP was not directly referenced in this meeting, the content that was documented, in addition to the decision to begin and complete the RW lessons, specifically, is important for the PLP work as it figures prominently, later, in the team’s decision for the shared problem of practice: improving students’ thinking while they read. The teachers also documented their decision with respect to lesson implementation. Finally, on August 27, teachers documented their discussion about how to prioritize team needs and the appropriate amount of time that should be allotted to the PLP work.

\[
\text{Meeting focus: (20 min,) 2:10-2:30} \\
\text{Get a consensus if we want a focus.}
\]

\begin{itemize}
\item \textbf{T1} \quad \text{Other pressing things come up. Use PLP to focus on reading. Allot for time to talk about other subjects.}
\item \textbf{T2} \quad \text{Make a calendar of slots available and needs. Prioritize needs into slots. Divide up time with operations needs. Need to decide focus.}
\item \textbf{T3} \quad \text{With operations we don’t know what is coming up. Discuss it over email. Do a weekly update.}
\item \textbf{T1} \quad \text{It becomes confusing over email.}
\item \textbf{T4} \quad \text{Do half of meetings as operations, set curriculum priority for second half of meeting.}
\item \textbf{T5} \quad \text{Half of meetings as operations, set curriculum priority for second half of meeting.}
\item \textbf{T6} \quad \text{Try it on schoology. Has a thread.}
\item \textbf{T1} \quad \text{Need everything in curriculum on one calendar. (Do later as a project)}
\item \textbf{T6} \quad \text{Focus Mondays on PLP. Then figure out other priorities. Check schoology for operations notifications.}
\end{itemize}
In the meeting documentation excerpt above, teachers have an extended exchange as they consider how to use their time to complete their work. Immediately following this exchange, teachers document a series of proposals for the use of their meeting times. The team proposes to use Mondays to discuss operations and PLP work and their Wednesday PD time to focus on PLP work, targeting check in and ongoing assessment progress.

What is exciting about this early set of exchanges, is that this shared decision-making process was also reflected in the way in which teachers initiated the study portion of the PDSA cycle during their PLP meetings throughout the year. In this case, teachers used a similar process to reflect as a team. Teachers opened with a ‘check in’, sharing what they had learned in the process of engaging in the current PDSA cycle. Teachers’ check ins were similarly documented in the PLP meeting notes. Once all teachers checked in and shared their progress and learning, there was a portion of the meeting dedicated to sharing next steps. The following excerpt from February 4 illustrates how each teacher’s reflection was recorded in the PLP document.

*Reflections on first lesson:*

**T1**  Students familiar with strategies. Isolated sentence frame. Need more practice on why it is an appropriate strategy. Reading ahead/reading before because “gives me context clues” vs. giving the example that helped them

**T2**  I did guided instruction only. For two days I only modeled. Focus on why did I choose this strategy? It doesn’t make sense for me to choose this strategy because...

**T3**  Students having a hard time choosing a strategy. The ones that can choose an appropriate strategy say they chose it because it “helps them”. So we go back to context clues.

**T4**  Students know strategies well. Need to work on evidence. I modeled more, country=farm. Understand that your strategy could be wrong so the picture is not always what you think.
Occasionally, recorded input was highlighted to identify those points that had been agreed upon thereby reflecting the team’s shared decision-making process. In the following example from January 27, teachers first offered possible change ideas.

- check in more during IRA
- check in more RW small groups
- model effectively strategies (how to use them) for when ideas break down vs. when we don’t understand words
- Identify a plausible strategy to use. Focus on ideas we don’t understand.
- develop specific lessons to ideas (separate strategies and charts)
- using sentence frames for giving evidence
- use sentence frames to identify if problem is with an idea or a word... and

Teachers ultimately selected two of the ideas from the list above. The highlighted bullet point above was the first change idea identified in the document. The second change idea was identified in the point immediately following the highlighted text, as follows.

What:
- model effectively strategies (how to use them) for when ideas break down vs. when we don’t understand words.
- Identify a plausible strategy to use. Focus on ideas we don’t understand.

Here, too, all teachers had the opportunity to voice their ideas about the direction the team should take in the context of what they were learning. Again, teachers’ next steps were first documented and then prioritized through a shared decision-making process. On this same date, the team documented their agreements and commitments, summarized in the following statement, “We will implement lessons differentiating strategies during Interactive Read Alouds for when meaning breaks down because of words vs. ideas. Identify plausible strategies.” In this example,
teachers used the PLP document to memorialize the agreements they made as they engaged in the PDSA process to support students’ improve literacy.

These shared decision-making processes for prioritizing work, reaching consensus, and making commitments may, at first glance, seem to reflect superficial interactions. Yet, I suggest, that these were actually processes that were frequently documented throughout the meeting and PLP documents. Every meeting began with a team check in. These check in opportunities were a way to help others gauge participant’s current status and provided each member with the space to share things that they wished to disclose to the team. In this way, the team check in process demonstrated value in the members as people, not just teachers working to make progress on a particular task. Processes like these matter as they are at the heart of a team’s ability to work through simple and complex tasks. While the PDSA process did not necessarily provide a structure for organizing shared decision-making work processes, it did offer a template that the team could use to chronicle their learning over the course of the year as they worked to improve a shared problem of practice.

_Distribution of labor._ Teachers regularly distributed work tasks among the team members. Like the shared decision-making process examples illustrated above show, each team member was responsible for actively contributing to the team’s work. This translated to other team tasks as well. For example, on August 27 the team assigned the following yearlong team roles: note-taker, focus reminder, facilitator, and copy request. At the end of the fall semester, a member of the team went on leave and was replaced. The team member’s role, on the team, had been to submit copy requests. On December 8, the team documented their welcome to the new teacher in their meeting. They introduced the team positions, along with clear descriptions of the expectations for each position.
QUICKLY INTRODUCE TEAM POSITIONS:
Recorder: (records important information/salient points from den word/conversation/decisions)
Timekeeper: (keeps track of time designated to each item on the agenda and thinks ahead of possible time changes according to other needs)
Facilitator: (facilitate conversations, ensures the foci is kept which means they may give friendly reminders and redirect back to foci/schedule other items for other times)

Note the changes and revisions to the team positions reflected in the titles and descriptions above from those in August. There was no longer a ‘focus reminder’ or ‘copy requester’, and the note-taker was now the recorder. Instead, all teachers now had assigned roles, representing a distribution of labor across all team members. Another change was that every position was assigned to two teachers. Every team member now had a specified assigned role in the team, including the new teacher who was assigned to be a timekeeper.

In addition to the regular team roles/positions described above, the team regularly distributed increasingly complex tasks among team members in the context of their PDSA work. Because teachers practiced a distribution of labor in the team, teachers’ work together in the context of their PLP work was dedicated to problematizing instructional practice and engaging in the task of reaping the benefit from each team member’s learning to make decisions about how to improve practice. Generally, a distribution of labor was evident in the types of tasks that were assigned in support of the team’s agreements and commitments to their PLP work. These tasks varied in range and complexity. Generally, distributed tasks involved more mundane activities like making copies for the team (August 7, August 25, September 8, October 6, November 12, December 1, December 15, February 4, May 4, and May 11), and translating instructional tasks or materials (September 15, October 13, and February 4). As the PLP work progressed, distributed tasks became increasingly complex. These tasks involved content development, like developing content for agreed upon posters and getting these posters made for the team.
(December 15, January 28, February 9, and May 4), testing out specific change ideas (November 12), and trying different ways to document students’ thinking (January 27). For example, on January 27 teachers were concerned about the sustainability of the ways in which they were measuring students’ thinking. Teachers wanted to try new ways to document student thinking because their current assessment measure was very time consuming. It took teachers anywhere from 15 minutes to 40 minutes to administer the agreed upon assessment to gather ongoing evidence of student’s thinking. In this meeting, teachers recorded the following questions for consideration:

*How can we create more sustainable ways of assessing students’ thinking during read alouds in an ongoing manner?*

**A. Metacognition Graphic Organizer**
- How useful has it been?
- How can we help our students identify the clues (evidence) that helped them infer the meaning of word/idea?

**B. Journals**
- How can we set up journals that allow students to quickly jot down their thinking?
- We have the Metacognition chart, but what about for other strategies?

By the end of the meeting, teachers made decisions about how to distribute the labor of figuring out a method that might work best for assessing students’ thinking. Teachers developed the following check off sheet to collect ongoing evidence of students’ thinking:

<table>
<thead>
<tr>
<th>Student:</th>
<th>Date</th>
<th>appropriate strategy:</th>
<th>not appropriate strategy</th>
<th>Why did you choose this strategy?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2/3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2/4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2/5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2/6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2/9: Final assessment</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Here, teachers distributed the task of using different forms to collect evidence to help them figure out which would be most sustainable.

*T1, T2, T3 will jot down notes about what kids said and the others will check off if they used an “appropriate strategy: a strategy that helps make accurate meaning”*

They agreed that half of the team would use the check off sheet while the other half would jot down notes, documenting what kids actually said during the read aloud.

During the second semester, distributed tasks were the most complex. Here, teachers were tasked with developing differentiated sentence frames (January 28 and February 9), and designing lesson sequences and content (January 28 and February 9) to support the team’s PDSA work. Teachers assigned the tasks to themselves and were careful to make sure that all team members had a range of opportunities to participate in task assignments. Though not explicitly stated, the act of dividing increasingly complex tasks among team members, I suggest, signifies a level of collegial trust in team member’s ability to do the work. When there is a lack of trust, team members might take control of particular types of tasks, especially those involving higher levels of intellectual work. In March and April, content and lesson development tasks returned to being shared by the group. Dedicated meeting time was assigned to the completion of these tasks. A possible explanation for the shift might be that the burden and responsibility placed on a single person to complete the tasks was time consuming and did not reflect the expertise of the team. Given the work teachers were doing in the context of the PLP and the PDSA process, teachers learned that they were better able to meet the needs of students when they harnessed the collective learning and expertise of individual team members. In this way, PDSAs supported teachers in shifting the way they approached complex tasks. In the absence of shared agreements that reflected the group’s learning, a single member working on developing content to support the team was a much more challenging task.
Interdepartmental collaboration. As teachers continued to make progress in learning how to best support improvement in students’ thinking during reading, they expanded their view of the problem, as it existed in their current context. Over time, teachers developed a bird’s eye view on the problem and also began to see their work as interconnected with the work of others, specifically beyond the members of their immediate team.

Through the content analysis, evidence of the teachers’ desire to work with another disciplinary team to support students’ literacy emerged. The moment seems to have occurred on March 10 during the team’s thirds full-day PLP meeting. At this meeting, during the check in process, teachers took stock of their learning. After engaging in two sequences of PDSA cycles, teachers found that students at lower levels of reading were less verbal and struggled with the selection of appropriate strategies. Teachers decided that they needed to provide students with access to differentiated instructional scaffolds in the form of questions and sentence stems, in addition to the strategies they were already using. As a next step, teachers made the decision to focus on oral language development during small group discussions and whole group discussions about texts. During the meeting, teachers shifted their focus to support students’ ability to infer character’s feelings and traits as part of a unit on character analysis. It was in this moment that teachers documented, as a next step, “articulation” with the K-1 team. Because the PLP focus shifted to include an oral language development component in supporting students’ thinking while reading, it was construed as an opportunity for interdepartmental collaboration. The focus for this collaboration was documented as work to develop vocabulary for feelings. There was a specific mention of the use of additional resources, like the Second Step program or community circle routine, to support students’ engagement in character feeling analysis in the unit they were preparing to teach. While I am unaware of the outcome of this collaboration - if it manifested or
not - that the teachers saw the opportunity to collaborate as worthy of documentation as a next step, echoes previous findings (see Lozano, Inquiry I). The finding suggests that teachers’ engagement in the PDSA process fosters collaboration with colleagues in other grade level teams and departments, and can be used to promote interdepartmental collaboration. The data suggests that people shifted the ways that they see themselves professionally. There appears to be a shift in perspective, recognizing the expertise that they possess in their practice and, in the same way, recognizing the expertise of others. PDSAs engage people in working together to solve shared problems of practice. Engaging in this kind of work supports the view that teams can benefit the most when they harness collective learning experiences to move forward. It makes sense then that, over time, teams expand their vision of who can contribute to their collective learning experiences. Collaborating with other teams and departments is essential to the process of growth and improvement.

Because this team was comprised of teachers who share the work of teaching the same curriculum to students in grades 2 and 3, it makes a lot of sense that the team had work processes in place to support the team’s engagement in shared work tasks. Teachers on this team share multi-age classrooms where they are responsible for teaching the same standards through similar modes of instruction. Teachers regularly work together to assess students’ reading levels, plan lessons, revise curriculum, as well as share students during mixed teaching segments throughout the school year. The level of collaboration required to accomplish these tasks necessitates a set of processes to coordinate activity within and across team members. It is no surprise, then, that study findings suggest PDSAs complement existing processes to support the coordination of teaching and learning activities within and across teacher teams.
RQ2: Did, and if so, how did PDSAs support teachers’ learning about improving their students’ literacy?

We learned that after looking at data and considering student responses to lessons, modifying instruction to meet their needs takes considerable amounts of time, slows down units, and is more helpful to do with colleagues. (End of Year Reflection - May 6, 2015)

The quote reflects the ways that PDSAs supported teachers’ professional learning progress throughout the year. Teachers used PDSAs to support their engagement in a yearlong cycle of learning focused on improving students’ metacognitive abilities. At the beginning of the school year it was evident that this team of teachers had structures and processes in place that supported their ability to work together. Nonetheless, they recognized that although their shared structures were a strength, what was needed was a consistent approach to instruction. Study findings suggest that PDSAs helped teachers develop greater coherence in their understanding of comprehension, build shared instructional routines, and interrogate measures of progress as they worked to improve students’ metacognitive abilities.

PDSAs supported the development of coherence about comprehension.

Teachers interacted regularly to discuss their PLP work and PDSA progress. Of the 53 documented entries, 472% of them (38 meetings) dedicated some portion of the meeting to engage or check in on the progress of PLP/PDSA work. Because PDSAs were used as a process to discipline the team’s comprehension teaching during their Interactive Read Aloud, and later as part of Reading Workshop (RW) and Guided Reading (GR), there were usually several questions or issues that the teachers brought to team meetings for discussion and clarification.

Coherence in common understandings about metacognition. As teachers began to work on developing their PLP focus to enhance students’ reading comprehension they used portions of

---

4 I did not include the meeting with overlapping content documentation in this calculation.
their meeting times making sure they all had common understandings of the things they were committing to and that they had shared understandings of the concepts they were discussing. For example, once the team settled on improving students’ metacognition they found that they needed a common definition that they could use as they taught students to engage in more metacognitive behaviors during read aloud. On September 18, teachers documented the need for a common definition of metacognition and added the following parenthetical information: being aware of when I read, using fix-up strategies. There were at least three more instances when meeting time was used to make sure that teachers were all on the same page when it came to problematic or confusing terms. For example, on October 22 teachers got together to score their Major Point Interview for Readers (MPIR) assessments. As they used the rubric to score student responses they realized that they were not all clear about how to interpret the scoring criteria in the rubric. Teachers specifically wondered, “How many is ‘a lot of other ways I can fix the problem’?” As a result, teachers generated a list of strategies that students could use to solve comprehension problems related to difficulties with words or ideas in the text.

Strategies used to solve word/idea problems:

1. Rereading
2. Looking at pic
3. Looking at parts of the word
4. Looking at context clues (words in the sentence)
5. Cognates
6. Synonyms
7. schema (What do we know about the topic? plot?)
8. How does the character feel?
9. What happened before?

The list above serves two purposes in terms of establishing coherence. First, it supports teachers in understanding the different strategies that students can draw on to support their comprehension. Secondly, it serves to anchor teacher’s instructional practice, giving them a
shared vision of strategies that they themselves can draw on when they model strategy use and guide students to apply strategies in their own classrooms.

Coherence in student learning expectations. Using PDSAs as a springboard to develop coherence around comprehension was not limited to terms and criteria, like the above examples detail. Teachers also used meeting times as opportunities to develop coherence and clarity around student learning expectations and how to best support students in adopting metacognitive practices. For example, during the second full-day meeting (January 27) teachers reflected on the progress their students were making and shared their focal students’ assessment progress. One teacher was confused by her students’ performance in relation to the rubric. The teacher posed the following question during the team’s dedicated time to check in about the assessment:

Does it matter if kids use multiple strategies, but do not solve the problems accurately?

Teachers discussed this together and, as a result, made the decision to revise the language in the rubric to include to solve the problem:

I have some problems when reading this book. Some are on words and some relate to the ideas in the book, but I usually know what to do to solve the problem.

Teachers also made the decision to implement a practice of asking students the following two questions when they engaged in metacognitive work: How did that strategy help you solve the problem? If it did not help you solve the problem, what can you do? And finally, this question also brought teachers to reflect on their own instructional practices and the degree to which they are modeling what to do when comprehension breaks down. During this meeting teachers noticed that their students frequently referenced difficulty with words when recounting the problems they experienced in the text. Teachers wanted students to move towards discussing challenges with the ideas of the text, not just word difficulties. Because teachers embarked on the metacognition journey in the hopes that they could help students reach higher levels of
comprehension in preparation for “reading longer stretches of text devoid of visuals…. to access deeper themes”, moving students along a metacognitive continuum was important. To this end, they reflected on the degree to which they explicitly modeled and showed students how to engage in these ways of thinking.

*Coherence in approaches and supports for differentiation.* Achieving coherence was also evident in the supports and approaches to differentiation that teachers adopted throughout the year. As teachers continued to engage in PDSAs, they regularly identified the need to set individual goals (October 6) and address different levels of proficiency through the use of differentiated questions (October 6, March 10, April 15), sentence frames (October 6, March 10, March 11, March 16), and differentiated application of the strategies (September 18).

Throughout the academic year, teachers worked together to gain clarity in instruction by highly specifying the scaffolds and supports that teachers would use. The work included the creation of differentiated questions, the development of shared note-taking tools, charts, and sentence frames. For example, on October 22, teachers documented the following actions and sentence frames to use during instruction to guide their students.

*STOP SIGN*
Signal for kids to show they are not having a conversation with the text. Put stop up with hand.

*Sentence frames:*
Help kids identify what they didn’t understand

*I DON’T UNDERSTAND THIS WORD*
WHAT DOES _____ MEAN?

*I DON’T UNDERSTAND THIS IDEA.*
I don’t understand why _______________ ____________________?
the character/ author/ illustrator

I don’t understand where___?
I don’t understand who _____?

The team conducted regular check ins, providing teachers with opportunities to voice their questions and leverage the expertise of the group in solving the problems they were experiencing in understanding metacognition and establishing clear expectations for what they wanted their students to be able to do. In this way, PDSAs were useful in promoting opportunities to engage in professional learning conversations that led to high levels of pedagogical coherence among team members.

**PDSAs were a vehicle to shared instructional routines**

Another way that PDSAs supported teachers’ learning was through the targeted work to increase consistency in teachers shared instructional literacy routines. At the beginning of their PLP/PDSA work (October 6), teachers engaged in a reflective exercise where they reflected on literacy and instructional practices. During this particular full-day planning meeting, teachers identified strengths and areas of growth. The following excerpt lists only the reflections related to instructional routines and practices:

- We have structures in place to provide specific intervention
- We need a common way of documenting our conferring
- We need a common way of showing kids how to show their thinking, especially because we are not always conferring with them (once a week mostly)
- All teachers are embedding daily oral language development in lessons through the use of direct modeling, sentence stems, and partner share
- We are connecting IRA lessons to Reading Workshop lessons
- We are dividing up focus groups for word study
- We have all connected visualizing work to students’ work in narrative writing
- We are inconsistent as teachers how we use the Reading Journal and Guided Reading

Based on the reflections in this list, the teachers recognize the ways in which they are consistent and aligned. Similarly, teachers also document where they need to develop consistent structures and routines to continue to support their students’ literacy growth. As part of the PDSA work
during the year, teachers targeted achieving higher degrees of consistency in the following ways:
planning the scaffolds and supports that they used within the structures for intervention;
generating examples and sentence frames to support the ways that they modeled and showed
students to think through problems with text; sequencing and planning the lessons that they
taught within the IRA and RW structures; developing methods and forms to support their use of
the Reading Journal; and developing guided reading lessons to support students during small
group instruction.

Achieving consistency within and across lessons. Teachers concentrated efforts in
planning and coordinating the work within lessons. For example, on September 18 teachers
developed a lesson skeleton that they planned to use to achieve greater consistency in sequencing
instruction.

WEEK 1- Strategy Lessons: Monitoring Comprehension: Following the Inner
Conversation, pg. 78 (from Strategies That Work by Harvey & Goudvis)- week of
October 6th
DAY 1 (Monday): Direct Instruction (Models and charts)
DAY 2: (Tuesday) Guided Practice
DAY 3: (Thursday) Guided Practice
Day 4: (Friday) Independent Practice
*Wednesday-Direct Instruction in English
My Reflection on the Lessons of the Week:

In total, there was a sequence of five weeks that were included in the PLP meeting document
entry on September 18. While the content that corresponded to each week was different, the
instructional models listed were the same. Although the step-by-step work itself was not detailed
in the document, it did seem to form the basis for future detailed lesson development work. For
example, some of the weeks included an asterisk symbol (*) next to some of the lesson segments.
At the end of the lesson sequence there was a note that described what the asterisk signaled:
Each teacher will create sentence stems and visuals to aid in lesson implementation. At this
time, teachers were not yet in a place to work together to create highly specified shared
documents, supports, and routines. Teacher reflected on the strengths and needs of the work as
follows:

<table>
<thead>
<tr>
<th>STRENGTHS</th>
<th>NEEDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>- concrete strategies: HUH? Light bulb</td>
<td>- specific sentence frames</td>
</tr>
<tr>
<td>- identifying when their comprehension breaks down</td>
<td>- big lesson, not individual parts: model, guided, etc.</td>
</tr>
<tr>
<td>- 1 lesson focus for the WHOLE week Yes! Nice Skeleton</td>
<td></td>
</tr>
<tr>
<td>- Taking post-its and putting them in the journal</td>
<td></td>
</tr>
</tbody>
</table>

The reference to the weeklong lesson focus as a strength with the comment stating that it is a
‘nice skeleton’ leads me to believe that this structure was a new approach to doing work.
Furthermore, the reference to a need for ‘specific sentence frames’ and ‘big lessons, not the
individual parts’ at this early point in the PLP/PDSA work also signals the need to work together
plan lesson content. These comments are also suggestive of a shared need to develop consistent
instructional routines, dedicating time to think through the ways in which lesson content is
introduced and connected to future lesson sequences.

As the team’s professional learning and PDSA work unfold, teachers shift their attention
towards the joint development of shared instructional practices within the weeklong lesson
content sequences. For example, on February 12 teachers dedicate time to continue lesson
development for a ‘monitoring ideas’ mini-unit. They have completed lesson development for a
‘monitoring word problems’ mini-unit. I access the mini-unit through a linked Google document
in the team’s meeting notes document. I study the artifact and note that it contains the detailed
lessons teachers have developed to support instruction for this mini-unit. The lesson sequence
itself has been revised from 4 days (September 18) to include 5 days of instruction. It also
includes detailed examples of the following: a list of idea-related foci where comprehension might break down along with corresponding questions to support comprehension monitoring; sentence frames to aid in discussing idea problems in English and Spanish; detailed step-by-step Day 1 Teacher Modeling plan; and a detailed plan for Independent Work (see Appendix X). The detailed lesson sequence for Day 1 includes organized stopping points and examples from the shared text they have agreed to read. The document reflects the level of planning and consistency that teachers have developed as they plan the series of lessons. The plan highlights efforts to achieve consistency in the department and illustrates how the department has moved from the development of the ‘nice skeleton’ routine mentioned in early work to a highly structured and specified plan for instruction. It offers teachers a balance by leaving the models and guided practice sections in the middle of the week available for teachers to plan based on their students’ needs. Furthermore, although the sections are open, the structure that these should follow is included in the plan. For example, every sequence of instruction begins with a connection to the previous day’s learning, includes a teaching point, a teach/model section, pair share stopping points, and closes with a teacher “revoice” segment.

To achieve consistency in instructional practice required teachers to reflect and think deeply about their own practice. The examples above illustrate the kind of work that arose from teachers’ reflection on the instructional challenges they faced as they worked to support students’ metacognitive development. In this way, teacher engagement in PDSAs afforded them the regularity of engaging in weekly reflections, documenting their progress, and sharing these during team meetings. It was in the context of reflecting on their own practice, examining how it aligned with their student learning goals, and determining to what degree they were being successful each week that consistency in instruction was made possible.
PDSAs emphasized measurement to signal improvement

The issue of measurement was a recurring theme in teachers’ meeting documentation. Teachers frequently referenced the challenges they faced as they struggled to document ongoing evidence of student thinking. In total, there were 21 instances where teachers made reference to the ways that they aimed to document, monitor, or collect ongoing evidence of student thinking.

Study findings suggest that one of the most challenging features of PDSA work is defining a quick, efficient, and valuable way to measure evidence of improvement. Teachers did create a long-term goal of supporting their focal students to improve at least one level on the IRL assessment. Short-term goals included documenting evidence of growth in students’ ability to monitor comprehension as measured by the MPIR Monitoring Comprehension assessment. Teachers administered the MPIR assessment at the onset and close of every PDSA cycle. The MPIR was conducive to supporting teachers engage in reflective conversations about metacognition, teaching practices, and student learning. Nonetheless, it was time consuming, taking teachers, on average, 15 to 40 minutes to complete for each focal student.

In this team’s work, challenges with documenting, monitoring, and collecting ongoing evidence of student thinking were pervasive throughout the year. Teachers realized quickly that they needed to develop faster and more efficient means to document students’ thinking. Teachers experimented with a range of documentation practices including collecting student-generated jottings on post-its (October 6), thought bubbles in reading notebooks (October 13), anecdotal notes of what students say they do when comprehension breaks down (January 27), and keeping track of metacognition using check off sheets (January 27). Teachers expressed confusion over what they should do with post-it notes (September 29) to monitor student thinking. Teachers also expressed the desire to find sustainable ways of monitoring and assessing student thinking.
(January 12 and January 27). As teachers engaged in PDSAs, they experimented with different methods to gauge students’ thinking.

Teachers used a combination of methods to document and monitor progress. Aside from the MPIR assessment, during PDSA cycle enactment teachers distributed the task of documentation equally among themselves. For example, half of the team kept track of strategy use through jottings they collected while the other half of the team used a metacognitive half sheet. This practice, though probably not the most efficient, did provide the detailed level of information that teachers could use to make informed decisions about subsequent instructional action during the study portion of meetings in the PDSA process. In the following example, teachers report what they learned from the collection of ongoing evidence of students’ thinking using two different methods:

**T1** Used mainly schema and looking for clues in illustrations to solve problems.

**T2** One student chose appropriate and different strategies. Second focus student used appropriate strategies and could not regularly provide evidence. Overall class half is grasping concept of idea.

**T3** One student 2/4 times was able to provide evidence with guided practice. Still focused on words. Second student was able to identify 4/4 times. Overall using schema to do character analysis. 2nd and 3rd grade mix of who’s able to do it. Under J level readers struggle more.

**T4** One student used appropriate strategies. re-read, asked questions, schema. Other student focused on figuring out words, not thinking. Not appropriate use of strategies. Overall in discussions getting it.

**T5** First student was successful, the second, David was not. successful and she notices it’s due to his lack of verbal development and practices of responsibility to participate in large as well as focus on conversations other than those with themes he’s interested in.

**T6** One able to choose strategies and provide evidence in detailed way. Other student had difficulty providing evidence. Relies heavily on picture clues. Overall student who are at a higher level are using character analysis. Lower level picture.
Overall: Students who function highly verbally participate and provide evidence for their ideas, inferences, etc. Students went back to use schema to identify and use characters’ feelings to solve problems.

In this example, teachers used multiple methods to document and monitor learning. At the end, the accrued learning of the team is summarized and used to move forward with the next PDSA cycle. Teachers continue to experiment with several ways to monitor and document student thinking. To share what they are learning, they draw on the collective knowledge of the team and rely on these insights to develop the next steps in the PDSA work.

**Student outcomes.** In May, teachers administered the IRL assessment for the second time that year. Teachers had set out to improve focal students’ comprehension by at least one level on the IRL assessment. Teachers met the goal for the end of the year. All 12 of their focal students improved at least one level. Furthermore, 10 of the 12 students improved two or more levels on the IRL. Although teachers did meet their aim of supporting all students improve at least one level on the IRL, it is unclear to understand the degree to which teacher engagement in PDSA work contributed to improvement in students’ reading level outcomes. Nonetheless, supporting teachers’ ability to set goals, use methods of disciplined inquiry to regularly and methodically evaluate student learning, and better align instructional action to support students in and of itself is a valuable practice.

**Conclusion**

Study findings suggest that PDSAs helped teachers develop greater coherence in their understanding of comprehension, build shared instructional routines, and interrogate measures of progress as they worked to improve students’ metacognitive abilities. In this study, teachers were accustomed to working collaboratively to accomplish shared tasks. Study findings suggest that because teachers had a set of shared decision-making processes and regular engaged in
distributed labor practices, PDSAs were a complementary tool to support professional learning. Findings suggest that PDSAs supported teachers in developing pedagogical coherence and instructional consistency. Through this work, teachers worked together to build their knowledge of metacognition, to understand how to best support students to develop metacognitive skills along a continuum, to develop a shared set of scaffolds and supports to meet the developmental needs of their students, and to develop highly specified instructional routines to support their teaching. Finally, teachers also experimented with a variety of methods to gather ongoing evidence of student thinking. Through PDSAs, teachers were better able to align their instructional actions with desired learning outcomes and deepened their understanding of the connections between oral language development and students’ reading. By the end of the year, teachers had developed a weeklong sequence of instruction that they could use as a frame for lesson development. Furthermore, teachers gained greater insights into the importance of interconnected lesson sequencing, building on the previous week’s learning in support of future work.

**Implications**

The present study findings suggest that there is a need for greater attention to teachers’ ongoing work processes in the context of professional learning. In the current context, this dual-immersion teacher team had processes in place to accomplish work tasks that ranged in complexity. While the literature on professional learning highlights the importance of linking learning to practice, keeping documentation of practice-based learning experiences, and engaging in collective knowledge-building activities, there is limited work that highlights the relationship between shared decision-making processes, distribution of labor, and professional learning. The work of improvement in this context was supported by teachers’ existing work.
processes, and proved complementary to, and supportive of, these work processes. Future research on the ways these interact is warranted.
Inquiry III. An Inquiry into the Benefits of Teachers' Use of PDSAs in Refining Literacy Pedagogy in Science

Abstract: The present work builds on previous empirical research about the use of PDSA cycles as a tool to support a two-teacher team of secondary science teachers’ professional learning as they worked to improve an authentic problem of practice. In this article, I investigate the teachers’ views on the ways in which PDSAs contributed to and constrained changes in their conceptions of literacy and learning in science. I draw on data collected as part of a larger multi-year effort for this study. Study findings suggest that PDSAs contributed to teachers’ integration of literacy-based routines into their science teaching. Teachers understood the inherent value in providing students with opportunities to read and discuss text in support of learning how to use arguments in discussion and writing. Despite reported challenges with using PDSAs, findings suggest that the benefits far outweigh difficulties. Thus, PDSAs should be considered as a method for supporting school-based professional learning efforts.

Keywords: design-based research, partnerships, teacher learning, student learning

Along with reading comprehension, writing skill is a predictor of academic success and a basic requirement for participation in civic life and in the global economy. (Graham & Perin, 2007, p. 3).

In this article, I investigate the teachers’ views on the ways in which PDSAs contributed to and constrained changes in their conceptions of literacy and learning in science. Specifically, I seek to understand how teachers interpreted changes in practice by focusing on the ways in which they talked about literacy in relation to science learning. I draw on data collected as part of
a larger multi-year effort for this study. The findings suggest that PDSAs contributed to teachers’ integration of literacy-based routines into their science teaching.

**Study Design and Methodology**

The current study explores the reach that engagement in PDSAs over the course of a year can have on two teachers’ science teaching practice. I extend a previous examination of two teachers’ use of PDSAs as a tool to record experimentation and practice. The previous study’s findings suggest that PDSAs were a method that supported teachers to engage in processes of iterative enactment and reflection. Through the use of prompts included in a school-wide professional learning plan document, teachers were guided to track their instructional work practices and processes. Careful iterative refinements of practice were made possible through a process of careful documentation. Documenting their practice and reflecting on how planned changes in instruction helped them get closer to their goals for student learning, supported teachers as they developed a better understanding of the ways in which literacy practices were inherently connected to science teaching and learning.

The following research questions guided the study:

1. In what ways, if any, does PDSA enactment have an impact on how teachers characterize literacy learning in science? How did science teachers’ conceptions and understandings of literacy work in science change over time?

2. In what ways, if any, do teachers perceive PDSAs as contributing to, or constraining, their understandings of literacy and learning in science?

3. In what ways does teacher evaluation of classroom artifacts, like science lab reports, reflect changes in teachers’ conceptions of literacy and learning?
To address the research questions, I analyzed teachers’ PDSA documentation (online PDSA trackers), PDSA classroom observation field notes, professional learning meeting agendas, artifacts, and field notes, co-constructed artifacts, and structured teacher interview transcripts. I present examples from the data to illustrate the ways that teachers talk about changes in their science teaching practice and evidence of these changes in their instruction. I also offer an analysis of artifacts that highlight the ways that teachers’ revised understandings of science teaching were reflected in tools they used to support their work. In the next section, I describe the context of the study and offer relevant background information.

Study Context

During the 2013-2014 school year, science teachers were interested in supporting their students’ ability to write persuasively from arguments. This aim undergirded their yearlong PDSA focus and was evident in the team’s documented theory of change (see Figure X - Driver Diagram). Teachers believed that, if they could support students in developing the language and skills necessary to recognize, use, and write arguments, then they would be able to observe students’ regularly use evidence to support their claims during discussions and in their writing. Teachers on this science team highly valued science laboratory reports and identified the lab report, as genre, as one measure where they might see students’ progress with arguments. For example, in the lab report, teachers expected students to use the data that they collected and analyzed as the evidence that students would then use to formulate a response to their hypothesis, or claim.

During the first team meeting involving teachers and researchers (September 20), the team worked together to articulate a theory of change. In this discussion teachers identified the discussion and conclusion sections of the laboratory report as one site for a process measure, to
gauge the progress their students were making in their ability to recognize and use arguments. Teachers’ sustained engagement with PDSAs during the previous school year (2013-2014) did not include an explicit focus on driver 1C. *Writing persuasively from argument.* Instead, the team conducted PDSAs focused on the first two drivers: 1A. *argument recognition* and 1B. *argument use in discussion.* Although teachers did not launch explicit work on the lab report in the 2013-14 school year, as a target for change during their PDSA work, there was evidence that teachers saw their PDSA work as deeply connected to the laboratory reports they regularly assigned to students. The lab report figured prominently into teachers’ 3-day instructional cycle, with the instructional cycle itself culminating in the lab report (see Figure 4 on page 46).

Lab reports also figured prominently in the team’s thinking of argumentation. Lab reports were referenced during every full-day planning meeting as an important product that illustrated students’ argumentation abilities. Although the reports were a frequent focus of discussion during the team’s work together, what was less evident was whether the PDSA work throughout the school year, in concert with the conversations and work done together during full-day planning meetings that focused on the lab reports, had any changes in the way teachers evaluated students’ progress in the lab reports themselves. To gain a more complete understanding of the impact, if at all, of PDSA work on how lab reports were evaluated, I asked teachers to engage in an analysis of a set of laboratory reports.

I hypothesized that teachers’ PDSA work would translate into each teacher’s science teaching practices that were not directly related to the changes they were making and documenting. If there were a translation into practice, I hypothesized that it would be observable in the work that teachers highly valued in students’ science learning: the lab reports. In earlier professional learning discussions, teachers identified the analysis/conclusion sections of lab
reports as important. It was here that teachers expected to see their students using the data they collected during the experiment as evidence to discuss if their hypothesis was correct or, if not, how and why the evidence they collected did not support their original claim. In asking teachers to help me understand what features and characteristics they valued when they assessed lab reports, I hoped to begin to understand: 1) the degree to which PDSA work with annotation, reading entry journals, and summary writing, impacted their evaluation of argument use in writing in an important artifact, like the lab report; and 2) the role that shared artifacts, like lab report guidelines and rubrics, had in guiding their assessment of science learning in the lab report.

Participants

The two participants in the present study - Leonor and Frank⁵ - were selected based on their prior participation in collaborative design efforts with the researcher and their participation in the larger study focusing on the use of PDSA cycles.⁶ As part of the larger study, Leonor and Frank worked closely with the research team, comprised of two university faculty members, one graduate student researcher, and one post-baccalaureate research assistant.

I draw on documentation that was collected during the 2013-2014 school year as part of a broader multi-year partnership collaboration between UCLA and a local K-12 school. The teachers taught science courses in grades 9-12. The school is located in a large metropolitan west coast city and has an average enrollment of approximately 1000 students. Forty-four percent of the school’s student population is classified as English learners with a total of 81% having been

⁵ Pseudonyms have been used for all participants.

⁶ One science teacher who participated in the larger multi-year collaborative effort was not included in this study because she made the decision to transfer to another school. The teacher was in the process of closing out the school year and was not available to complete the lab report analytic task.
labeled as such at one point throughout their schooling trajectory. Eighty-one percent of the students were also classified as economically disadvantaged.

Data sources

In this study, my purpose was three-fold. First, my aim was to understand the ways that teachers’ characterization of literacy learning in science changed. In a previous study (see Lozano, Inquiry I), findings suggest teacher’s practice changed over time. Here, my goal to understand how teachers interpreted changes in practice by focusing on the ways in which they talked about literacy in relation to science learning. Second, I wanted to understand to what degree, if any, these revised conceptualization of literacy use to support science learning impacted the ways in which teacher’s evaluated classroom artifacts that they valued, like the lab report. And finally, I also wanted to understand how teachers perceived that the PDSA process had contributed or constrained these understandings. I draw on data collected during the 2013-2014 school year, including teacher interviews, online PDSA tracker entries, classroom observation field notes, team meeting documents, team meeting observation field notes, co-constructed teaching artifacts, student lab reports, and supplementary documents.

Data analysis

Documenting science teachers’ conceptions of literacy work in science learning. My first step was to analyze the transcripts of the interviews conducted with the science teachers at the end of the academic school year. It helped me to understand teachers’ conceptions of literacy work in science learning. A second step was to all PDSA tracker documentation and classroom observation field notes, by teacher, in chronological date and time sequence. I focused on identifying evidence of changes in practice, over time. Using interview data, PDSA tracker
documentation, and classroom observation field notes was important to the data analysis process because I used findings from one data source to triangulate findings in another data source.

**Contributions and constraints of PDSAs.** I drew on previous analyses of teachers’ interview data to identify the ways in which teachers talked about PDSAs in relation to contributions and constraints to their practice. I used a second data source for this analysis. I conducted a content analysis of meeting documents, artifacts, and observation field notes to understand the ways in which PDSAs and the work teachers were conducting was discussed during these meetings. This analytic approach helped me understand the contributions and constraints teachers attributed to PDSAs.

**Lab report evaluation.** I drew on data from an analysis of student work sort in which I asked teachers to sort the notebooks along four categories of their choosing. At least one teacher used a new rubric that the science team had developed in partnership with CRESST to guide the sorting of student work. Both teachers used a 4-point scale to sort student work and identified a set of characteristics reflected in the laboratory reports selected for each sorted category. While there was prior informal communication about the task, teachers received a formal email invitation for participation in the task. The email included a brief description of the task, a task protocol, and a recording sheet to keep track of the criteria for each designated category (see Appendix B for protocol). A follow-up meeting to review the protocol, analysis, and collect student work samples was scheduled with each teacher.

To analyze the data I first studied the criteria that teachers identified as important for each category in the continuum. My aim was to understand what, if any areas, of the lab report the teachers focused on as a means of understanding if, and if so, how these areas of concentration aligned with the revisions in the lab report guidelines that teachers revised over the
course of the year. Next, I read the student lab reports to identify the degree to which I agreed with the teachers’ category criteria. I used a Claims-Evidence-Reasoning rubric (McNeill & Martin, 2011) to guide my evaluation of student’s lab reports.

Findings

RQ1: In what ways, if any, does PDSA enactment have an impact on how teachers characterize literacy learning in science? How did science teachers’ conceptions and understandings of literacy work in science change over time?

Over the 2013-2014 school year, Leonor and Frank engaged in the design of a variety of literacy-focused routines in their science instruction. In the fall of 2013, teachers began their experimentation with an annotation routine. Through teachers’ engagement in iterative cycles of design through their PDSA work, they continued to refine the routine. Soon, it became apparent that they needed to build on the annotation routine if their end goal was to have students transition from recognizing claims and evidence in text to using evidence to support claims in writing. Shifts in teachers’ conceptions of literacy learning in science are evident in the kind of PDSA cycles they engaged throughout the year. As they refined their work to support students’ ability to identify main ideas and supporting details at the beginning of the year and later shift to the identification of claims and evidence in text, teachers also shifted their work to include routines for documenting science vocabulary, paraphrasing text-based information, and writing summaries of text-based information. At the end of the year, Leonor reflects on her work over the year. She describes the role of PDSAs in supporting the science work in the following way:

Well, I think this year we have done a lot of things that are very different compared to the last three years of my teaching. I mean, it might be for everybody else but PDSA brought just one more component of changes for us... in a good way. And again, it goes back to really looking at what we’re doing in the classroom a lot more than what I was doing last year. It feels like last year we were a lot less structured and focused as to what is it that we want from the kids and how we're going to get there. And it seems like now we have a
lot more tools to be more focused on our goals and, again, look at what it is that we are doing to see if that’s going to get our students to meet the goals that we’re setting for them.

According to Leonor, PDSAs supported them in gaining more clarity about the work they were doing in their classrooms to support students meet science learning goals. Not only did they have more clarity of the work, but they also had ‘a lot more tools’ to help them target instruction.

Like Leonor above, Frank shares his reflection on the impact that PDSAs had on his approach to science instruction in the excerpt below.

I’m going to give them annotations all the time so that’s going to be a norm. I’m going to give them laboratories and they have to have this certain set of structure, and that’s going to happen periodically, right. And they’re going to have classroom discussions. So, basically a set of structures has been developed... Maybe they go hand in hand because we were developing these PDSA cycles. We found that we needed to develop structures.

Frank talks specifically about annotations, laboratories, and classroom discussions as normative routines in his classroom as a result of the PDSA work. He attributes the development of classroom routines to his own involvement in PDSAs.

The structures and routines that Leonor and Frank reference in the excerpts above, I argue, are examples of the mental shifts they made in their approach to teaching science over the course of the year. These descriptions suggest that teachers view the literacy-focused routines as an important part of science teaching. In the following section, I offer a description of the ways in which Leonor and Frank developed and refined literacy-based routines to support science instruction over time. Specifically, these refinements involved teachers’ development of modeling and guided practice supports and the introduction of print-based tools and scaffolds to support students to learn science. For the following examples, I drew on documentation from Leonor and Frank’s online PDSA trackers and classroom observation field notes.

**Modeling and guided practice**
Leonor

Through her work with PDSAs, Leonor tested and iteratively refined literacy routines to augment her science instruction. Through this process, Leonor refines her modeling practices to include more frequent instantiations of step-by-step instruction and more opportunities for discussion during guided practice. In early PDSA work (September 17), for example, Leonor models the annotation process paragraph by paragraph. In this early version of modeling annotation, Leonor reads the first four paragraphs of the text aloud to students. After each paragraph, she pauses and asks students if there is any information in the text that will assist them in answering the guiding question. For each paragraph, she spends about 1 minute reading and asking students the follow up question after each paragraph.

After her model, Leonor directs students to read the rest of the text independently and follow the process to help her annotate the text that she modeled. She gives students 16 minutes to complete the independent reading and annotation task. When all students have annotated the text, she directs students to exchange articles in preparation for an annotation peer review. Leonor gives students a copy of her annotations to serve as a master checklist. As students review the annotations, she directs students to place a checkmark for the annotations that coincide with hers. The peer review process takes a total of 3 minutes. Students exchange papers once again and review their own work. Leonor tells students to mark with an asterisk * any questions or disagreements they might have. To help students look for any areas of disagreement, Leonor tells students that they should look through and ask themselves, “Why did she highlight that? I don’t see how that’s a main idea.” If they do come across anything that makes them think this way, then students should mark the text because they disagree with her annotation and she wants students to ask her so she can explain her reasoning. Students take about 4 minutes to
review their annotations and mark points where they disagree or want clarification. Leonor then guides students in a paragraph-by-paragraph review, checking in with students for any questions or points of disagreements. Over the next 10 minutes, she spends her time guiding students in this discussion.

Here, she poses questions, shares her reasoning, and asks students if they understand. In this example, Leonor enacts the process of modeling as a prompting exercise where she reads a portion of a text aloud and follows up with a question to reflect on the content of the text and whether it helps answer a question. In traditional models of reading, teachers make metacognition public through a think aloud process. This is something that Leonor begins to approximate in the questions that she asks students during her opening modeling of annotation, “Is there anything in the text that will help you answer the question(s)?” and during the annotation review, “Do you think that helps me answer the question?” In these ways, Leonor is sharing the question that helps her as she reads the text but is not being overtly explicit about the specific ways in which the text itself connect back to the question, or not, and why a specific annotation is a main idea or a supporting detail.

In October, Leonor revises her approach to modeling. Here, there is a more explicit reference to the identification of main ideas and supporting details. On October 7, field note documentation shows that Leonor experiments with a slower, step-by-step annotation model. Instead of reading paragraphs in their entirety before asking students whether there was any information in the text that helps to answer a guiding question. With the help of students, Leonor reads the first paragraph of the text, sentence by sentence. She asks different students to read a sentence in the paragraph. After each sentence, Leonor pauses and asks students to consider whether the sentence she just read is a main idea or supporting detail. She also advises students
that they “can’t read just to read” but that they have think to themselves, ‘from what I read, have I read anything important that helps me answer the question?’ In this version of modeling, Leonor takes 4 minutes to complete the process for a single paragraph. This is a shift from her model in September when modeling annotation for one paragraph took 1 minute to complete. In this example, Leonor has attempted to make her model more explicit by helping students think through the text in smaller chunks, sentence by sentence. In addition, her language is much more specific in that she makes reference to annotating for main idea or supporting detail and asks students to consider which it might be, and why.

In this observation, Leonor gives students 29 minutes to read and annotate the rest of the text. As she does so, she walks around to monitor and support students. If students complete their annotations, she provides them with a set of comprehension questions that they can answer while their peers finish reading. When all students have completed the reading and annotation task, Leonor introduces a change to the routine. She announced to the class that on this class day students will ‘self-grade’. She reminds them of the review steps - place a checkmark if it the annotation matches her version, an asterisk if they have a question or disagree - and proceeds to share her version of the annotations, page by page, in silence. Students complete the self-grading process independently and it takes 9 minutes to complete. After the 9 minutes, she shifts to the discussion of the questions and disagreements students have about the text. Here, the quality of the discussion has shifted. Leonor continues to guide students through the process of thinking through the text, discussing text in relation to why they are main ideas and supporting details, she also connects these discussions to comprehension of the text itself. For example, as Leonor moves through the text, she frequently refers to what they have learned from the text so far to connect to the main ideas and supporting details of a subsequent portion of the text. Here, she
guides students to verbalize these understandings and “revoices” to summarize, marking when students have made contributions to the discussion that aid to broader comprehension of the text. While this discussion is only 7 minutes long, in comparison to the 10 minutes she spent in September, the conversation is richer and involves more students in talking about the main ideas and supporting details in the text. To summarize, in this modeling version Leonor reads line by line with students, making sure they are involved in discussing the criteria that helps them understand when and why a sentence in the text would be identified as a main idea or supporting detail. Leonor also refines the quality of discussion to connect the process of annotation to broader understandings of science: pH in living organisms.

In these two versions of modeling, Leonor increasingly engages in public self-monitoring reading behaviors to help students develop the metacognitive behaviors they need to successfully complete these reading tasks. In later PDSAs, the teacher extends the annotation routine to include a focus on academic vocabulary, paraphrasing information, writing summaries of the text, and refining the peer review/self-grading process. With each refinement, the teacher targets the attainment of students learning goals through changes in her practice. She reflects on the explicitness of her instruction and identifies areas where she needs to continue to grow. It is important to note that during this first year of PDSA cycle implementation, Leonor was simultaneously piloting a new teacher evaluation process that included pointed reflection activities regular principal observations. Perhaps this also contributed to the teacher's acute awareness of the role that modeling and guided practice play in the apprenticing of students into a set of literacy practices to support science learning.

Frank
Frank’s PDSA engagement provided him with the opportunity to test and refine literacy routines to support his science instruction. In early PDSA cycles, his tracker entries reflect a sense of doubt and uncertainty. Observation field notes also document instantiations of this uncertainty in the ways in which he models and guides students through the annotation process. Over the course of the year, Frank’s engagement in PDSAs reveals shifts in his approaches to modeling and guided practice. The changes in his modeling and guiding approach, in turn, reflect the confidence that he has developed in his ability to meet his students’ learning needs over the course of the year. Like Leonor, over time, Frank becomes much more explicit in his modeling and guided practice approach, becoming better able to gauge his students’ learning needs in the moment. He increasingly becomes better able to provide appropriate pedagogical responses to help his students complete literacy-based routine tasks and participate in discussions.

When Frank completed his first PDSA cycle (October 4), he reflected on his ability to enact the routine effectively. He attributes his students’ struggles with text comprehension to his “extended explanations” and makes it a point to making sure that he is more thoughtful about “coming up with examples” to aid students’ reading comprehension. He also questions his selection of text, stating that next time he will find an article and not use an excerpt from the textbook. Observation field notes document his modeling approach during his enactment of this new routine, showing the ways in which his uncertainty came through. For example, like Leonor, Frank also initiates the annotation by read the first paragraph in the text aloud. After reading the paragraph he directs his students to reference the annotation handout (see Figure 6 below) and asks, “Can anybody guess before I actually tell you what the main idea is?... Look at the essential question.”
A student provides a response to this question that aligns with the teacher’s selection of a main idea. Frank talks students through his selection of the main idea as the third sentence in the text and explains that he didn’t select the first sentence in the paragraph as a main idea because it was “general”. He follows up by asking students, “So, now, what do you suppose I picked for supporting evidence?” Two students provide answers and the teacher confirms their selections as supporting evidence and refers them back to the essential questions that he posed at the beginning to help guide the focus for their annotation. The total time Frank spent on this segment of the annotation routine was 6 minutes.

After reading the first paragraph together, Frank directs students to read independently. Students read and annotate for 20 minutes. Upon completing the annotation, Frank directs his
student to exchange papers in preparation for the peer review process. Frank directs students to place checkmarks next to the annotations that match his own. After 8 minutes, students exchange papers again. At this point, Frank begins a review of the main ideas and supporting evidence in the text. He explains to students that he expects them to mark with an asterisk any points of disagreement with his annotation. Here, Frank continues to ask questions of the students when he is walking through his annotations. For example, after reading his selection of the main idea, Frank asks, “Anyone want to tell me why I chose that as the main idea?” As the discussion progresses, it shifts toward supporting students’ comprehension of the text and away from the annotation process. The discussion continues in this manner, fluctuating between a focus on the content and a discussion of the main ideas and supporting evidence in the text for a total of 23 minutes. In this fluctuation it is evident that Frank will have to learn how to navigate using text to support students in two ways: 1) support their understanding of science and 2) navigate and draw information from texts. At the end of the discussion, and routine implementation, Frank turns to the researcher in the room and says, “I forgot step 4.” In his reflection Frank wrote, “The goal for the first time was to teach them the process and not include additional content detail.”

The approach Frank used in his modeling of annotation makes a lot of sense. Frank appears to have been so preoccupied with getting the routine steps right, placing his emphasis in moving through the routine as planned, that he limited his attention to the content of the text and his overall learning goals. Frank seemed uncertain about the text annotations themselves as this was a new process for him. He often asked students what they thought and why they thought he selected particular bits of information because he likely wanted to draw on students’ responses to help him understand what information they needed to understand the annotation process.
As Frank became more comfortable with the annotation routine, he became much more explicit in his guidance to students, often being very specific in the examples he chose. Later that fall (November 21), Frank revised his annotation modeling approach. Frank begins by revisiting a familiar text with students. On this occasion, however, students read the text for a different purpose. The guiding question for the text is also different. In addition, here the teacher has changed what students will annotate in the text. During this PDSA, Frank expects students to identify claims and evidence. As a first step, Frank directs students to reread the text with this new focus independently. As they read, they should annotate for claims and evidence. Students read and annotate the text over a period of 10 minutes.

For the next 23 minutes, Frank guided students in a sentence-by-sentence review of the text. He led students in a discussion focused on the identification of claims and evidence. He guided students to first consider what the claim might be in the first three paragraphs. Here, there is consideration of whether a sentence is a claim based on its ‘strength’ and how ‘concrete’ the ideas in the text are. When students identify claims, it becomes easier for Frank to ask students to identify evidence in support of a specific claim. After reading through the first three paragraphs, sentence by sentence, and identifying the claims in the text, Frank calls on different students to read different sentences in the rest of the text. Each student that reads is then responsible for sharing their thinking about whether the sentence is evidence. Here, students provide reasoning along with their responses usually in the form of, “Yes, because _______________” or “No, there is no evidence because it doesn’t _______________.” There is also evidence that students are beginning to respond to each other when they engage in this discussion, not just the teacher. In this example, Frank has provided students with opportunities to revisit a text that they are familiar with to then lead a guided practice session discussing identification of claims and
evidence. He has gained confidence in his ability to guide students in a line-by-line text-based conversation on a science topic. He has also learned how to support students’ comprehension of important science information while guiding them in a process of identifying what is most important in the text through annotation of claims and evidence.

**Print-based tools and scaffolds**

Leonor and Frank expanded their literacy-based work beyond the annotation routine. Although teachers’ engagement in PDSAs was limited over the second semester, they nonetheless continued to build on annotation, developing additional routines to support students engage prior knowledge before science lessons, using an entry journal to paraphrase claims and evidence and writing summaries of the text using the paraphrased information. Teachers developed a series of shared templates for each of these additional routine steps. As teachers used them in their classrooms, they revised the shared templates. These became commonplace in classrooms over the second semester.

During the second semester, the lab report also featured prominently in Leonor and Frank’s instructional routines. At this time, teachers were regularly assigning students texts to read and annotate in preparation for lab experiments. The expectation was that students would use the texts to build background information about a lab experiment. Teachers expected students to use their understanding of the text to summarize important information that was relevant for the lab experiment. Students would use text annotations and summaries to support them as they wrote the introduction to the lab report. In January, the teachers revised a shared lab guidelines document - How to Write a Lab Report - that was shared with students. Because teachers had spent a considerable amount of time developing shared literacy routines that
included summarizing, the guidelines reflected these changes. The following excerpt illustrates the major changes in the document.

**November 2013 Version**

2. INTRODUCTION/PURPOSE/HYPOTHESIS

*This should be written in paragraph form. Three guiding questions should provide framework for the introduction.*

**Question 1:** Why did you conduct the experiment? *(This is your RATIONALE.)*
Some over-the-counter drugs are effervescent tablets that must be dissolved in water before ingestion. Directions do not include specific water temperatures.

**Question 2:** What did you hope to learn? Write a sentence or two explaining why we are doing this lab. Think of the question that you are trying to answer to help you with this section.
*(This is your PURPOSE.)*
The purpose of this experiment was to determine the effect of water temperature on the time required for effervescent tablets to dissolve.

**Question 3:** What did you think would happen? A hypothesis states what you expect or predict to see in the experiment. It must be a testable statement.
*(This is your HYPOTHESIS—written in if, then format.)*
The researcher hypothesized that if the temperature of the water is increased, then effervescent tablets will dissolve faster.

**NOTE:** In your report, the italicized sentences above would appear as a single paragraph. The questions are included above just to guide your thinking.

**January 2014 Version**

2. INTRODUCTION- Write a summary of the background information that was provided to you. If you are doing your own research then write at least one good paragraph. (5 pt)

3. PURPOSE: Write a sentence or two explaining why we are doing this lab. Think of the question that you are trying to answer to help you with this section.
Example: The purpose of this lab is to grow two species of the protozoan Paramecium, alone and together, to compare the growth curve of each.

4. HYPOTHESIS: What do you think will happen? A hypothesis states what you expect or predict to see in the experiment. It must be a testable statement.
Example: If P. caudatum is grown together with P. Aurelia then they will compete for resources and one of the species will outcompete the other.
One major change highlighted in the above excerpt is the prominence that the introduction, purpose, and hypothesis components now hold in the lab report itself. Whereas before these were all lumped together in a single category, the revised version not only separates these sections, but also reflects the changes in instructional practices that the teacher have made. Summary writing is an important component of item number 2 in the January 2014 version.

A second expectation in the lab report was that students improved their ability to use data as evidence to support or refute their hypothesis, or claim, for the experiment. Teachers saw this as a key application of their work with annotation, reading entry journals, and summary writing. The ‘Discussion and Conclusion’ section of the guidelines were revised slightly, but did not reflect major changes. Upon examination of the guidelines themselves, this is probably due to the fact that the section already reflected much of teachers’ shared expectations for science learning: to analyze data, to explain how the data supports or rejects your hypothesis, to reference the data tables or graphs to support your statements.

Because teachers now had a shared set of instructional literacy-based routines that were a regular part of their teaching practice, they revised the shared guidelines artifact to reflect these changes. The shared artifact also reflected a shared understanding of the components that should be included in the lab report and the common expectations for student learning.

**RQ2: In what ways, if any, do teachers perceive PDSAs as contributing to, or constraining, their understandings of literacy and learning in science?**

Leonor and Frank found that engaging in PDSAs during the 2013-2014 school year was essential to their understanding of literacy and learning in science. Earlier I shared Leonor and Frank’s reflections about the PDSA process. In these interview excerpts, Leonor emphasized how the PDSA process helped bring about a lot of positive changes to her practice. She stated
that PDSAs helped her do things very differently this year in comparison to her “last three years of teaching.” Frank also describes the changes that he made in his classroom instruction as a result of his engagement with PDSAs. I also described some of the ways that teachers’ use of PDSAs contributed to the ways in which they changed their understanding of what it meant to use literacy to support learning in science. Through those examples, I showed how Leonor and Frank’s perceptions about the utility of PDSAs to their practice were also revealed in changes to the ways they modeled and guided students engage in literacy-based work. It was through the PDSA process that teachers actively participated in the design, enactment, and iterative refinement of shared literacy routines.

In addition to Leonor and Frank’s interview responses, meeting documentation and field notes also show that teachers also devoted meeting time to discuss how their work in PDSAs was supporting their science learning goals. For example, during the final full-day meeting for the school year (April 1), teachers spent time explicitly discussing the connections between their literacy-based work in PDSAs and students’ science learning goals. Teachers visually represent the ways in which they see their work with PDSAs connected to their long-term aim of supporting students’ ability to reference text-based evidence to support claims when writing arguments. Teachers map the target areas of their literacy-based routine work through PDSAs along with the measures that they see as important to informing their work (see Figure 7). Teachers identify annotations, discussions, summary writing, and lab report introductions as important measures for their work.
Teachers continue to discuss the connections between the different tools in supporting their instructional work to meet their aim (see Figure 8). Here, they problematize a process for text summary, drawing on the knowledge of the group to document existing processes to help create a stable routine. Finally, there is a connection to the lab reports. Teachers in this case reflect on the questions that they have included in the conclusion section of the lab report guidelines. Teachers are wondering about the degree to which these questions are “fulfilling the product”.

Figure 7. PLP – PDSA Work
It is important to note that after teachers had these discussions, the university researchers shared a document that had been put together to support teachers to reflect on the routines they had developed in the course of PDSA work for the year and to think in concrete terms about the measures they might use to signal improvement (see Figure 9).

*Figure 8. PLP – Data Analysis Work*
The challenges of doing PDSAs

While PDSAs are a powerful tool for professional learning and practice-based improvement, they are not without challenges. Although teachers did not report that PDSAs in any way constrained their understanding of literacy and learning in science, they did identify some of the difficulties that they experienced in the course of their work. I draw on interview
data to describe Leonor and Frank’s perceptions of the ways in which PDSAs were difficult and challenging. Teachers identified three primary challenges they experienced in their use of PDSAs: documentation, identifying the right measures, and relying on external partners to develop tools to support their instruction.

*We’re always so busy.* First, teachers talked about the difficulty with keeping up with the documentation of their practice to support their implementation of PDSA cycles. Early in this project it was clear that asking teachers to document their practice might be challenging. To support teachers in tracking their PDSA work, an online tracking tool was developed and shared. The online tool was a shared Google spreadsheet. Leonor and Frank regularly used Google-based tools to create and share meeting documents and regularly accessed computer and internet-based resources to support their teaching. Developing a shared Google spreadsheet for their use seemed like a natural fit. The document could be easily accessed and updated by teachers at their convenience. Although teachers recognized that PDSAs were helpful, the documentation aspect of the work was challenging. In the following excerpt, Leonor points out the challenges she experienced with the documentation.

*I know you have to lay it all out on this, on this database, right? But, again, to me, like us teachers, like we’re always so busy that it was kind of like… you needed to force yourself to. You have to fill this out, in a timely manner. But, I can’t say that it was, like there were some periods of time where it was kind of difficult for me. To, okay, you know, I need to go back and think about, what did I do last time? And that’s just being honest.*

Leonor references time as a personal challenge with PDSAs because teachers are busy. She recognizes that the document should be completed ‘in a timely manner’ to be useful, but identifies this as inherently challenging because she, as a teacher, is busy. To complete the documentation aspect was challenging for Leonor because she needed to take time away from her other responsibilities to think about her work and what she did.
How to track it. A second challenge with PDSAs was understanding how to select the right measures to evaluate progress. An important component of the PDSA process is collecting data to gauge whether a change you are implementing is an improvement. When teachers became much more adept at using literacy-based routines to support their students’ learning, they began to consider how to transition students’ abilities to recognize claims and evidence in text to using evidence to support claims in writing. For Frank and Leonor, the lab report was an important component of their science learning program. It was the culmination of their work with text and writing (see Figure X - Three-Day Instructional Cycle). Teachers, however found it challenging to understand how to best support students, instructionally, to meet the goals that they talked about for the lab report. Frank describes the challenge with PDSAs in the following excerpt.

*I mean it seemed like for us, somehow, the second semester or... PDSA cycle number two was a lot more difficult. It was just hard to, not only because we didn't have time but because of how to track it, you know? I think our focus was on lab reports so, really having some sort of graphic, per se, to see if we're following a trend line. It was kind of hard.*

Frank discusses finding the right measure as a challenge. Because using literacy to support science learning was a new pedagogical approach, it was understandable that the teachers struggled with the identification and collection of data that they could use to help them understand improvement during the second PDSA cycle.7

Leonor shares her own insights about the challenge they faced in identifying the right measure during the interview.

*I think I know what happened. Cause, like first semester we were very focused as to like we’re going to check annotations and identification of main ideas, and supporting sentences. So, we knew... how we were going to check it. We knew we needed to look for*

---

7 Teachers talked about the accumulation of PDSAs over a semester as one PDSA cycle. While they understood each instantiation as one cycle, they referred to the PDSAs conducted in the fall as PDSA cycle one and those in the spring semester as PDSA cycle two.
articles. We knew how we were going to score it and right, get feedback to see if we were moving kids along. Second semester we talked about looking at students’ lab reports of the writing.

According to Leonor, it was much easier for them to measure if they were making progress in annotation at the beginning of the year. She also references that it was clear that they had to locate texts to use as the basis for the annotation routine. When it came to the second semester, they talked about looking at students’ lab report as a focus for their PDSA work. Because it was another major instructional shift the science team was considering, teachers realized that they were uncertain about how to best approach instruction to support the kind of writing they wanted to see in students’ written lab reports. Although the team did spend time revising the lab guidelines to match their current conceptions of literacy and learning in science, it was a document that was designed to support students, first and foremost, not teachers.

*The problem was the rubric.* The third challenge that Leonor and Frank discussed was closely related to the challenge of measurement described previously. Because they were unsure of the instructional routines required to support students’ writing, the team decided to reach out to a former external partner for support with the design of a laboratory report rubric. Through the rubric criteria, the shared laboratory rubric would help teachers think about the instructional routines they might develop to support student performance according to the rubric dimensions. The rubric, however, was provided to the team in June that school year. Ultimately, this had an impact on the team’s desire to be consistent. Leonor talks about this challenge as follows:

... thing is that we waited for the lab rubric for a very long time so we could be consistent. So, if we were looking at lab reports, we were able to compare data from like your kids to mine and to Alicia’s. “Oh the kids know how to formulate a hypothesis, yes, no.” You know? So, we didn't get that rubric. The problem was the rubric, we got it like until last week.
Through shared work in PDSAs, teachers developed a desire to be consistent. The desire for consistency was expressed through the design of shared routines and artifacts, like the annotation routine, the routine to support paraphrasing and summary writing, the 3-day instructional cycle, and the lab report guidelines. Consistency was also evident in the ways that teachers sought to evaluate student learning. For example, teachers developed a mid-year assessment to measure students’ annotation progress. Together, teachers planned the texts they would use for the mid-year assessment and how they would evaluate the progress students were making. In the following excerpt, Frank talks about how waiting for the rubric impacted their work over the second half of the year.

So, we didn't start the PDSA cycle until very late on. And, you know we were kind of like falling behind on our goals that we wanted to carry out. So, it was just difficult tracking that information. And like coming up with like some sort of testable ways to see if the kids are on track. You know what I mean.

Frank refers to the infrequency that PDSAs were conducted over the second semester. For example, for Frank, there is documentation for 20 PDSA cycles, including observation field notes. However, Frank only documented 9 out of the 20 PDSA cycles in his online tracker. Similarly, there is documentation of a total of 4 PDSA cycles that Leonor completed during the second semester. Nonetheless, Leonor only documented 1 cycle in February in her online PDSA tracker. In the excerpts above, both Frank and Leonor attribute the paucity in PDSA engagement over the second semester to the delayed rubric. In the interest of consistency, teachers waited for the rubric to be developed by an external partner rather than attempt to design a rubric themselves.

Meeting artifacts and observation field notes corroborate teachers’ interest in articulating a shared rubric for the lab reports. While the lab report is referenced in all five full-day meetings over the course of the 2013-2014 school year, meeting times were allocated to the revision of the
lab report guidelines (November 19), the design of a lab report rubric (January 23 and February 28), and the explicit connections teachers envisioned between the lab reports and their PDSA work (April 1).

**RQ3: In what ways does teacher evaluation of classroom artifacts, like science lab reports, reflect changes in teachers’ conceptions of literacy and learning?**

Leonor and Frank had spent the entire school year experimenting with the use of literacy-based routines to support students draw meaning from text-based sources. Over the second half of the school year, both had made explicit attempts to draw connections between practices like annotation and summary writing to student’s lab report writing. Teachers were refining their understanding of the role of literacy in science learning and were struggling with the types of additional routines they could introduce to support students prepare for, conduct, and reflect on laboratory experiences. One way to gain insight into what teachers understood was to ask them to share their assessment practices with respect to lab reports. Understanding what each teacher emphasized in their evaluation would help me understand what type of supports teachers might need to promote professional growth over the following year. To this end, I asked teachers to collect a set of lab notebooks and, from that set, select student lab reports to sort along a continuum of their choosing. What I wanted to know from them was the criteria that they used to sort students. Findings suggest that, while teachers approached the task similarly, they marked and engaged with the notebooks quite differently. I describe each teacher’s approach and what I learned in the process.

Leonor had been largely responsible for the original development of the lab report guidelines. She introduced the artifact to the science team long before we began our collaboration. I share this information to foreshadow her engagement in the review of lab reports.
When Leonor reviewed her lab notebooks, she identified 14 samples that she wanted to share. She sorted them along a scaled continuum from 1 to 4, with 4 being the highest (see table 8).

Table 8

*Leonor’s Student Lab Report Samples*

<table>
<thead>
<tr>
<th>Category</th>
<th>Samples</th>
<th>Examples of Highlighted Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>2</td>
<td>Summarized Introduction Results include data tables and graphs Analysis section is complete and uses echo answer Uses references to data to support or reject hypothesis Makes conclusion that shows understanding of concepts</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>Does not echo answer in analysis questions Incomplete answers to some analysis questions Conclusion includes contradicting statements about data rejecting hypothesis but then stating that others found data that supports it</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>Summary is incomplete Incomplete data table Analysis questions are incomplete, missing or answers are not specific Conclusion is missing 2 parts</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>Summary for introduction is too short Hypothesis is unclear Sections of lab are out of sequence Does not echo analysis and does not answer questions</td>
</tr>
</tbody>
</table>

In her comments about the lab report samples she has selected, she attends to both the lab sections as important components that should be included in the report and the content of the responses to demonstrate science learning. Leonor frequently places checkmarks next to sentences that she agrees with. In the samples, Leonor comments most frequently on students’ hypothesis section (9 instances), followed by the follow-up experiment explanation (7 instances), analysis (6 instances), and introduction (5 instances). Leonor offers more substantive comments in relation to the Analysis section. It is here that Leonor challenges students’ thinking, encouraging them to include echo answers or posing follow-up questions for response like, “Such as? Be specific.” or “What statement? How?” These questions are positioned adjacent to
the sentences that they reference, for the purpose to push students to provide more complete responses. Another strategy Leonor uses when she reflects on students’ lab reports is the use of checkmarks next to sentences she identifies as aligned with the goals of the lab or for hypothesis, for example, that are clear and follow the if, then format.

Frank approached the task slightly differently than Leonor. He first identified 7 samples to share and sorted these along the same scaled continuum of 1 to 4, with 4 being the highest (see table 9). In contrast to Leonor, Frank could not locate any samples that fell in the highest category of ‘4’.

Table 9

Frank’s Student Lab Report Samples

<table>
<thead>
<tr>
<th>Category</th>
<th>Samples</th>
<th>Examples of Highlighted Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>0</td>
<td>No examples found</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Intro includes purpose</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Intro lacks information</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>Procedure is testable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Uses results to discuss hypothesis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Intro lacks information</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Results lack calculations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lacks clarity in how data supports/rejects hypothesis</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>Intro lacks information</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hypothesis not correlated to purpose</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>Procedures not testable, lack precision, can’t follow step-by-step</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Graphs lack appropriate labels (x-axis)</td>
</tr>
</tbody>
</table>

In Frank’s case, his review of the lab report samples highlight his approach as more focused on whether students included sections or not. His comments, in contrast to Leonor’s, are significantly more vague and less focused on the specifics of the content and how it demonstrates learning. In his review, Frank also attempts to make use of the rubric that was created by another partner to guide his lab report sample sort. It is unclear to what degree this influences his
emphasis on what sections were included in the lab report. Frank also comments on nearly every section for every sample he shares. The sections he comments on the most are the introduction (6 instances), the hypothesis (6 instances), and the results sections (6 instances). When he comments on the introduction, Frank is much clearer in his focus on the content. I attribute this attention to the continued work on summarizing and the connections made between using text to support the writing of the introduction for the lab report.

In summary, teachers attended to the lab reports differently. While Leonor considered the lab sections and the content described within them as equally important, Frank appeared to approach the lab report sort as more of a check on section completion. He attended to the sections themselves by checking whether they were included or not. Both Leonor and Frank, at that point, had very different understandings of what it meant to support science learning with literacy in the written lab reports.

**Limitations**

In this study, there are several limitations that I must acknowledge. First, I was limited in the data that I collected for this study. While I envisioned that teachers would provide me with a complete set of lab reports, the samples they each provided in addition to the level of detail that they used to describe students’ work varied greatly. Furthermore, I did not have a set of criteria that I drew on before I asked teachers to participate in the study nor did I have the foresight to request the tasks that accompanied the lab reports teachers shared with me. In terms of sample size, only having two participants for this research could be conceived as a limitation. While I recognize that the sample size is small, it is also important to recognize that conducting detailed inquiries into teachers’ professional work practices takes time. Deep engagement, however, is valuable. It is especially so in this case when there is limited research on the ways in which
improvement science tools, like PDSAs, can be used to support learning. Research that explores how learning occurs in this case can contribute to the field’s understandings by providing insight into the nuanced ways in which professional learning occurs when PDSAs are used to support improvement.

**Conclusion**

The teachers in this inquiry were not only learning a new process for working on a common problem of practice, they were also adopting a new pedagogical approach to science teaching. When teachers are leading lessons, in the moment, on stage, they are often working hard to ‘get it right’. In Frank’s case, he emphasizes the completeness of routine enactment. He is conscious of the routine steps he forgets and, similarly, he is conscious of the sections in the lab reports themselves, attending to completeness more so than the quality of the writing and students’ ability to formulate arguments in their discussion and conclusion sections of the lab reports. As Frank continues to progress in his ability to support students’ lab report work, he will gain confidence and shift his attention to quality or completeness. Leonor will also continue to refine her understanding of what it means to support students writing work. Because these two teachers are members of the same science team, their progress can happen quickly if they make the decision to take on the work of designing routines to support students as they engage in the lab experimentation process.

**Implications**

The findings reported in this study suggest that engagement in PDSAs has the potential to support teachers’ pedagogical approaches more broadly. In the examples above, teachers changed their pedagogical practices in ways that directly related to the PDSAs they enacted as well as indirectly. Teachers took on the work of co-constructing shared artifacts and routines to
support their science learning work. Through the study of these shared artifacts it is possible to begin to understand how reflection shapes practice. Study findings also reveal the ways in which PDSAs support teachers to identify data measures that they can use to gauge student learning in relation to instructional practice. Additional research in understanding what teachers attend to in their assessment and evaluation practices in relation to professional learning work can be one way to track professional growth over time.
CONCLUSION

Schooling organizations were founded on the premise of creating an educated populace (Cremin, 1989). While the purposes of schooling have historically varied, and at times been at odds with the ideals of democracy (Labaree, 1997), today schools are touted as optimal learning spaces where all students can succeed. With an increased focus on college and career readiness, changes in assessment practices, and evolving measures of student learning, the meaning of what counts as success continues to reflect a system of education where unequal outcomes are rooted in persistent educational disparities (O’Day & Smith, 2016). In education we are often plagued by the need to find immediate solutions to persistent challenges. In our haste to improve quickly, we fail to learn our way through obstacles. Often, those who are charged with making change happen in organizations place limited attention to the conditions necessary to bring about organizational improvement. If we are to truly create spaces for students to succeed, we must recognize that organizational processes are part and parcel with what it means to foster professional learning in schooling organizations.

The three inquiries in this dissertation contribute to the literatures on professional learning and teacher learning. Here, I have aimed to provide a lens through which to view teachers’ work. These depictions of learning through practice are nuanced and detailed, reflecting the kinds of activity taken up in the context of working towards improvement. In the examples presented here, teachers used several improvement tools to help them hone in, and work through, the problems of practice they experienced and which were of concern to them in their day-to-day practice. Learning was driven by teachers’ desire to improve students’ literacy and learning outcomes in ways that mattered and were also consequential. I have demonstrated that teachers working together to define what counted as success, and how success can be
meaningfully measured, ultimately refined their understandings over time based on what they were learning. As such, they were able to make great progress towards achieving their goals in a relatively short amount of time. Working together to develop a shared set of instructional practices resulted in a greater amount of accumulated learning; much more than if they were working to improve practice individually. Taken together, these three inquiries offer perspectives into the types of changes in practice that can occur in organizations that simultaneously attend to optimal learning conditions for both professionals and students at different levels.

In the first inquiry, I illustrated one secondary science team’s learning journey as they sought to improve students’ ability to use evidence in support of claims. In this process, teachers took up the use of improvement tools to help them map out a shared theory of action. Teachers, together, delineated the ways in which they thought they could better align instructional practice and student learning. The process supported them to develop a common set of instructional literacy practices that supported students to better navigate a variety of science texts, document their understandings, and use these text-based understanding to help them support science claims in discussions and writing. As a result of designing, refining, and fine-tuning these instructional practices, teachers also improved their use of formative assessment practices. The science team developed shared measures to assess the learning goals of their lessons and, in turn, evaluate the degree to which their teaching practices resulted in the kinds of student learning and literacy outcomes they valued.

On the other hand, the second inquiry offered a view into one dual language elementary school teams’ work to improve students’ metacognitive abilities during reading. Through a detailed study of this team’s documentation, I learned that having clear structures and routines for collaboration are equally important when working on a shared aim for improvement. In
contrast to the first inquiry, where each science teacher taught markedly different science topics, this teacher team shared curriculum responsibilities and was accustomed to working collaboratively to make decisions about what content to teach and develop shared artifacts to support their instruction. This process of improvement complemented the kind of collaboration work they were already accustomed to and helped them to focus more deeply on the pedagogical actions they were taking in response to some of their students’ behaviors and responses to instruction. In this case, this teacher team already had structures and routines for getting work done. What was missing was having tools to help them hone in on a shared problem of practice to establish highly-specified levels of coherence in instruction on a problem that they all experienced. The application of improvement methods, like PDSAs, helped them to identify gaps in their own understanding of reading and pedagogy. Like the science team in the first inquiry, working through a shared problem of practice supported their ability to create and refine assessment measures. Refining their methods of assessment supported their ability to pinpoint additional areas of instruction that they needed to focus on and, in turn, develop a shared set of instructional practices to get them closer to their aim of increasing students’ ability to use reading strategies when comprehension breaks down.

Finally, in the third inquiry I focused my attention on understanding the kinds of learning that can co-occur as a result of taking up tools of improvement, like PDSAs, in teacher practice. In my inquiry, I studied two individual science teachers’ learning, working to identify traces of learning reflected in teachers’ pedagogical practice in areas that were not directly related to the shared PDSA work they were doing as a team. In this case, I opted to ask teachers to evaluate a set of laboratory reports from their own classrooms to understand what counted as learning in these classroom artifacts. I learned that teachers’ use of quality as an indicator of learning varied
greatly. Here, the more experienced teacher, Frank, evaluated the quality of students’ responses using completion as the marker that mattered most. For example, Frank was much more focused on whether students included the components required, like hypotheses. If it was there, in some form, the student received credit. He was less attentive to the content of the hypotheses themselves. That is, he did not seem to focus on the level to which the content reflected an understanding of the science concepts under study. In contrast, Leonor, who consequently was the teacher that spearheaded the team’s PDSA work in the first inquiry, focused her attention on the content of students’ writing. For her, quality resided in students’ ability to represent their science understanding in ways that reflected learning from texts and data collection activities. Leonor had, in essence, spent all year attending to the quality of student responses in oral and written forms and this, to a large degree, was reflected in her assessment of students.

**Implications**

The examples and findings reflected in this set of inquiries have broad implications for re-envisioning the design and implementation of professional learning in schools. While there is much value in supporting teachers to continuously develop content knowledge and pedagogical practices, common approaches to support teachers’ professional learning typically fall short. Findings suggest that one-shot professional development sessions are meaningless if they are standalone opportunities for learning. The three dissertation examples demonstrate the value in supporting teachers to take up and use methods of inquiry that will guide them in defining and improving a shared problem of practice with members of a team. While structures like Professional Learning Communities (PLCs) and Communities of Practice (CoPs) are valuable, what is missing is an inherent sets of tools to support teachers in learning their way through complex problems. In this dissertation, professional learning experiences were enhanced and
supported through the use of improvement science methods, like PDSAs. They were integral components in a holistic approach to professional learning and were useful in sustaining a focus on student learning and improvement.

In this dissertation, I have provided three case examples of professional learning. Each case details the ways in which optimal organizational conditions supported the creation, and sustainment of teacher learning, in one public K-12 school. Improvement is difficult, laborious work and the journey towards growth is not without its challenges. Through simultaneous attention to the content and conditions for learning, growth for both teachers and students was made possible. Persistence through these challenges and the application of methodical approaches were key contributing factors that made improvement possible. Furthermore, because teachers are charged with designing lessons that meet both learning standards and student needs, attention to the ways in which improvement methods, like PDSAs, contribute to teachers’ use of formative assessment practice are needed. In this set of studies it was evident that teachers became much more aware of the learning they expected their students to do at the end of each lesson. They also increased their ability to align their instruction with these learning expectations in large part due to their attention to measurement of learning. The teachers in these examples became much more adept at developing and implementing shared measures for learning. These measures contributed to teachers’ refinement of learning expectations and better equipped them to respond to students’ learning needs in the classroom.

As a field, we continue to grapple with the problem of how to address variation in professional learning. Despite increased attention to professional learning, there continues to be great variance in the degree to which teacher learning occurs and is, in turn, put into practice to improve student learning. While we know that teachers need systems of support to help them
refine their practice to improve student learning, we know less about how to plan professional learning experiences to achieve these goals (Guskey, 2014). The issue can be largely attributed to poorly planned professional learning experiences. If professional learning experiences do not have a clear purpose for the work, teachers are left to work together in ways that are counterproductive. According to Guskey, when teachers engage in professional learning experiences without a clear focus on results, they end up focusing their work on planning lessons, developing activities, and identifying resources for their work (p. 14). Such work does little to bring teachers closer to the goal of becoming better equipped to meet students’ learning needs.

Schools typically have professional learning structures in place to support teacher collaboration. To enhance professional learning experiences for teachers, schools would benefit from paying closer attention to how these structures are used to support teacher learning. The examples of teacher learning in this dissertation showcase the ways in which tools and processes for improvement can be instituted school-wide in ways that are closely connected to classroom practice. In these examples, teachers began their work with a specific aim for improvement. Professional learning had a clear purpose and this supported teachers as they worked to develop measures to assess their own progress along the way. The implications for practice involve attention to the specific goals for professional learning experiences, the structures in which this learning should take place, and the tools and processes to support teachers as they learn their way through the desired outcomes.

Limitations

The three studies in the dissertation all take place in a single school site within one of the largest school districts in the country. While this school has shared characteristics with other
schools in large metropolitan cities, it is a unique place given its access to resources and the high level of professional autonomy afforded to teachers at the site. Nonetheless, it is precisely because of these characteristics that this site was optimal for the dissertation. I studied professional learning in this context and provided detailed examples of professional learning experiences that were focused on specific targets that fit within a broader school-wide focus. In addition, I provided accounts that showcased the ways in which teachers learned to use specific tools of improvement to help them reach their aims. While I was limited in the data I collected in at least one of the inquiries (see Lozano, Inquiry II), taken together, all three dissertation inquiries provide readers with a nuanced perspective of the ways in which teacher learning can unfold in settings that have simultaneously attended to the structures, tools, and processes to support professional learning. When professional learning experiences are designed and supported with the use of improvement science tools to improve practice, measurable gains in student learning can be achieved.

**Future Research**

There has been a proliferation in the number of school districts who are making use of improvement science tools and methods to support systemic improvement. Despite this rapid implementation of these methods, there is limited research in this area. The inquiries that comprise the current dissertation are a beginning step. They provide detailed snapshots of the use of improvement tools, like PDSAs, to support teacher learning and enhanced student outcomes. Nonetheless, more examples of the ways in which these tools are taken up and used in the context of school improvement are needed. Furthermore, examples of what teachers actually learn, and how they apply their learning, through participation in professional learning experiences that make use of improvement science tools are warranted. Research in these areas
would support practitioners, school leaders, and researchers to re-envision the design and implementation of professional learning that resulted in improved student learning for all students.
Appendix A
Teacher Interview Questions

1. What is a PDSA cycle?

2. How many can you do in a school year?

3. Has your use of the PDSA cycles helped your students? If so, how?

4. Do you think the use of PDSA cycles have helped you as a teacher? How?

5. Has the use of PDSA cycles supported you in becoming a more reflective practitioner? If so, how or in what ways?

6. Is there anything you do differently now, as a teacher, that you didn’t do before your engagement in PDSA cycles? Tell me about it.

7. Do you think about teaching/planning differently than you did before? If so, how?
Appendix B
Laboratory Report: Analysis of Student Work

This year the science team has been using PDSA cycles as a tool to inform and improve teaching and learning experiences for you and your students. As we prepare for the upcoming school year, we are asking you to gather the student laboratory reports that have been completed during the current school year. We would then like you to engage in a reflective analysis activity using the reports.

The purpose of this task is three-fold. First, this activity will help us understand what features of the lab report work you consider important. Second, it will help us understand if, and if so, how annotation, triple-entry journals, and science writing support students in completing the lab reports. Finally, your reflections will serve as one of the baseline data measures for next year’s PDSA work.

To carry out this activity:

1. Gather a class set of laboratory reports that your students wrote this school year.

2. Decide on one laboratory assignment that you asked students to complete this year and read the lab reports from that assignment. As you read through the lab reports, sort them into one of four stacks based on your assessment of the quality of the lab report. We have purposely not given you any categories. The first round of reflective analytic exercises like this work best when you decide the categories that you will use to sort the lab reports. The only thing that we ask is that you categorize the lab reports along a continuum e.g., best to worst, high to low, more or less complete in response, etc.

3. As you categorize each lab report, on a sticky note jot the reasons why you placed that sample in that category. Place the sticky note on the lab report itself.
4. After you have completed sorting the lab reports into stacks, review the stack for each category and complete the attached form. At the top of each column, write the title of the categories that you created for your lab reports. So, you should have four column headings that are each named after one of your four category stacks. Underneath each category, identify and synthesize the features of the corresponding lab reports (the lab reports you placed in each category).

5. Have the completed form along with the lab reports ready (in their categories) so that we may copy them.
References


Glynn, S. M. & Muth, K. D. (1994). Reading and writing to learn science: Achieving scientific


Miller, (Eds.), *Teachers caught in the action: Professional development that matters*, (pp. 23-44). New York, NY: Teachers College Press.


of practice-based scientific literacy. *Journal of research in Science Teaching, 41*(3), 234-266.


