

CALIFORNIA STATE UNIVERISTY, NORTHRIDGE

The Impact of Professional Development on Teachers' Perceptions
and Practices Regarding Inquiry-Based Science

A Dissertation submitted in partial fulfillment of the requirements For the Doctor of
Education Degree in Educational Leadership

by

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Table of Contents

| | |
|---|-----|
| Signature Page | iii |
| Acknowledgement | iv |
| List of Tables | vii |
| List of Figures | ix |
| Abstract | x |
| Chapter 1: Introduction | 1 |
| Problem Statement | 6 |
| Purpose | 7 |
| Significance | 8 |
| Research Questions | 9 |
| Conceptual Framework | 9 |
| Overview of Methodology | 12 |
| Limitations and Delimitations | 12 |
| Organization of the Dissertation | 13 |
| Definition of Terms | 14 |
| Chapter 2: Literature Review | 18 |
| Professional Development | 18 |
| Traditional Professional Development | 22 |
| Reform Professional Development | 23 |
| Professional Development in Science Education | 29 |
| Professional Development for Science Education Reform Efforts | 35 |
| Computer Supported Collaborative Learning | 37 |

| | |
|--|-----|
| Summary | 42 |
| Chapter 3: Methodology | 43 |
| Research Tradition | 44 |
| Research Setting | 45 |
| Data Sources and Samples | 49 |
| Data Collection Instruments | 54 |
| Data Collection Procedures | 59 |
| Data Analysis | 63 |
| Researcher Roles | 66 |
| Chapter 4: Findings | 69 |
| Participants | 70 |
| Perceptions of Teaching Science | 71 |
| Practice of Teaching Science | 82 |
| Implementation of CSCS | 96 |
| Conclusion | 111 |
| Chapter 5: Discussions and Conclusions | 114 |
| Discussion | 115 |
| Perceptions | 116 |
| Practices | 119 |
| Implementation | 120 |
| Generalizability | 122 |
| Recommendations | 122 |
| Implications for Future Research | 126 |

| | |
|---------------------------------------|-----|
| Summary | 128 |
| References | 130 |
| Appendix A: Research Invitation | 143 |
| Appendix B: Informed Consent Form | 144 |
| Appendix C: CSCS Survey | 148 |
| Appendix D: CSCS Focus Group Protocol | 154 |
| Appendix E: CSCS Interview Protocol | 158 |
| Appendix F: Artifact Analysis Rubric | 162 |
| Appendix G: Codes | 164 |
| Appendix H: Participant Background | 166 |
| Appendix I: Lesson Artifacts | 168 |

List of Tables

| | |
|--|----|
| 1. A Comparison of WPD and IPD Models | 48 |
| 2. Enrollment in Workshop PD (WPD) | 53 |
| 3. Enrollment in Immersion PD (IPD) | 53 |
| 4. Backgrounds of Teacher Participants Directly Quoted | 70 |
| 5. First Year CSCS Teacher Perceptions | 72 |
| 6. IPD Teacher Perceptions | 75 |
| 7. WPD Teacher Perceptions | 78 |
| 8. Veteran CSCS Teacher Perceptions | 81 |
| 9. Artifact Analysis Results | 84 |

List of Figures

| | |
|--|-----|
| 1. Modified Framework | 11 |
| 2. Framework | 11 |
| 3. Elements of a Professional Development System | 19 |
| 4. Professional Development Components | 21 |
| 5. Frequency of Data Pooling and Graphing | 90 |
| 6. Frequency of Textbook and Worksheet Driven Activities | 93 |
| 7. Frequency of Data Analysis Activities | 93 |
| 8. CSCS Implementation Confidence Levels Post PD July 2013 | 98 |
| 9. CSCS Implementation Confidence Levels Post PD July 2014 | 99 |
| 10. CSCS Implementation Confidence Levels December 2013 | 100 |
| 11. CSCS Implementation Confidence Levels December 2014 | 100 |
| 12. Plans to Implement CSCS Post PD July 2014 | 101 |
| 13. Self-Reported CSCS Implementation by Type | 102 |
| 14. Average Self-Reported CSCS Implementation by Program | 104 |
| 15. CSCS Implementation vs Experience | 105 |
| 16. Average Self-Reported CSCS Implementation by District | 111 |

Abstract

The Impact of Professional Development on Teachers' Perceptions
and Practices Regarding Inquiry-Based Science

By

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Doctor of Education Degree in Educational Leadership

With California's adoption of the Next Generation Science Standards (NGSS), science teachers will need to shift from more traditional content driven curricula to an inquiry-based pedagogy. For many science teachers, this is a paradigm shift as inquiry-based teaching is typically not the norm. The purpose of this mixed methods study is to examine the extent to which two innovative professional development (PD) programs impact secondary level science teachers' perceptions and practices regarding the implementation of inquiry-based science. Survey data was collected from both Immersion PD and Workshop PD participants over the course of three years. Further, focus groups were conducted with participants from both programs in the summer of 2014 along with follow up interviews and artifact analysis in the fall of 2014. Findings from this study suggest that innovative forms of PD, particularly those involving clinical teaching, as well as those that spanning multiple years, produce changes in teachers' thinking about and teaching of science.

Chapter 1: Introduction

Since the publication of *A Nation at Risk* in 1983, Americans have expressed concern over the quality of science and mathematics education in the United States (Fowler, 2008). In 2009, the Program for International Student Assessment (PISA) ranked the United States 17th in science and 25th in mathematics achievement internationally (Walker, 2010). Again, in 2012, PISA scores demonstrated stagnancy for the United States with rankings of 17th in science and 28th in mathematics (Kelly, Xie, Nord, Jenkins, Chan, and Katsberg, 2013). These rankings indicate that American students are not excelling in science and math on an international level. This causes critics to look unfavorably upon mathematics and science education in the United States when compared to other countries' academic achievement.

Not only are the nations' students performing poorly in science and mathematics as compared to their international counterparts, they are not pursuing academic degrees or careers in STEM (science, technology, engineering, and mathematics) related fields (Kelly, Xie, Nord, Jenkins, Chan, and Katsberg, 2013). For example, in the U.S., approximately one third of U.S. students' bachelor's degrees are awarded in the fields of science and engineering. At the same time, over half of international students attending American universities graduate with such degrees (National Science Board, 2008). Estimates indicate the U.S. will have over 1.2 million unfilled jobs in science, technology, engineering, and math by 2018 (Bertram, 2012). Given this deficit of American students' ability and desire to pursue STEM careers, paired with the large projection of unfilled jobs, the American education system needs to reevaluate its

approach to STEM education in order to remain academically and economically competitive (Bertram, 2012; National Science Board, 2008).

In response to this deficiency, the National Research Council (NRC), the National Science Teachers Association (NSTA) and the American Association for the Advancement of Science (AAAS) have worked together to put forth a new standards document, known as the Next Generation Science Standards (NGSS), in an attempt to reform science education in the United States (Willard, Pratt, & Workosky, 2012). In 2012, 26 states began the process of reviewing the Next Generation Science Standards (NGSS) (Willard et al., 2012). The NGSS represent a national set of internationally benchmarked learning goals for K-12 science which include: a) clearly delineated science and engineering practices, b) core disciplinary ideas and c) crosscutting concepts (Willard et al., 2012). Over the coming years, several states, including California, intend to adopt the NGSS in conjunction with The Common Core State Standards (CCSS). The shift toward NGSS and CCSS represents a shift not only in instruction, but also in student academic assessment. Many states will be moving away from the traditional multiple choice assessments geared towards science vocabulary and isolated facts and will instead begin to evaluate students based on their understanding and implementation of inquiry as early as the middle school grade levels (Johnson & Marx, 2009).

On the local level, multiple U.S. schools and districts have also attempted to ameliorate the existing shortcoming in STEM student achievement and account for the instructional shifts set forth by NGSS by instituting professional development (PD) targeted at improving STEM education designed to promote inquiry-based science instruction (de Vries, van Keulen, & Peters, 2011; Grigg, Kelly & Borman 2012;

Hammrich, 1997; Johnson & Marx, 2009). Professional development, or PD, is defined as activities in which teachers take on the role of learners in order to gain skills and knowledge to enhance their teaching practices (Guskey, 2009; Guskey 2002; Guskey 2010). When delivered effectively, PD is one of the keys to improving instructional practice and in turn, teacher quality (Borko, 2004; Guskey, 2009; Guskey 2002; Guskey 2010). Despite the known benefits of effective PD, school districts spend relatively little on professional development programs. California school districts receive, on average, \$5,129 per student. Of this, far less than 1% (only \$24 per student) is spent on professional development (Loeb, Grissom & Strunk 2007). As a result of this lack of spending, PD programs are often under supported as districts frequently lack the infrastructure to implement and support ongoing, successful, professional development.

Historically, school districts elect to spend their allotted PD funds on traditional professional development (Whitby, 2012; Mathews, 2012). Traditional PD typically consists of one time workshops or presentations delivered to teachers. This traditional approach has resulted in limited overall effectiveness, as teachers tend to work in isolation and have few opportunities to practice new skills (Richmond & Manokore, 2011). Given the traditional approach to PD, combined with an under supported infrastructure for such programs, using professional development to implement programs intended to improve teachers' content knowledge and pedagogical skills generally does not allow teachers to be successful.

In addition to the research detailing ineffective PD programs, there is also recent research identifying practices associated with effective PD (Guskey & Sparks, 1996; Guskey, 2009). According to Lowden (2006), effective PD is job-embedded, meaning

that participants take part in the PD in the context of their job, rather than in an outside or stand-alone program. Musanti and Pence (2010) define effective PD as activities that take place within the context of learning communities where participants interact through collaboration. Multiple studies cite effective PD as that which is ongoing, lasting over multiple sessions, and providing ample follow-up opportunities for participants (Borko, 2004; Guskey, 2009; Lowden, 2006). The existing studies on effective PD, however, fail to provide specifics as to how often and how frequently initial and follow-up sessions ought to occur to ensure optimal results. Further, few studies have investigated the job-embedded nature of clinical teaching as a form of PD for in-service teachers (Musanti and Pence, 2010).

Hallmarks of successful science specific PD have also been identified. Since 1993, many who deliver science PD have been shaping inquiry-based training around the American Association for the Advancement of Science's (AAAS) Project 2061 Framework (Hamrich, 1997). Project 2061 set the bar for science educators' approach to science as a skills based, inquiry driven discipline (Hamrich, 1997). This seminal movement cites the importance of incorporating scientific inquiry for the understanding of the nature of science. The specific set of tenets or beliefs is centered on adopting the understanding of science as experiential and tentative, into science teacher preparation programs (Aldridge, Taylor & Chen, 1997; Bell, Matkins, & Gansneder, 2011).

According to Bybee (2002), scientific inquiry can be defined as instructional practices "such as observation and experiments that result in empirical evidence about the natural world" (p. 26). Further, Bybee discusses the common public and often instructional misconception that science is a neat and tidy process that can be completed

in a linear fashion, following a predetermined sequence of steps. Instead, he argues that the scientific enterprise is a complex, often messy undertaking. Given the ambiguous nature of inquiry, full implementation is often challenging (Grigg, Kelly, Gamoran, & Borman, 2012). At the same time, Bybee insists that students of science, regardless of age, engage in scientific inquiry. This position is corroborated by the Project 2061 Framework, which supports the practice of having “students themselves participate in scientific investigations that progressively approximate good science” (Benchmarks for science literacy, 1993, p.9). The framework argues that engagement in true scientific inquiry is the key to students’ ability to genuinely understand and apply scientific concepts. Given the importance of inquiry in science education, PD that incorporates strategies for inquiry-based science teaching will be necessary for improving the state of science education in the United States.

A bulk of the research examining professional learning targeted at inquiry-based science instruction has focused on pre-service teacher preparation programs and teachers working at the elementary level (Bell et al., 2010; Demir & Abel, 2010; Grigg et al., 2012). Bell et al. (2010) found exposing pre-service teachers to explicit discussions regarding the nature of science made significant gains in their own understanding of science. The work of Demir & Abel (2010) showed that pre-service science teachers in teacher preparation programs often held partial views of inquiry. Similarly, Grigg et al. (2012) studied in-service elementary school teachers and found that these individuals often implemented inquiry-based curriculum incompletely. These studies demonstrate both the importance of inquiry-based lessons as well as highlight the challenges associated with this type of curriculum. Based on these findings, this study seeks to

examine the role of clinical teaching as one piece of effective PD delivery specific to inquiry driven, secondary science instruction.

Problem Statement

With the adoption of the Next Generation Science Standards (NGSS), science teachers will need to shift from more traditional content driven curricula to an inquiry-based pedagogy. For many science teachers, this is a paradigm shift as inquiry-based teaching is typically not the norm. Rather, a more traditional approach to science teaching would typically include curricula driven by a textbook or worksheet. Additionally, traditional science teaching might also include hands-on activities that have a predetermined outcome where students verify a solution, rather than inquiry-based investigations where students need to discover a possible explanation (Bybee, 2002). Given this shift, science teachers need to be provided with effective professional development that will result in lasting changes in instructional practices.

The problem of implementing lasting and effective PD is especially prevalent in the early secondary sciences. At these foundational grade levels, only one in ten middle school science teachers have a science degree and often teach outside of their degree area (Koebler, 2011; Wheeler, 2007). This lack of experience with content knowledge creates an additional layer of complexity for such individuals. Due to the skills-based nature of scientific disciplines, effective science PD must focus on the skills of questioning, analyzing data, and communicating findings (Grigg et al., 2012). Individuals teaching these subjects without first-hand knowledge of scientific disciplines, typically obtained through an undergraduate education in the field, may lack an understanding of the fundamental importance of data analysis (Wheeler, 2007).

In order to effectively align instructional practices of these science teachers with the NGSS, schools and districts need access to effective professional development that will yield lasting results. While existing research establishes effective PD as job embedded, ongoing, and collaborative, the specifics of employing clinical teaching as a means to deliver professional development to in-service teachers has yet to be determined (Borko, 2004; Guskey, 2009; Lowden, 2006; Musanti & Pence, 2010).

Statement of Purpose

The purpose of this comparative mixed methods study was to examine the extent to which two innovative professional development programs impact secondary level science teachers' perceptions and practices regarding the implementation of inquiry-based science. In order to better understand the merits of each PD delivery method, the outcomes of these two particular professional development programs were compared. Both programs are different from traditional PD in that they involve clinical teaching, a hands-on type of professional development in which participants practice newly learned skills immediately in a clinical setting.

While clinical teaching is most often associated with the student teaching process, in which a veteran teacher mentors a new teacher in a classroom setting, this study investigates the underexplored application of clinical teaching as a means of professional development for in-service teachers (Grossman, 2010). Clinical teaching for in-service teachers is centered on the idea that teachers improve their practice by relying on their colleagues for "mutual assistance" (Darling-Hammond, 1998, p.1). This study employs clinical teaching for in-service teachers in two different summer professional development settings.

The clinical setting used in these two programs was a summer school class. One program focused heavily on clinical teaching by allowing participants to partake in this activity on a daily basis whereas the second program had a smaller clinical teaching component. This program also emphasizes collaboration and reflection through daily planning time. The second program allows for participants to spend a greater amount of time planning and refining lessons in teams. Participants in this program also receive a greater amount direct instruction from the PD providers in the form of a workshop.

Examining these two PD methods yields evidence that both supports the use of clinical teaching as a form of PD and suggests how clinical teaching can most effectively and efficiently be implemented in a professional learning environment. Findings from this study will be used to inform future professional development design in order to address the continuing need for high quality professional development to assist schools and science teachers in preparing for NGSS implementation.

Study Significance

Determining effective models of clinical professional development for secondary science teachers will aid educational institutions, both locally and nationally. Utilization of effective job-embedded, clinical professional development will ensure that schools and districts reap the benefits of their investments in PD, both financially and in terms of human resources. At the school level, implementation of effective professional development will yield improved outcomes for both teachers as well as their students. Additionally, successful implementation of the NGSS, along with a shift toward inquiry-driven instruction, will improve science instruction on the local and national levels.

Research Questions

The research questions for this study compare two professional development programs that both use clinical teaching as a form of PD. These programs were compared based on the impact that each program has on the participants' ideology around inquiry-based science practices as well as their pedagogy as it relates to inquiry-based science. Finally, the study also compared the manner in which participants implement the specific skills practices in the PD.

The research questions that guided this study are:

What impact do two specific professional development (PD) delivery methods have on teachers' perceptions and practices related to inquiry-based science?

- How do the different PD delivery methods in the two programs in the study impact teacher perceptions regarding inquiry-based science?
- In what ways do these different programs impact teachers' classroom practice as it relates to inquiry-based science?
- To what extent do participants from either program differ in their implementation of the CSCS data collection and analysis skills learned in the PD?

Conceptual Framework

This study utilizes a framework built upon research depicting the interactions between the various factors that contribute to successful PD outcomes. Specifically, the conceptual framework in this study provides a theoretical lens through which to investigate the impact of various components of PD programs on the outcomes of teacher knowledge and practice. The framework for this study draws on an existing framework developed by Guskey and Sparks (1996), whose work is explored in greater depth in the

review of the literature. According to Guskey and Sparks' framework, the relationship between professional development and student learning outcomes is intricate as it is influenced by multiple external factors. Given the potential for these confounding variables, studying student learning outcomes is beyond the scope of this study. Instead, this study will focus on three input components (content characteristics, process variables, and context variables) that contribute to the quality of a professional development program as well as the resultant change in the perceptions and practices of teacher participants.

Guskey and Sparks (1996) cite three major components as having the ability to affect the quality of a professional development program: content characteristics, process variables, and context variables. Content characteristics, account for the new skills, both content and process based, that teachers will acquire through completion of the PD. Process variables represent the planning and organization that goes into orchestrating the PD activities, the learning activities themselves, and how these learning activities impact participant perceptions. The context component accounts for the environment, both physical and otherwise, in which teacher learning occurs.

This study employed a modified version of the framework presented by Guskey and Sparks (1996) as a lens for examining professional development as shown in Figure 1. This study examined the process factors and context components in a manner similar to that put forth by Guskey and Sparks. Further, the output factors of teacher perception, teacher practice, and implementation of the specific skill presented in the PD were measured.

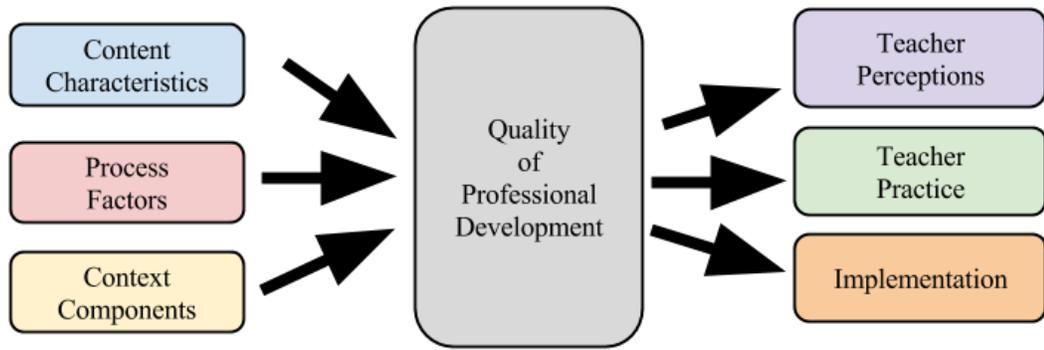


Figure 1. Modified Framework based on the work of Guskey & Sparks (1996).

In order to assess the differences between these two programs, the framework in Figure 1 was repeated twice to represent each program. Figure 2 shows the framework for this study. As seen in Figure 2, the content characteristics, process factors, and context components of two different programs were analyzed. Further, the resulting teacher perceptions, practices, and implementation were measured and compared.

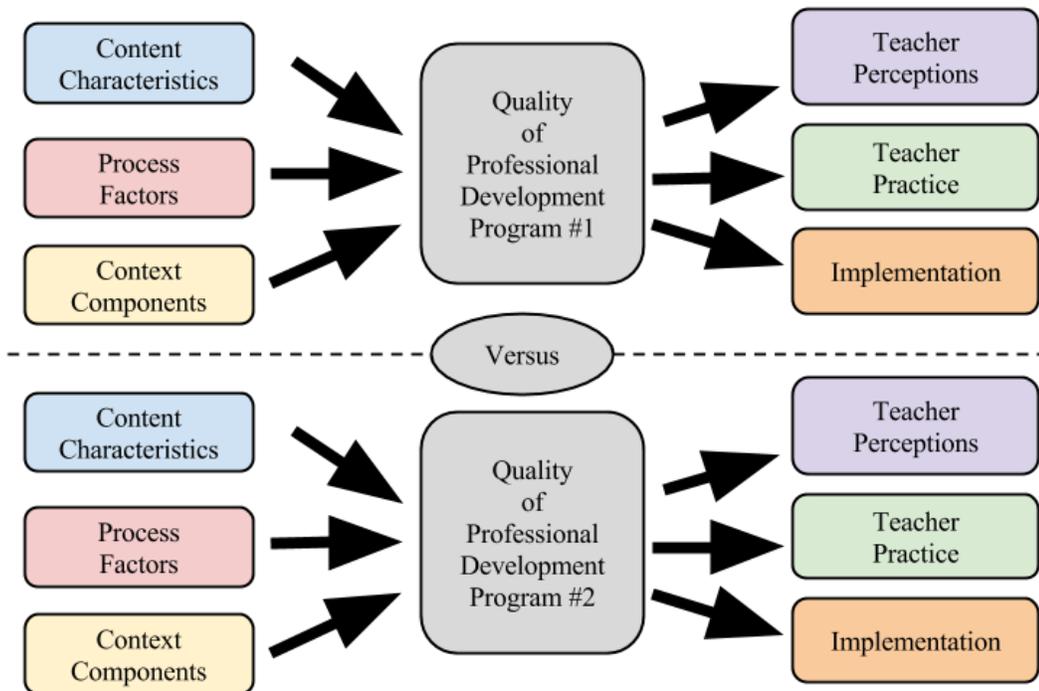


Figure 2. Framework. This figure presents the framework used in this study.

Overview of Methodology

Participants are teachers selected from two professional development programs run by a large public university in the southwestern United States. This mixed methods comparative study drew from the convergent parallel design (Creswell, 2012). Data was collected through a survey that was administered in a pre, post and delayed post fashion spanning three years, 2012, 2013 and 2014. During the third year of the study, 2014, participants took part in focus groups and interviews. Additionally, artifacts of classroom practice, including lesson plans, generated by the participants were collected and analyzed using a rubric. Quantitative data from the survey and the rubric were analyzed using descriptive statistics through SPSS and displayed graphically. Qualitative data from transcripts and lesson plans were coded thematically and analyzed using Dedoose, a computer assisted qualitative data analysis software. Both quantitative and qualitative data is reported using the framework for this study. A further description of this study's methodology will be presented in chapter three.

Limitations and Delimitations

One delimitation of this study lies in the fact that the participants in the professional development programs self-selected and chose to participate in these programs as well as to remain in the programs for the duration of the study. Additionally, participants self-selected the program in which they were enrolled in 2012 and 2013. In 2014, participants were randomly assigned to either of the two programs after voluntarily signing up for either program. Given this, the findings may not be applicable to all teachers, regardless of their willingness to participate in professional development. Further, this study examined the experiences of secondary science teachers and their

perceptions and practices regarding inquiry-based science teaching. Due to the specific nature of inquiry-based teaching practices, it is unlikely that the findings from this study will be generalizable to other disciplines. It is also beyond the scope of this study to measure the impact that either of these programs have on student learning. While it is expected that such a connection exists, additional research including the collection of longitudinal student data would be needed to establish correlation or causation of such connections.

A limitation of this study comes from the fact that data collected via survey was self-reported on the part of participants. This may have led to inflation on the part of the participant if they felt pressure to report particular behaviors. The programs included in this study involved a specific pedagogy, which were heavily reliant on technology. Further, both of these programs attracted individuals interested in this type of PD. As a result of the specific nature of the programs included in the study, results from this study will likely not be generalizable to a wide population.

Organization of the Dissertation

This introductory chapter serves to set the stage for this study by establishing the need for research regarding professional development for secondary science teachers. Chapter two, the review of the literature begins with the broad topic of professional development, and then goes on to examine traditional and reform efforts at professional development. Next, the review looks specifically at professional development as it relates to science education. Finally, the second chapter examines recent reforms in science education as well as how these efforts contribute to the need for increased and effective professional development. Following a review of the literature, chapter three

provides a description of the methodology used in data collection. The third chapter describes the setting and the participants in this study as well as the tools to be used to collect and analyze data. Chapter four reports on the findings of the study. Finally, chapter five discusses the findings of the study, drawing conclusions related to the research questions, and suggests areas for further research.

Definition of Terms

The following terms are used both in the broader discussion of professional development in science education as well as in presenting specific elements of the PD programs examined in this study.

1. **Professional Development (PD)** - Activities in which teachers take on the role of learners in order to gain skills and knowledge to enhance their craft. When delivered effectively, PD is the key to improving instructional practice and in turn, teacher quality across the board (Borko, 2004; Guskey 2002; Guskey, 2009; Guskey 2010).
2. **Clinical Teaching-** Hands-on teaching practice in a setting that closely mirrors the actual educational environment of classroom teaching, typically seen in student teaching. (Darling-Hammond, 1998; Grossman, 2010).
3. **Responsive Teaching Cycle (RTC)** - A collaborative pedagogical strategy in which teachers experiment with a teaching strategy, reflect on its effectiveness via examination of student work and consultation with colleagues, and then proceed to reteach or correct as necessary (Cheng, 2010; Whitin, Mills, & O’Keefe, 1990).
4. **Inquiry-Based Science-** A practice of teaching science set forth by the National Research Council and enumerated in the National Science Education Standards to

include five specific features. Specially, inquiry-based science will prompt students to 1. Engage in scientifically oriented questions 2. Give priority to evidence in answering questions 3. Formulate explanations from evidence 4. Connect explanations to scientific knowledge and 5. Communicate and justify explanations (Grigg, Kelly, Gamoran & Borman, 2012; NRC, 2000).

5. **Next Generation Science Standards (NGSS)**- A set of national standards developed by 26 states specific to K-12 science instruction. The NGSS are based on the National Research Council's Framework for Science Education and are organized by both content and performance expectations for students in these grades (Willard, Pratt, & Workosky, 2012).
6. **NGSS Science and Engineering Practices**- These eight skills enumerated in the NGSS document compose Domain 1 of the standards. These skills represent the performance expectation for students engaging in STEM fields. The NGSS Science and Engineering practices are: 1. Asking questions (for science) and defining problems (for engineering) 2. Developing and using models 3. Planning and carrying out investigations 4. Analyzing and interpreting data 5. Using mathematics and computational thinking 6. Constructing explanations (for science) and designing solutions (for engineering) 7. Engaging in argument from evidence and 8. Obtaining, evaluating, and communicating information (NGSS Lead States, 2013).
7. **Common Core State Standards (CCSS)**- A set of standards adopted by 45 states in 2012 intended to ensure college and career readiness by promoting critical

thinking and literacy skills across the curriculum (Calkins, Ehrenworth, & Lehman, 2012).

8. **Computer Supported Collaborative Learning (CSCL)**- A pedagogy that integrates technology into classrooms with the intention of building a collaborative, student-centered environment that values problem solving (Stahl, 2002).
9. **Computer Supported Collaborative Science (CSCS)**- Based on work done in the field of CSL (Computer Supported Learning), CSCS is an effort to adapt the work of CSL to a secondary science class, typically with the motive of supporting collaborative data collection and analysis for students (Herr & Rivas, 2012; Jeong & Hmelo-Silver, 2010).

Chapter 2: Literature Review

The review of the literature begins by examining the field of professional development (PD). Citations from major contributors to the field, Borko (2004), Darling-Hammond (1999) and Guskey (2002; 2009; 2010), will be used to establish the urgency related to continuing to study professional development. Next, traditional models of professional development are compared with reform efforts, specifically approaches including clinical teaching and the responsive teaching cycle. This section defines and provides examples of different models of PD. The review of literature then narrows in scope to explore professional development as it relates to science education. In particular, studies are delineated according to the level of the participants, pre-service, elementary, and secondary. The review of the literature also connects to education reform by looking at trends in science education reform, including an overview of Common Core State Standards (CCSS) and an in depth analysis of the Next Generation Science Standards (NGSS). Finally, this chapter concludes with a review of studies related to Computer Supported Collaborative Learning (CSCL), as well as an analysis of how this pedagogy applies to science classrooms and the role it plays in science education reform. Computer Supported Collaborative Science (CSCS) is examined as a viable pedagogy to support the implementation of NGSS. This organization will provide the reader with an overview of PD, and then move to specific examples. Further, the review of the literature connects academic research to education reform in a way that validates the need to study PD specific to science education.

The literature reviewed in this chapter was primarily accessed through the library system at California State University. During the preliminary stages of research, the

EBSCO databases ERIC and Academic Search Premier were utilized. Further research was conducted using frequently occurring authors and the following key word searches: a) professional development, b) science professional development, c) secondary science teachers, d) elementary science teachers, e) science curriculum, f) clinical teaching, g) computer supported collaborative learning, h) computer supported collaborative science and i) responsive teaching cycle. Lastly, authors provided links to additional resources specific to RTC and CSCS.

Problem Statement

As outlined in Chapter one, the adoption of the Next Generation Science Standards (NGSS) marks one of the latest efforts in America's desire to improve STEM education. Given the nature of the shifts in instructional practices inherent in implementing these new standards, effective professional development specific to secondary science teachers is in more demand than ever. Further, effective PD for science teachers will encourage participants to make the transition from a traditional text-based, verification driven approach to one that is skills based, includes data analysis, and encourages exploration through inquiry.

Review of the Literature

Professional Development

Professional development (PD) is defined as activities in which in-service teachers take on the role of learners to enhance their skill as educators. Professional development has long played a role in education reform. Historically, PD has been relied upon to improve teaching, implement curriculum, as well as a response to national level education reform, all with the ultimate goal of improving student learning outcomes

(Guskey, 2009). According to Guskey (2009), “no improvement effort in the history of schools has ever succeeded without thoughtfully planned and well implemented professional development activities designed to enhance educators’ skills and knowledge” (p. 226). Further, Borko (2004) explained that professional development consists of not only the professional development program itself, but also the teachers, who take on the role of learners, the facilitator, who guides the learning of the teachers, and the context in which the learning takes place. This relationship is presented visually in Figure 3.

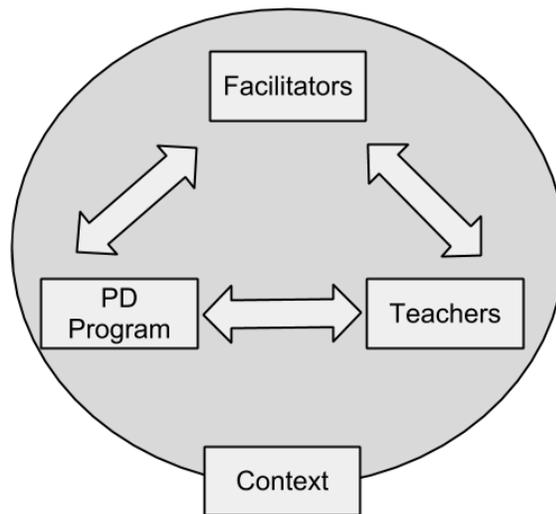


Figure 3. Elements of a Professional Development System. This figure shows the inter-reliance that various professional development have on the system at large (Borko, 2004, p. 4).

According to Borko (2004), the relationship between facilitators, teachers, and even the PD program itself are all interrelated. Further, this interrelationship occurs within the greater context of all three components. Thus, many factors, all of which are dependent upon each other, contribute to the degree to which the PD eventually succeeds.

Given this, the study of PD itself is a complex process. Ultimately, professional development programs and their potential impact on student learning should not be thought of in an oversimplified manner.

Professional development programs vary greatly from one school district or school site to another (Garet, Porter, Desimone, Birman, & Yoon, 2001; Guskey & Sparks, 1996). Not only do PD programs vary in terms of enrollment, duration, and funding, most notably, they vary in terms of PD dissemination models. Variables related to PD programs themselves often complicate how successful implementation is measured and tracked. Furthermore, results from PD programs can also be difficult to interpret as they are often confounded by a number of different external factors, including multiple, simultaneous reform efforts (Guskey, 2002). In response to the complexity and challenges presented by studying and evaluating professional development programs, Guskey (2010) presented the diagram shown in Figure 4. This model, originally constructed by Guskey and Sparks (1996), emphasizes not only the complexities of such PD systems, but the impact that three components have on the quality of professional development programs: content characteristics, process variables, and content variables.

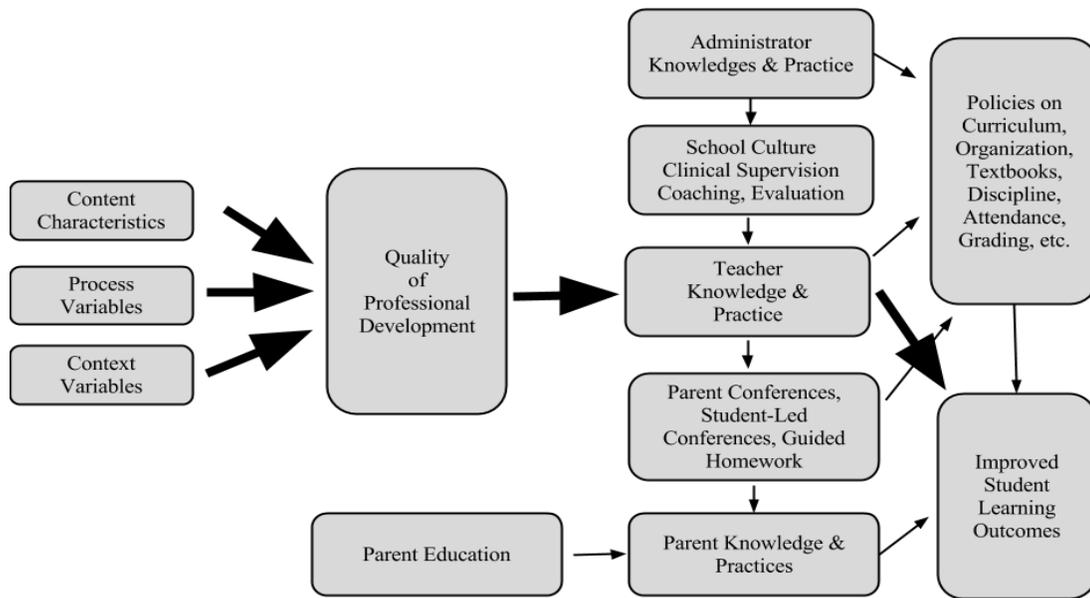


Figure 4. Professional Development Components. This figure depicts Guskey and Sparks’ model of the relationship between professional development and improvements in student learning outcomes. Note: The thickness of the arrows is indicative of the strength of causation of each factor on the next (Guskey, 2010, p. 73).

In examining how different types of PD are delivered, two categories of PD emerge, traditional and reform (Guskey, 2002). Traditional PD is typically provided in a mandatory decree by a school or district. This type of PD is usually delivered in a workshop or conference during a one-time event and does not provide follow-up. Conversely, reform PD is professional development marked by collaborative, ongoing, job-embedded learning opportunities. Reform PD requires teachers to work together and usually incorporates some level of choice on the part of participants, especially in terms of what will be learned as well as how it will be learned. This study focused on a comparison of two professional development programs. Both of these programs have

characteristics consistent with transformation PD in that they include collaboration and mentoring among teachers, as well as clinical teaching on the part of participants.

Traditional Professional Development

Historically, school districts have elected to spend their allotted PD funds on traditional professional development including one time trainings and lecture style content delivery (Desimone, Porter, Garet, Suk Yoon, & Birman, 2002; Garet et al., 2001; Musanti & Pence, 2010). The ineffective nature of “the short term transmission model [which] is still the dominant approach to in-service professional development” (Musanti & Pence, 2010) has left teachers referring to this approach as “sit and get,” “drive-by” or even “spray and pray” PD (Walker, 2013, p. 37). While these pejoratives may appear humorous, they shed light on a majority of teachers’ true perceptions and experiences with regard to professional development. This traditional approach has proven to be ineffective as it tends to require that teachers work in isolation while providing teachers with few opportunities to practice new skills (Richmond & Manokore, 2011; Whitby, 2012).

According to a three year longitudinal study conducted by Musanti and Pence (2010), participants accustomed to traditional professional development are often “constrained by the belief that professional development is meant to fix teachers, to provide them with knowledge that they don’t have, and that professional development is difficult because teachers are reluctant to change” (p. 4). This study demonstrates how a deficit thinking model, or the assumption that PD participants need to be fundamentally changed in order to be successful, can prevent positive interactions and serve as a barrier to effective PD. The qualitative data collected from this study was corroborated by the

longitudinal survey data collected by Desimone et al. (2002) which found that traditional approaches to PD are often limited to specific activities in which information is directly presented to participants, primarily conferences and courses. Even when PD approaches include workshops or hands-on lessons, they are often ineffective as they tend to be short term and lack follow-up (Penuel, Fishman, Gallagher, Korbak, & Lopez-Prado, 2009).

Traditional PD has been found to be ineffective as its short term nature does not allow teachers the opportunity to revisit their practice as they seek to implement these new skills (Musanti & Pence, 2010). The direct presentation style of traditional PD limits participants' voice and choice, thus reducing implementation rates as traditional PD becomes an activity that is viewed as top-down or mandatory (Walker, 2013). The deficit thinking associated with traditional PD, as exemplified by Musanti & Pence (2010), causes traditional PD participants to resist changing their practice. Ultimately, all of these factors combined lead to the ineffective nature of traditional PD. It is no wonder that teachers, experienced professionals who have worked in their field for years, often resist the term and the activities associated with professional development. As such, using professional development to implement programs intended to improve teachers' content knowledge and pedagogical skills is an ongoing challenge.

Reform Professional Development

Despite these negative findings related to traditional methods of professional development, there is also existing research that both establishes effective PD as necessary and demonstrates that there are components characteristic of non-traditional PD that have a positive impact on teacher behaviors (Desimone, et al., 2002; Grigg, Kelly, Gamoran, Borman, 2012; Guskey, 2009). Reform PD, or non-traditional

professional development, these effective types of PD are marked by teacher input and collaboration, are integrated into the work day and typically span a long period of time (Garet et al., 2001; Guskey, 2002). Based on these findings, it can be concluded that PD that which is embedded in the teachers' daily work and allows teachers to work in concert while still maintaining some element of personal choice will be most successful. Such PD efforts will not only produce positive results in terms of teachers' practices; they will likely be sustainable as teachers act as willing participants. Garet, Porter, Desimone, Birman, and Yoon (2001) examined a national sample of survey responses from teachers engaged in various types of PD. Findings from this study promote the inclusion of content knowledge as well as connections to current reform efforts in reform PD efforts, as these factors, when combined with increased contact hours over a long period time, strongly benefit participants. According to Garet et al. (2001),

[O]ur results indicate that professional development that focuses on academic subject matter (content), gives teachers opportunities for hands-on work (active learning), and is integrated into the daily life of school (coherence) is more likely to produce enhances knowledge and skills (p. 935).

Further, Garet et al.'s finding showed that enhanced knowledge was linked to teachers' reporting a change in teaching practices.

These findings are also consistent with Johnson and Marx's (2009) claim that it is necessary to "abandon existing frameworks for professional development, which are typically prescriptive and developed without involving practicing teachers from participating schools" (p.130). Instead of relying on more traditional approaches, they recommended that PD provide teachers with opportunities that are job-embedded,

meaning that the professional development takes place within the context of the participants' jobs, rather than as a standalone event. Lowden (2006) add that PD ought to be ongoing, and therefore, more meaningful to participants.

Despite the abundance of research opposing traditional models of professional development, few studies have been conducted regarding the successful implementation of long standing, reform professional development models. This study tracked and compared different degrees of reform models of PD over multiple years in order to shed light on the initial challenges as well as strategies used to mitigate these challenges over time.

Clinical Teaching. Clinical teaching is defined as supervised practice in a school setting through which participants are able to combine academic knowledge with practitioner skills thus learning in a hands-on matter (NCATE, 2010). During clinical teaching, pre-service participating teachers receive feedback on their teaching from experienced teachers. Typically, clinical teaching is most closely associated with the student teaching experience. Research suggests, however, that this clinical teaching is an effective means of molding sound instructional strategies and creating effective teachers (NCATE, 2010). According to Grossman (2010), "Despite the hands-on nature of teaching, practical skills are rarely addressed once an individual has passed the credentialing period" (p.3). However, clinical teaching can also serve as a powerful form of professional development for in-service teachers (Clift & Brady, 2005; Grossman, 2010).

Grossman (2010) highlights the use of Professional Development Schools (PDS), or sites specifically dedicated to providing clinical practice for both new and experienced

teachers. The PDS programs to which Grossman refers are based on university and school partnerships, allowing teachers to work side by side with professors. This collaborative relationship has been the solution to many of the logistical barriers to implementing clinical teaching at an independent school site, as the university faculty contributes to the supervision of the program (Grossman, 2010).

Alter and Coggshall (2009), also contend that applying theory to practice should extend beyond the preliminary credentialing phase, “because teaching, like any other clinical practice profession, is highly complex, teachers must receive regular, relevant professional development, ongoing opportunities to learn from their peers in communities of practice, and the opportunity to consistently reflect on and improve their own practice” (p. 7).

When using clinical teaching as a part of teacher training, teachers are able to practice new skills in a safe environment that closely mirrors their typical classroom setting yet remains low stakes (Alter & Coggshall, 2009; Darling-Hammond, 2006). Historically, this approach has been considered to be effective for pre-service teachers because it shortens the time between teachers’ acquisition of a new skill and the practice of this skill (Desimone, 2009; Penuel et al., 2007). Further, effective clinical teaching also allows for collegial support and feedback (Alter & Coggshall, 2009). These clinical teaching opportunities can also provide current teachers to practice job embedded skills in a supportive, collaborative environment are most successful when teacher participants dictate their own learning (Burke, 2013).

Franke, Carpenter, and Fennema (1998) found, in a study of effective PD, those teachers who were provided with multiple opportunities in which to practice new skills

experienced lasting, generative change in their teaching practice. Continued, hands-on practice can “bridge the gap between theory and practice” (Darling-Hammond, 1998, p.6), thus developing and maintaining successful teaching professionals. Further, given the dynamic nature of the teaching profession, a regular opportunity to refine skills in a clinical setting promotes professional learning (Hammerness, Darling-Hammond, Bransford, Berliner, Cochran-Smith, McDonald, & Zeichner, 2005). According to Desimone (2009), one of the essential components of successful PD is enabling the teacher to see that they are, in fact, able to implement a new way of teaching. Clinical teaching allows for this realization. Allowing teachers to see that are in fact, capable of having success with a new skill not only builds confidence, but it empowers and motivates participants to continue to implement this skill both in the clinical setting and beyond, to their own classrooms.

Clinical teaching plays an important role in this study as the frequency of and philosophy behind clinical teaching professional development experiences will be examined. Both professional development models under study employ some degree of clinical teaching in their delivery. Unlike the traditional use of clinical teaching, which typically targets pre-service teachers, the PD models included in this study examine the application of clinical teaching strategies with in-service teachers, an area that has not been previously explored in depth. One PD model will focus on clinical teaching while the other uses clinical teaching to supplement the direct instruction delivered to participants.

Responsive Teaching Cycle. The Responsive Teaching Cycle (RTC) is a form of collaborative inquiry in which teachers regularly reflect on their teaching and plan for

upcoming lessons (Cheng, Gainsburg, & Schlackman, 2013). Like clinical teaching, RTC incorporates actual classroom teaching into the professional development experience. Instead of an experienced teacher providing guidance for a new teacher, however, RTC supports collaboration and reflection among peers wherein multiple experienced teachers work together to improve their practice. In order to be successful, RTC participants would ideally take part in reflective planning sessions on a daily basis. RTC can also serve as a form of professional development in that it trains teachers to approach their lesson planning differently. One of the hallmarks of RTC is the collaborative planning of lessons based on immediate student needs as opposed to a textbook or pacing guide (Cheng, 2010).

The RTC model is supported by many of the findings related to effective professional development. In keeping with the findings of Burke (2013), like an effective clinical teaching model, RTC also provides its participating teachers with continuous feedback in a supportive environment. Additionally, a longitudinal study by Franke, Carpenter, Levi, and Fennema (2001), found that professional development efforts are most sustainable when teachers focus on the students' understanding rather than a particular instructional strategy. RTC enables this by keeping student learning at the forefront of reflective planning discussions. This philosophy is also reflected in the student driven nature of RTC. Further, planning time, a structure inherent in the RTC model, was found to be vital to the success of long term implementation resultant from PD (Penuel, Fishman, Yamaguchi, Gallagher, 2007).

A study tracking the use of RTC in student teachers found that pre-service teachers who partook in RTC were able to design engaging lessons that resulted in an

increase in student achievement, as measured by common periodic assessments, in classes where teachers used RTC as compared to the rest of the school (Cheng, 2010). Another study of RTC found that, when employed regularly and with fidelity, previously low performing students performed at a level that closed this achievement gap after a school year of RTC based instruction (Cheng et al., 2013). Both studies of RTC demonstrated that teachers partaking in this process were able to create classrooms that enabled low performing students not only to succeed, but to out-perform their peers who were not in classes where teachers took part in RTC. Despite this success, the time commitment, financial obligation, and institutional infrastructure required to make RTC an integral component of most schools is a barrier to implementation, making RTC an under implemented form of PD (Darling-Hammond, 1999).

The study of RTC is relevant to this study as one of the professional development models under investigation is based upon the RTC model investigated by Cheng et al. (2013). While the model in this study is not identical to that described above, daily reflective planning time and incorporation of student work are integral to the program.

Professional Development in Science Education

Professional development in the area of science education has presented its own set of unique challenges and demands. Given the specific pedagogy of inquiry-based instruction, combined with the amount of content knowledge required of science teachers, PD specific to science is often complex and difficult. PD in this field, however, is necessary to address the international disparity currently experienced by students in the U.S. as well as the socioeconomic disparity present in domestic urban schools (de Vires et al., 2011; Johnson & Marx, 2009). In order to better understand the distinctive nature

of PD as it relates to science education, one must first explore the concept of scientific inquiry, an idea that is challenging and counterintuitive to many teachers. When discussing science education, inquiry is the predominant focus of many PD efforts (Guskey & Sparks, 1996).

Further, challenges of science specific PD also need to be examined differently depending on the experience level and grade level of the teacher. Given the fact that beginning teachers and teachers of lower grade levels typically have less experience with teaching science, many studies focus on these populations (Bell, Matkins, & Gansneder, 2010; Grigg, et al., 2012; Hammrich, 1997; Richmond & Manokore, 2011; Rogers, Abell, Marra, Arbaugh, & Hutchins, 2010; Ucar & Sanalan, 2011). Finally, an understanding of the current climate of science education reform efforts is essential. All of these context variables are relevant to developing an understanding of the quality of science specific PD (Guskey & Sparks, 1996).

Inquiry. Inquiry-based science instruction is a practice of teaching science set forth by the National Research Council and enumerated in the National Science Education Standards to include five specific features. Specially, inquiry-based science will prompt students to 1. Engage in scientifically oriented questions 2. Give priority to evidence in answering questions 3. Formulate explanations from evidence 4. Connect explanations to scientific knowledge and 5. Communicate and justify explanations (Grigg, Kelly, Gamoran & Borman, 2012; NRC, 2000).

In developing an instrument used to gauge teachers' perceptions of school science, Aldridge, Taylor, and Chen (1997) found that such perceptions can be delineated along a spectrum ranging from the objectivist view explained as "science as a body of

knowledge which is unproblematic and representing the absolute truth” (p. 4) to the post-modern view in which the individual “recognizes the need to continuously examine and re-examine the viability of scientific knowledge” (p.4). This post-modern view is consistent with the set of practices referred to as inquiry (Grigg et al., 2012; de Vires et al., 2011). Science is typically unfamiliar territory to elementary school teachers as well as secondary science teachers who are teaching outside of their degree area. The complex concepts of the discipline can be overwhelming and intimidating. Due to the skills-based nature of the scientific disciplines, effective science PD can seek to improve instructional practices by focusing on the skills of questioning, analyzing data, and communicating findings (Grigg et al., 2012).

Pre-service Teachers. A phenomenological study conducted by Demir & Abell (2010) used qualitative methods to study new teachers’ perceptions of the meaning of inquiry. It was found that, upon entering the profession, these teachers held incomplete views of inquiry (Demir & Abell, 2010). A mixed methods study conducted by Bell et al. (2010) consisted of 75 pre-service teachers. This study also demonstrated that explicit instruction in inquiry-based teaching resulted in statistically significant gains in teacher perceptions of the nature of science in both embedded and stand-alone programs (Bell et al., 2010). The studies of Bell (2010) and Demir and Abell (2010) combined suggest that inquiry driven, science specific PD, when provided early on in a science teacher’s career, can positively impact their behaviors in the area of inquiry. This implementation of inquiry is typically an area of high need in terms of having potential for growth.

In Hammrich’s (1997) study, conducted as part of a microethnography, teacher credential candidates were interviewed to determine how these pre-service teachers

perceive national science reform efforts produced by American Association for the Advancement of Sciences (AAAS) and the National Resource Council (NCR). Using grounded theory as a method of analysis, Hammrich found that these pre-service teachers found the reform efforts to be “beneficial but very time consuming” (p. 10) and suggests that instructors remedy this by providing time for these teachers to develop curriculum and interact with the standards. Additionally, Hammrich discovered that, while her pre-service teachers appeared open to these reform efforts, “they clung to their prior conception of science when pressured with uncertainty in a teaching situation” (p. 5). This finding makes a strong case for claims made by de Vries et al. (2011) that teachers benefit from science specific PD in that it influences their perceptions and practices related to the implementation of inquiry.

Elementary School Teachers. Grigg, et al. (2012) conducted a three year large scale randomized trial studying the professional development programs offered to elementary science teachers at schools implementing two different science curricula, Immersion and FOSS. The PD for the immersion group was consisted of a two week long summer workshop whereas the FOSS group received a one day in-service training provided by the school district. Both of these approaches to PD can be identified as traditional and neither approach involved clinical practice. This study found that schools from the immersion program were 84% more likely to demonstrate inquiry during science lessons than those schools that did not participate in the Immersion PD (Grigg, et al, 2012). Further, it was found that both intervention treatments, Immersion and FOSS, had an impact on teaching practice resulting in an increase in the likelihood of observing scientific questioning (Grigg et al., 2012). The authors caution that, despite

extensive exposure, neither PD resulted in full implementation of the inquiry cycle, citing lack of time and limited teacher familiarity with the inquiry process as causes (Grigg et al, 2012).

Findings from this quantitative study mirror those of Brandt's (2012) in depth case study in which it was found that science teachers often struggle to implement new curricula as they tend to wrestle with concepts of power and identity. In another study of elementary science teachers using the same FOSS curriculum, findings were similar to those of Grigg et al. (2012). Pine, Aschbacher, Roth, Jones, McPhee, Martin, Phelps, Kyle, and Foley (2006) reported that teachers were likely not teaching the curriculum at an appropriate level of depth as student achievement demonstrated no difference when comparing students receiving the FOSS curriculum versus those receiving a textbook curriculum.

In a five year longitudinal study of elementary science teachers, Richmond & Manokore (2011) studied verbal discourse (teacher talk) during professional learning community (PLC) meetings in order to determine the components that are necessary to establish effective and sustainable PLCs. Specifically, the authors examined the experiences of first and fourth grade teachers taking part in a multi-year grant using a PLC model to support implementation of elementary science curriculum. According to Richmond and Manokore (2011), these key elements are teacher learning and collaboration, professional community, confidence in content knowledge, pedagogical content knowledge (PCK) and practices, accountability, and sustainability. Additionally, the authors found that, if the proper collaborative environment is built early on,

successful PLCs can be sustained after funding has expired as the individuals involved continue to work together (Richmond & Manokore, 2011).

In addition to creating a collaborative climate such as that seen with a PLC, Heller, Daehler, Wong, Shinohara, and Miratrux (2011) argue that science professional development that focuses on content alone will be insufficient. According to this large scale study encompassing over 270 teachers across six states, elementary science teachers benefit from professional development models that include strategies on how teachers can work together to analyze student thinking. It was these programs that had the most sustainable and positive outcomes on student learning.

Secondary Teachers. The problem of building pedagogical content knowledge (PCK) is especially prevalent in the early secondary sciences, given the fact that only one in ten middle school science teachers has a science degree and those who do often teach outside of their degree area (Koebler, 2011; Wheeler, 2006). In spite of this disparity, a majority of the research studies analyzing the impact of science professional development on teachers' practices have been conducted at the elementary and pre-service level (Grigg et al., 2012; Hammrich, 1997; Bell et al., 2010). As such, models of successful professional development for in-service secondary science teachers remain an under-explored area.

One such study, a mixed methods study by Johnson and Marx (2009), analyzed a model that they coined TPD (transformative professional development). This study examined an intensive (120 hours), school wide form of PD, implemented for science teachers in urban middle schools. The authors used a Local Systemic Change (LSC) rubric to evaluate school climate and teaching in the classrooms of participants as

compared to a control group of schools whose teachers did not receive TPD (Johnson & Marx, 2009). Results showed that seven out of eight teachers receiving the TPD treatment improved practice after year one as compared with only one teacher out of seven in the control group, who received no intervention (Johnson & Marx, 2009). Additionally, the authors cite professional relationships, similar to the PLCs described by Richmond and Manokore (2011) as the pertinent factor in the success of these teachers.

In an effort to address this gap in the research, this study will sample secondary science teachers, like Johnson and Marx (2009). The design of this study will follow the comparison model observed in the elementary science studies on inquiry-based practices seen in Grigg, et al. (2012).

Professional Development for Science Education Reform Efforts

Since 1993, those who deliver science PD have been shaping inquiry-based training around the American Association for the Advancement of Science's (AAAS) Project 2061 Framework (Hammrich, 1997). Project 2061 set the bar for science educators' approach to science as a skills based, inquiry driven discipline (Hammrich, 1997). In recent years, the new national standards known as the Common Core State Standards (CCSS) and then the Next Generation Science Standards (NGSS) (the discipline specific set of learning goals to support CCSS) have come to the forefront of educational reform.

Common Core State Standards. The Common Core State Standards (CCSS) are a set of national learning goals benchmarked against international standards with the intent of preparing students to be college and career ready (National Governors Association, 2010). This shift in instruction and assessment marks one of the largest

initiatives in education in recent history. It has been said that prior to CCSS, “no single document will have played a more influential role over what is taught in our schools (Calkins, Ehrenworth, & Lehman, 2009).

While the CCSS target mainly English Language Arts and Mathematics, the responsibility for literacy skills will fall to science teachers as well (Calkins et al., 2009). This will come at a cost for many districts whose science teachers have not been trained in writing. While CCSS is not a curricular plan that can be purchased, Calkins et al. (2009) remind us:

The only expense is that of providing teachers with the professional development and the teaching resources they need to become knowledgeable in this area, both of which are important, as this is an area where few teachers have had any training at all. (p. 16)

This shift further emphasizes the continued need for effective professional development in this country.

Next Generation Science Standards. Following the release of the Common Core State Standards, in 2012, 26 states began the process of reviewing the Next Generation Science Standards (NGSS) (Willard, Pratt, & Workosky, 2012). The NGSS represent a national level of science standards which include clearly delineated science and engineering practices, core disciplinary ideas and crosscutting concepts (Willard et al., 2012). Over the coming year, several states, including California, intend to adopt the NGSS.

The shift toward NGSS represents a shift in assessment, as many states will be moving away from the traditional multiple choice assessments geared at science

vocabulary and will begin to evaluate students based on their understanding and implementation of inquiry (Johnson & Marx, 2009). Further, students will be expected to demonstrate capacity in specific science and engineering practices, thus modeling the work typical to the scientific disciplines (Herman, 2009). Similar to CCSS, implementing NGSS will require a rethinking of pedagogical practices and represents an increased need for effective professional development. Additionally, both NGSS and CCSS will assess student learning using electronically delivered, computer adaptive testing, thus creating an imperative for effective use of technology in the classroom (Porter, McMaken, Hwang & Yang, 2011).

Both professional development programs in this study seek to assist teachers in incorporating the use of technology into their instruction. Given the shift in assessment methodology under both CCSS and NGSS, these technological skills will increase in relevancy. Thus, studying ways to successfully empower teachers to effectively use technology is a necessary endeavor.

Computer Supported Collaborative Learning

Computer Supported Collaborative Learning (CSCL) is a constructivist form of pedagogy that integrates technology and collaborative problem solving (Porcaro, 2011; Shell, Husman, & Turner, 2005). While much research regarding classroom application of CSCL has been conducted regarding the role of CSCL in math secondary level math classes (Mullins, Rummel, & Spada, 2011; Oner, 2008; Lazakidou & Retalis, 2010), CSCL has also been found effective when used with younger children to develop reading and writing skills (Lingnau, Hoppe, & Mannhaupt, 2003) all the way up through the

university level (Stahl, 2002). Therefore, this pedagogical approach also has applications for all levels of students in secondary science classes (Baker & Lund, 2007).

CSCL first came to forefront in the 1990s (Stahl, Koschmann, & Suthers, 2006). According to Porcaro (2011), “CSCL environments seek to provide students the opportunities to discuss and argue, and negotiate meaning together” (p.105). CSCL is not just integrating the use of technology into a classroom. “Whereas students may engage in solo work supported by technology such as learning from hypertexts and the Internet, computer-supported learning in schools often involves students working with others in groups in joint problem solving and collaborative inquiry on a shared task” (Chan, 2012, p. 63).

According to some of its earliest researchers, the roots of CSCL can be found in “communication between a team of learners” (Tomlinson & Henderson, 1995, p. 132). While opponents of technology often view integration of technology as a step toward isolation, CSCL promotes the exact opposite, a technologically mediated environment based on collaboration (Stahl et al., 2006). Given the collaborative and critical thinking integral to CSCL, this instructional model is a valid vehicle for delivery of both CCSS and NGSS based lessons.

Implementing CSCL. While CSCL has been found to be an effective means of engaging students and building their knowledge base (Rienties, Tempelaar, Bossche, Gijsselaers, & Segers, 2009; Shell, et al., 2005), its implementation also presents many challenges (Janssen & Bodemer, 2013; Urhahne, Schanze, Bell, Mansfield & Holmes, 2010). Despite the benefits to implementing CSCL, “there remains little evidence of widespread adoption of CSCL tools by practicing teachers” (Porcaro, 2011, p. 103). This

hesitancy to implement CSCL is most likely due to one of the most marked shifts in implementing CSCL, the changing role of the teacher.

Like inquiry, teaching with CSCL is often viewed as a nontraditional instructional method as it requires the “alteration of the teacher’s role from transmitter of information to facilitator of knowledge building” (Shell, et al., 2005, p. 330). According to Chai and Tan (2012), in order to implement CSCL effectively teachers need practical, hands on professional development in the areas of both technology and fostering collaboration. Specifically, “teachers should be provided with ample opportunities to collaborate and discuss critical issues with peers and researchers, experiment with the innovation that could involve technology, observe exemplary models, and reflect on pedagogical beliefs and teaching practices” (Chain & Tan, 20120, p. 1298). Given this, successful implementation of CSCL will require extensive and successful professional development efforts.

Computer Supported Collaborative Science. Computer Supported Collaborative Science (CSCS) is a form of CSCL developed by the College of Education faculty at California State University, Northridge (Herr & Rivas, 2010). Like CSCL, CSCS utilizes technology in order to create a collaborative learning environment. CSCS is unique in that it specifically employs the use of cloud-based technologies to foster inquiry based thinking in secondary science classrooms (Rivas & Herr, 2010).

The developers of CSCS posit that implementing these pedagogical practices will mirror a collaborative research based scientific community within a secondary classroom.

According to Rivas and Herr (2010),

The use of collaborative web-based documents to collect and analyze data, and to document and present findings, imitates the collaborative environment of a professional scientific community in which researchers develop hypotheses and explanations in light of their own findings and those of their colleagues (p.852).

Further, this is consistent with the goals of the wider science educational community as set forth by the National Research Council (Herr & Rivas, 2010).

CSCS and NGSS. The thought processes supported by CSCS are also consistent with those enumerated as science and engineering practices in the NGSS (Herman, 2009). One of the hallmarks of CSCS implementation is data pooling. The cloud based nature of the CSCS tools allows students to create large data bases across class periods, classrooms, and even across schools (d'Alessio & Vandergon, 2013; Herr, Rivas, Foley, Vandergon, & Simila, 2011). Students' ability to collect and analyze this type of data is explicitly mentioned in the science and engineering practices of NGSS.

Further, CSCS allows for collaboration and sharing of ideas through the use of continuous formative assessment (Herr & Tippens, 2013). With CSCS, students are able to share ideas in real time, thus allowing the instructor to address misconceptions immediately and on an as needed basis. Additionally, the real time exchange of ideas and data allows students to engage in data based argument as well as communication of their findings, both ideas central to the science and engineering practices of NGSS (d'Alessio & Horey, 2013; Rivas & Herr, 2010).

CSCS and teachers. Professional development for CSCS has been studied on a limited scale in both pre service elementary school teachers and in service secondary

science teachers (d'Alessio & Lundquist, 2013; Foley, Castillo, & Kelly, 2013). An experimental study conducted by d'Alessio and Lundquist (2013) compared the data analysis skills of pre-service elementary level teachers who had taken a CSCS based science course with those who did not. It was found that the constant data comparison provided by CSCS yielded more accurate responses when these pre-service teachers were asked to explain a new data set and corresponding graph when compared to pre-service teachers in a non CSCS classroom. The authors concluded, "After completing a semester of using frequent CSCS activities, even students with limited science background can see data as experts see it- subject to error" (d'Alessio & Lundquist, 2013, p.427). The findings of this study verified that, like Shell et al.'s (2005) work with CSCL, CSCS techniques can build a student's knowledge base in a way that traditional instruction typically does not.

In working with in-service secondary science teachers, Foley et al. (2013) found that clinical teaching paired with designated time for collaboration during a summer professional development lead to increased confidence related to CSCS implantation. Ultimately, however, limited technology and reduced opportunity for collaboration as the school site inhibited consistent implementation of CSCS during the school year (Foley, et al., 2013). The findings of this study are consistent with those of Chai and Tan (2012) in that both studies argue in favor of consistent, designated, and structured collaboration in order for teachers to be successful with sustained implementation of the CSCL.

The work presented in this study builds upon the earlier work of Foley et al. (2013) in that the same clinical teaching program will be explored. Additionally, this program will now be compared with another professional development program, both of

which seek to influence the successful implementation of inquiry-based science, through the use of CSCS, in secondary science classrooms.

Summary

The historical nature of traditional PD has painted PD as an ineffective expense to the education system. Despite this negative connotation associated with traditional PD, the field for reform PD is rich with success stories and is able to suggest approaches to PD that will improve instructional practices of its participants. Given this, transformation models of PD, particularly those that incorporate teacher collaboration and span over a long period of time, are necessary and effective in impacting classroom instructional practice. Models including clinical teaching and RTC prove promising directions to provide relevant, job embedded PD. Further, given the recent adoption of CCSS and NGSS, districts and schools will continue to seek effective professional development, specifically in the area of secondary science. Given the shift in instructional practices required by NGSS, CSCL is one pedagogical approach that can be used to deliver effective, inquiry based science instruction through the implementation of CSCS.

Chapter 3: Methodology

Purpose

The purpose of this mixed methods study is to examine the impact that professional development delivery method has on secondary level science teachers' perceptions and practices regarding the implementation of inquiry-based science. Teachers were sampled in order to compare two particular professional development programs, both of which possess similar characteristics in terms of content and participants yet, at the same time, represent two different delivery methods. This study provides evidence that supports the use of clinical teaching as an effective form of long term professional development for secondary science teachers. Findings from this study will be used to inform future professional development design in order to address the continuing need for high quality professional development for science teachers.

Research Questions

This study investigated the following research question as well as the three proceeding sub research questions.

What impact do two specific professional development (PD) delivery methods have on teachers' perceptions and practices related to inquiry-based science?

- How do the different PD delivery methods in the two programs in the study impact teacher perceptions regarding inquiry-based science?
- In what ways do these different programs impact teachers' classroom practice as it relates to inquiry-based science?
- To what extent do participants from either program differ in their implementation of the CSCS data collection and analysis skills learned in the PD?

Research Tradition

This study is a mixed methods study following convergent parallel design (Creswell, 2012). Quantitative data was collected through closed ended questions and frequency reporting in survey administration as well as through the use of rubric scores in artifact analysis. Further, in answering the research questions, qualitative data was collected through focus groups and interviews, as well as short answer questions within the survey.

Convergent Parallel Design

A hallmark of convergent parallel design is the simultaneous collection of both qualitative and quantitative data. Creswell (2012) explains the strengths of this design as follows,

One data collection form supplied strengths to offset the weaknesses of the other form, and that a more complete understanding of a research problem results from collecting both quantitative and qualitative data (p. 540).

As such, this study combines qualitative and quantitative data collection through closed and open ended survey questions, which are supported by focus group transcripts.

Further, interviews were paired with artifact analysis, as participants were asked to both talk through as well as submit lesson plans for scoring.

Research Setting

Demographics

This study takes place at Desert State University (DSU), a pseudonym for a large public university serving an urban center in the southwestern United States. DSU serves approximately 35,000 students through nine academic colleges and is part of a state university system with the largest teacher education program in the state. Additionally, DSU has multiple summer programs offering professional development to local in-service teachers. The two cases under investigation in this study are drawn from one of these programs, based in an institute focused on reforming science education.

A majority of teacher participants in both programs work in the nearby Southern School District (SSD), a pseudonym for the local, large urban school district. SSD serves over 400,000 students K-12, a majority of whom (75%) identify as Hispanic or Latino. Further, approximately one third of these students are classified as English Language Learners and over 80% are classified as Socioeconomically Disadvantaged (SED) (Accountability Progress Reporting, 2013).

History

DSU faculty members from the College of Education and the College of Science and Math have worked together for several years to provide professional development opportunities for local teachers. This group will be referred to as the Institute for Science Education (ISE).

In 2009, the faculty members of ISE began experimenting with cloud based technology and classroom applications, with the purpose of improving inquiry-based science instruction in local classrooms. In the summer of 2010, ISE offered their first

summer professional development workshop for teachers focused on using these tools. Based on the model of Computer Supported Collaborative Learning (CSCL), these workshops sought to teach secondary science teachers how to use these tools in their classrooms to promote inquiry among students. For the next four years, this group would continue to offer a two week long workshop each summer for new and returning teachers.

These initial PD efforts did not yield the rates of teacher implementation that the ISE team had hoped for. As a result, the ISE team began to implement clinical teaching into their professional development workshop program. In the spring of 2012, ISE was approached and asked to expand the reach of their methods by introducing a second program to the summer offerings. This program debuted in the summer of 2012. The structure of this program was different than the original workshop based model. This second group of teachers learned the same applications for cloud-based technology but did so by putting these skills into immediate practice during daily clinical teaching.

Professional Development Programs. In this study, two professional development programs, both of which include elements of clinical teaching as PD for in-service teachers, are studied in depth. The program that came into existence first will be referred to as Workshop Professional Development (WPD) and the recently developed program will be referred to as Immersion Professional Development (IPD). These pseudonyms reflect the diverse nature of these programs. Both programs last approximately two weeks in length, draw participants from the large, urban, local school district, focus on using cloud based technology to improve inquiry-based science instruction, and include a component of clinical teaching. The marked difference

between the two programs, however, lies in their delivery method and the extent to which each program utilizes clinical teaching as a PD method.

Workshop professional development (WPD). WPD, as its name suggests, is primarily a workshop based professional development program. This program fits with workshop model presented by Garet, Porter, Desimone, Birman, and Yoon (2001) in that it involves a leader who provides information to participants. WPD combines this workshop model with a brief clinical teaching experience. Under WPD, teachers take part in eight days of detailed training and experience with the tools of CSCS before requiring them to teach with. The PD includes hands-on science activities, training on technology, collaboratively designing a model lesson, clinical teaching of that lesson, observation of other teachers, lesson revisions, as well as a second clinical teaching of the same lesson to a new group of students. This clinical teaching experience utilizes summer school science enrichment classes for secondary school students that are taught at DSU. Teachers new to the workshop are paired up with returning teachers who participated in previous years in order to provide support. Project staff work closely with teachers during lesson design and then observe lessons so they can provide detailed feedback and facilitate reflection within the teacher teams. Each team teaches and reteaches one lesson over two days.

Immersion professional development (IPD). Conversely, IPD is based primarily on clinical teaching. Under this model, teacher participants begin the summer by attending a two day intensive training. Then, they teach on a daily basis while participating in collaborative reflective planning, in a model based on the Responsive Teaching Cycle (Cheng, Gainsburg, & Schlackman, 2013). The teachers begin teaching

actual secondary students in the third day of the PD and continue to teach for 8 days total. They teach one block-length period daily and devote the remainder of the day to reflection and collaboratively preparing for the next day with the support of project staff and one another. This model expands upon PD research on clinical teaching that calls for the need to facilitate teacher transfer of newly acquired pedagogical skills (Alter & Cogshall, 2009). Unlike PD in the workshop environment, the guided clinical immersion model repeatedly exposes teachers to the real-life complexities of a live classroom. The WPD and IPD models are compared visually in Table 1.

Table 1

A Comparison of WPD and IPD Models

| | Workshop Professional Development (WPD) | Immersion Professional Development (IPD) |
|-------------------|---|--|
| Goal | Implementation of cloud based technologies for inquiry-based science instruction. | |
| Duration | 75 hours over 10 days | 59 hours over 11 days |
| Enrollment | Approx. 20 teachers over one summer session | Approx. 15 teachers over two sessions each summer |
| Structure | 9 days of training, 2 days of teaching | 2 days of training, 9 days of teaching |
| Clinical Teaching | Twice 3 hours total | Daily 2 hours/day for 9 days |
| Lessons taught | One 1.5 hour lesson Taught twice 3 hours total | Nine 2 hour lessons Each taught once 18 hours total |
| Format | Workshop style delivery Marked by direct instruction | Time is split between teaching and collaborative planning |
| Curriculum | Participants design original lessons, observe each other, & provide feedback | Participants provided with skeletal lessons and pacing guides/topics |
| Based on | Lesson Study | Responsive Teaching Cycle |

Site Selection

A combination of sampling strategies was used to select this site. The use of criterion based sampling in conjunction with sampling for maximum variation yielded one site with two distinct programs for comparison in this study (Glesne, 2011; Miles & Huberman, 1994). First, the site needed to meet certain criteria. The site needed to offer

multiple types of professional development programs for in-service teachers. Additionally, in order to conduct as direct a comparison as possible, these programs need to be similar in terms of number and type of participant, length of PD, and have similar objectives or learning outcomes for the participants. Further, maximum variation between the clinical teaching components of each program was desired in order to draw a comparison (Miles & Huberman, 1994). I argue that this site is ideal to conduct this study because of the fact that while both of these programs use a nontraditional reform-based approach to PD, they vary in the amount of direct training versus clinical teaching that they each employ.

Data Sources and Samples

In studying the impact that professional development programs have on teachers' perceptions and practices, teachers and their class websites were used as data sources. Data was collected through surveys, focus groups, individual interviews of participating teachers as well as from artifact analysis in the form of examining science lessons posted on class websites.

Sampling Strategies

Criterion-based sampling combined with typical case sampling was used to identify participants from each of the case studies under investigation (Bloomberg & Volpe, 2012). All 2014 study participants took part in surveys and focus groups. A smaller sample of teachers was purposefully selected from those who volunteered to take part in lesson submission and individual interviews. In selecting teachers to take part in lesson submission and individual interviews, teachers who were representative of the typical case participants from each of the two PD programs were purposefully selected.

Survey and focus groups. All participants in the study fit the following criteria, they were enrolled in either of the PD programs in the study and needed to be secondary science teachers intending to teach science in a middle school or high school in the coming fall. Of 79 teachers enrolled in either PD program in both 2013 and 2014, all but two met the criteria for inclusion in this study. All willing and eligible participants were included in both the survey and the focus groups. Of these teachers meeting the eligibility criteria, there was a 90% participation rate in summer surveys administered in 2012, 2013 and 2014 as well as in summer focus groups conducted in 2014 only. The response rate for delayed post surveys dropped to approximately 40% in all three years. Ensuring that participants were teaching science in the fall was necessary as participants needed to draw from recent classroom experience in order to answer follow up survey questions as well as questions presented in the focus groups.

Lesson submission and interview. From the pool of participants described above, ten participants, five from each PD program, who represented the typical participant from their particular program, were purposefully selected to submit lessons and take part in the semi-structured individual interview. These teachers were characteristic of others' in their group in terms of CSCS experience level and type of school year implementation. Using these criteria when sampling ensured that participants were able to provide artifacts from their classrooms for use in the study. Additionally, the use of typical case sampling provided a representative sample from each program, making for a clear comparison of the typical phenomena seen in each program.

Sampling process. Participants in both PD programs volunteered to take part and were provided with stipends as compensation for their time. Participants signed up for

both programs using online registration. Additionally, participants in both programs signed up to take part knowing that each program would be used in multiple research studies. During their orientation meeting, participants were given information about the studies as well as the research invitation and informed consent forms for the coming summer (See Appendix A for the text of the Research Invitation and Appendix B for the text of the Informed Consent Form). All participants were invited to take part in the survey and focus groups and were all interested participants in the collection of this data. Following the summer programs, all participants were invited to take part in the interview and lesson submission. From those who demonstrated willingness to be interviewed, typical cases were then selected.

The purpose of this study was to compare the perceptions and practices of participants as they related to inquiry-based science teaching; using the criteria of participation in either program as well as teaching in the coming fall yielded participants who have completed either program and have had the opportunity to implement what they have learned. Further, selecting representative cases from each case study allowed for a comparison of what is typical in each case in order to best compare the two distinct programs.

Sample Characteristics

All participants were secondary level science teachers who taught science to students in grades six through twelve. This study included survey data from three summers, 2012, 2013, and 2014 with an emphasis on the survey data, focus groups, individual interviews, and artifact data collected during the summer of 2014. Of the 81 participants who contributed to three years of data, approximately 80% work in Southern

School district during the school year, while approximately 15% work in other public school districts and approximately 5% work in private or independent schools.

Additionally, a majority of participants, 70%, held a single subject science credential while 30% held a multiple subject teaching credential. Participants in all aspects of the study were enrolled in either of the two professional development programs in the study, which are referred to as Workshop PD (WPD) and Immersion PD (IPD), pseudonyms for the two different professional development programs, as well as descriptors for the nature of each program.

Given the mentorship opportunities provided by both programs, participants often returned for a second or third year. In 2014, approximately 62% of participants were participating in a CSCS program for the first time. Whereas approximately 20% were returning for a second year and approximately 18% had experience that reached beyond two summers of CSCS involvement. Returning teacher participants returned voluntarily. Further, returning teacher participants were purposefully selected and invited to return based on their success in the previous year.

Tables 2 and 3 detail enrollment in each program over the past three years. In total, there were 48 unique participants from the WPD group and 33 from the IPD group. Participants listed in these tables also account for the criteria of the study. Any participant not teaching science and thus not meeting the criterion for inclusion in the study have already been removed from this pool.

Table 2

Enrollment in Workshop PD (WPD)

| Year | Returning Participants | New Participants | Total Participants for the Year |
|-------------|------------------------|------------------|---------------------------------|
| Summer 2012 | 1 | 23 | 24 |
| Summer 2013 | 6 | 12 | 18 |
| Summer 2014 | 6 | 12 | 18 |

Table 3

Enrollment in Immersion PD (IPD)

| Year | Returning Participants | New Participants | Total Participants for the Year |
|-------------|------------------------|------------------|---------------------------------|
| Summer 2012 | 1 | 7 | 8 |
| Summer 2013 | 6 | 12 | 18 |
| Summer 2014 | 7 | 13 | 20 |

Ethical Issues

Ethically, it was important that interview and survey participants were able to freely express their opinions and experiences about their participation in the program without repercussions from leaders in the program (Kvale, 2009). Further, selection of participants for all methods of data collection was voluntary and data remained confidential, as individual names were not tied to responses or conclusions. In order to further ensure that participants' identity was protected, codes were used to categorize data by individual and pseudonyms were used when reporting specific statements from surveys, focus groups, and interviews. The IRB process at the institution hosting these

professional development programs was also utilized to ensure that human subjects were protected.

Data Collection Instruments

Data was collected using a variety of instruments including a survey, a focus group protocol, and an interview protocol. Through the use of these instruments, data collected reflects the evolution of the perceptions and practices of the participants throughout the course of the study. These instruments also allowed for a greater understanding of both programs in the study. Using a variety of instruments to collect both qualitative and quantitative data is characteristic of a mixed methods research study. Further, the simultaneous collection of both types of data is consistent with convergent parallel design, as both types of data were collected simultaneously (Creswell, 2012).

Surveys

The surveys for this study, referred to as the CSCS Workshop Surveys, consist of both free response and multiple choice questions. (See Appendix C for the text of the CSCS Workshop Surveys). The surveys were administered to teacher participants electronically prior to participation in PD (pre-test), immediately after participation in PD (post-test) and then during the following school year (delayed post-test) in all three years of the study, 2012, 2013, and 2014, for a total of nine survey administrations. The surveys are divided in four main sections, participant confidence, professional development, use of technology, and science instruction. All administrations of the surveys asked teacher participants to respond to both Likert-scale questions reflecting the frequency of CSCS classroom activities as well as open ended questions that asked participants about their opinions on these practices and how it relates to their teaching.

Questions regarding confidence levels asked participants to rate their personal confidence related to their ability to successfully implement CSCS in their classrooms during the school year. These types of questions only appear in the post and delayed post version of the surveys as they draw from participants' experience in the summer PD. These types of questions, phrased as "Describe your confidence with the Google tools you are learning about (what we call CSCS) - How confident are you that you can implement CSCS tools successfully in your 2014-15 school year classroom?" These questions informed the study by allowing for a comparison of teacher perception upon the completion of either PD program. Further, such data allows for tracking of teacher confidence level over multiple years of participation in the summer PD programs.

Questions in the category of technology use asked teacher participants to reflect on their use of technology in the classroom as well as that of their students. Using the prompt, "Thinking about your teaching from the previous school year, how often did you employ the following technology-assisted instructional activities with students in your classroom?" these questions range from traditional uses of technology including, "PowerPoints or other non-collaborative technology to present information to students" to technology based skills specifically covered in the PD, "Data pooling and graphing (combine student data into a single spreadsheet)." Data from these questions allowed for changes in classroom practices related to specific applications of technology to be tracked over time.

The survey questions specific to science instruction were developed based on the eight scientific and engineering practices presented by NGSS (Next Generation Science Standards). Participants were asked to reflect on how much importance they placed,

philosophically, on each of these practices and well as how much time they spent engaging their students in activities related to these practices. Sample questions included “In your experience, what are the most important keys to good science teaching?” and “Discuss potential advantages to pooling data for an experiment across groups or classes.” Questions in this section also used the prompt, “Thinking about your teaching last year, how often were your science students engaged in the following activities” to ask about activities ranging from textbook use to data analysis following a hands on laboratory investigation. The purpose of this section was to track the teacher’s perceptions regarding inquiry-based science as well as their classroom practice.

Focus Group Protocol

The CSCS Focus Group protocol provides a guideline for a semi structured conversation with small groups of teacher participants (Morgan, 1996). (See Appendix D for the text of the CSCS Focus Group Protocol). The questions in this protocol were developed using the study’s research questions as a guide. Each focus group began with the prompt, “Tell me about how you spent a typical day while enrolled in this program.” Next, participants were asked about the technology skills they learned about over the summer, “How was the use of technology different this summer than in your regular classroom?” Then, they were asked specific questions about the nature of their specific program including “What components of this program make it unique, or different from other teaching experiences you’ve had?” They were then asked to reflect on what impact this experience had on their own thinking about teaching science as well as their plans to implement these new skills into their classroom instruction. “How has your teaching of science been different during this summer as compared to how it has been in the past?”

Finally, participants were asked reflective questions and provided with an opportunity to solicit their ideas for improving the program in which they participated.

Data from the focus group was used to support the results of the post-test survey. By asking participants similar questions in two different forums, data points were able to be confirmed and their responses validated. Also, asking participants to compare their experience in either summer PD program, the nontraditional approach of both programs was established. The focus group and survey formats allowed the study to include a maximum number of participants, thus including all willing and eligible participants. Additionally, homogenous focus groups allowed participants the opportunity to express their opinions in a group who shares their experience, thus eliciting rich data (Morgan, 1996).

Interview Protocol

Similar to the rubric and the survey, the CSCS Interview protocol, is based, in part, on the eight scientific and engineering practices found in the Next Generation Science Standards. (See Appendix E for the text of the CSCS Interview Protocol.) The interviews were semi structured in nature and asked teachers to reflect on how they had used CSCS with their students (Bernard, 1994). First, participants were asked to reflect on the professional development program they completed over the summer. Next, they were asked to walk the interviewer through one of the lessons posted on their website in a think aloud interview. This lesson was also evaluated using the rubric. The interview, however, allows the participants an opportunity to expand on the lesson in a way that might have been missed by the rubric. Finally, the interview was closed by asking participants how they spend most of their instructional time in their school year

classrooms. The interview differs from focus group in that the focus group questions pertain specifically to the participants' summer PD experience while the interview questions are specific to a lesson that an individual participant has taught in his or her school year classroom.

The interview protocol was established to provide insight into the participants' perceptions and practices after participating in the summer program and having some time to implement what they have learned in their classroom. Individual interviews also allowed participants to explain their thinking in greater depth than the focus group setting. Interviewing in a one on one setting helped to elicit data that is specific to each teacher and reflects that individual's classroom implementation, as stated in the first research sub question. Data generated by the interview protocol will enhance the data generated by the rubric and will support the findings of the delayed post-test administration of the survey.

Artifact Analysis Rubric

The artifact analysis rubric was developed using the science and engineering practices of the Next Generation Science Standards (NGSS) as a guide and allows each lesson to be scored on the extent to which the teacher's lesson and corresponding student work reflects each of these eight practices (See Appendix F for the text of the CSCS Artifact Analysis Rubric). Further, this instrument utilizes a point system, based on a Likert-scale style response ranging from zero to four points for each of the eight science and engineering practices. A score of zero would indicate that this particular lesson did not reflect any components of a particular practice. Conversely, a score of a four would suggest that a particular lesson exemplified all aspects on this practice.

This rubric has categories that utilize the same science and engineering practices highlighted earlier in the survey. While the survey provided self-reported data regarding time spent on each practice, the rubric provided evidence based data about a particular lesson. The data generated by the artifacts and the rubric helped to validate the responses from the survey as well as provided additional evidence about teachers' classroom practice (Glesne, 2011).

Data Collection Procedures

Data was collected through participant survey, focus groups, semi-structured interviews, and artifact analysis. This data was collected using the instruments and protocols described in the previous section.

Surveys

Participants were asked to complete the surveys described in the data collection instruments section at three points during each year of the study. The surveys were disseminated using an online, cloud-based form and were made available to participants on the website for their particular professional development program. Time was built into both professional development programs for the first and second administration of the survey. Additionally, participants were provided with computers for these administrations of the online survey. The third administration of the survey was sent to participants electronically. Participants were asked to complete the third administration of the survey on their own time. If they were not able to complete it, computer access and time was provided for them at a monthly follow-up professional development session.

The first administration of the survey, referred to as the pre-test, took place prior to the start of the summer professional development in early July of 2014. The second administration of the survey, referred to as the post-test, took place immediately upon the conclusion of each summer professional development program in mid to late July of the same year. The final administration of the survey, referred to as the delayed posttest, took place once participants had ample time to implement and practice their new skills in their school year classrooms. In 2014, the delayed post survey was distributed in December and responses were accepted through February of 2015.

Additionally existing data was accessed from this same survey which was also administered in a pre, post and delayed post fashion in previous years. This data was drawn from a data set collected in the previous two years of each program. Hence, the existing data includes participants from both programs during the summers of 2012 and 2013. For the summer of 2012 cohort, pre-test data was collected in early July of 2012, post test data in late July of 2012 and delayed post test data in March of 2013. Similarly, data for the summer of 2013 cohort was collected in early July of 2013, late July and early August of 2013 and delayed post test data was collected in December of 2013.

Collecting survey data for each cohort at these three different time intervals allows this study to examine data on the teachers' perceptions and practices of inquiry-based science over time. The pre, post, and delayed post model of the methodology produced data will provide a baseline as well as that which can be linked to both the professional development experiences as well as the classroom implementation experiences of the participants. Further, including the existing data sets allows for the examination of longitudinal trends in returning participants' perceptions regarding

inquiry based science as well as allowing the ability to track their self-reported classroom practices over a multi-year period. Additionally, multiple years of survey data enables the expansion of the sample size to include additional one time participants from previous years. Survey data also served to inform my second research sub question regarding teacher perceptions.

Focus Groups

Participants each took part in one focus group during this study. Focus groups were held upon the conclusion of the participants' summer workshop. Time was built into the final day of the professional development program to allow for focus group participation. Participants were screened for criterion based eligibility verbally prior to the focus groups. Focus groups took place in classrooms on the same site as the professional development programs

During the focus groups, small groups of participants were engaged in a conversation, using a semi structured format, for about an hour. The focus group protocol guided these discussions. Each focus group consisted of approximately four teachers from the same professional development program (Morgan, 1996). While each focus group was also asked the same open ended questions, the group dynamics also helped to shape the ensuing conversation.

In total, ten focus groups were conducted, five from each professional development program. The data from the focus groups contributed to the background needed for this study. Each group was asked to explain the nature of the professional development in which they participated. This data served as the basis for all research questions in that it will form the foundation of the similarities and differences between

the two professional development programs. Additionally, data from the focus groups also served to corroborate survey data regarding participants' perceptions.

Interviews

Semi-structured interviews were conducted as a follow-up to participants' completion of summer professional development (Bernard, 1994). All participants were invited to be interviewed. Of the willing and eligible individuals, ten were purposefully selected to participate. Five individuals from each of the two professional development programs were included. These individuals were interviewed during the professional development follow-up sessions that take place during the school year. These sessions, and the interviews, took place on the campus of the professional development programs. Time was built into these sessions to allow for these individuals to take part in an interview.

Interviews lasted approximately 30 minutes in length. The interview protocol described in the previous section acted as a guide for the discussion resultant from each interview. All ten interviews were conducted in the fall of 2014. Five participants from each program were purposefully selected to represent typical cases for interview. Interview data contributed to all three research questions in that participants had the opportunity to reflect on their perceptions and practices related to inquiry based science as well as their implementation of skills learned during the summer professional development programs.

Artifact Data Collection

The interviews described above were paired with the artifact analysis process. In addition to talking through a lesson plan during the semi structured interview,

participants submitted this same lesson plan to be analyzed using the artifact analysis rubric. In total, ten lessons were analyzed, five from each of the professional development programs. Further, individuals were purposefully selected to submit lessons to reflect a variety of experience levels with CSCS. Artifacts from these science lessons included information presented to students, samples of data collected by students, data analysis completed by students (including graphs) as well as any final product that students completed for assessment. Data from the artifact analysis connects directly to the first and third sub research questions in that it will provide insight as to the actual classroom practices and implementation strategies of the participants (Glesne, 2011).

Timeline

The overall timeline for this study spanned from early July of 2014 with the pre-test survey administration through late October of 2014 with the conclusion of the follow-up interviews. In total, the survey was administered at three different intervals, ten focus groups were conducted, ten interviews were conducted, and ten lessons were analyzed. With the inclusion of existing data, this study tracks three cohorts of participants through both professional development programs over a three year time period.

Data Analysis

Data for this study, in the form of survey responses, completed artifact analysis rubrics, and transcriptions from focus groups and interviews was analyzed to address the research questions. In keeping with the convergent parallel design, both qualitative and quantitative data were analyzed simultaneously. Further, each type of data was relied upon to mitigate the gaps or weaknesses of the other (Creswell, 2012).

Analysis Procedures

Survey Responses. Closed ended survey responses generated from Likert scale questions were analyzed using SPSS. Data was separated according to professional development program as well as year of participation. This approach analysis allowed for the tracking of participants' self-reported practices with regard to inquiry based science both across programs as well as over time. Graphical displays, including histograms, double bar graphs, and line graphs were used to compare programs as well as display change over time. This analysis addressed the second and third research sub questions. Open ended survey data was coded by the principle investigator using the thematic data analysis procedures described in the next section. Analysis of free response questions contributed primarily to sub research question one regarding teachers' perceptions.

Artifact Analysis Rubric Scores. CSCS lesson submitted for review were assessed using the CSCS Artifact Analysis Rubric. Data was disaggregated according to professional development program and then again according to experience with CSCS. Mean scores for each of the eight NGSS science and engineering practices, along with corresponding standard deviations, were displayed in a table. Additionally, qualitative data from actual lessons were analyzed. This text included actual language from the lesson plans as well as researcher notes about the nature of each lesson. This qualitative data was used to exemplify the type of lessons that correspond with the highest scoring areas for each of the participants groups. Data from this analysis informed the second sub research question as lesson artifacts directly reported information relevant to teachers' classroom practice.

Transcribed Focus Groups and Interviews. Focus groups and interviews were transcribed from digital recording by a transcription company called Speechpad. Upon receipt of transcriptions, recordings were played while reading over the transcript to verify the accuracy of the transcript. Once transcripts were produced, they were also reviewed and any identifying information was redacted. In order to protect the identity of participants, random digit identifiers were used to label transcripts and pseudonyms were used to refer to individuals. The completed and verified transcripts were used in the following thematic data analysis process. Data from interviews and focus groups informed the first two sub research questions as the questions asked pertained primarily to teachers' perceptions and practices as related to inquiry based science.

Thematic Data Analysis Process

Once the qualitative data has been extracted from the free response survey questions, artifacts, and transcriptions, Dedoose, a web-based, computer assistive data analysis program designed specifically for mixed methods studies was used to code data. This program used term frequency to assist in the identification of codes based on which words or terms respondents use most often. Additionally, this program also provided the freedom to engage in manual open coding. This information was then used to establish hierarchical codes to show the relationships between the various components of the study's conceptual framework (Glesne, 2011). (Hierarchical codes applied in this study can be found in Appendix G: Codes.) Data was also analyzed using a cross case matrix, identifying both commonalities as well as incongruities between the two programs under study (Bloomberg & Volpe, 2012). Data displays were created highlighting specific

quotations to support findings related to all three sub research questions, all of which are presented in chapter four.

Timeline

The initial stages of transcription coding began in October of 2014. Survey and artifact data were analyzed from November of 2014 through January of 2015, along with more detailed analysis of transcripts and codes. Survey data was revisited in February of 2015 to allow for late responses. Data analysis was concluded in early March of 2015.

Researcher Roles

In addition to principal investigator, I take on many multiple roles within the context of my study. Over the past several years, I have worked with the teacher participants from both programs in the study as a teacher, a curriculum developer, and as a professional development facilitator. In my current role, I am responsible for delivering professional development to participants of both programs and created the student curriculum for one program. Additionally, many of these individuals have been my colleagues and classmates. Given these relationships and my connection to both cases in my study, I need to not only be aware of the biases that I bring to the study, but also be prepared to mitigate these biases in order to protect the integrity of the study and the privacy of the participants.

Researcher Bias

As a teacher, I have experienced multiple examples of traditional PD that proved to be insufficient. As a result of these experiences, I believe that traditional PD tends to fall short when it comes to facilitating implementation of new skills for most teachers. Conversely, I believe strongly in using clinical teaching as an alternative form of PD.

Based on my experience, I have observed that workshop style PD more strongly appeals to individuals who were good students themselves, characteristics that might not necessarily translate to being an effective teacher. I find that this traditional approach to PD focuses on skill of learning versus the skill of teaching.

During data collection, I was careful to give each program equitable time as not to collect more information from one group as the other. Additionally, I worked to ensure that my interview and focus group protocols are the same for each program. In analyzing data, my bias against traditional professional development may cause me to emphasize the negative aspects of the more traditional program while highlighting the positive aspects of the clinical teaching model.

Effect of the Researcher on the Case

As a result of this bias, participants in the more traditional professional development program may pick up on my suspicions of the traditional nature of their program. Similarly, during data collection, the clinical teaching group is likely to pick up on my desire to see them succeed. Additionally, in analyzing data, I will need to be aware of this bias and attempt to maintain objectivity in evaluating the various components of each program.

Effect of the Case on the Researcher

As a leader of professional development in this study, I have also worked more closely with the clinical teaching group. These individuals have developed relationships with me, and while they may be more willing to participate in the study, these relationships may lead to their desire to produce positive results. On the other hand, participants in the workshop program have had relatively minimal contact with me. As

such, these individuals may not be as comfortable with me at first but are also less likely to feel the need to produce any particular results. It is possible that I, as the researcher, have developed more of an affinity toward the group with whom I am more familiar, thus skewing my data and causing me to either collect more in depth data from this group or to view data from these individuals in a more positive light.

Strategies to Address Bias

Throughout my study, I worked to mitigate these biases by utilizing reflective writing and relying on the other researchers on my team to review my work. I have found that just sitting down and writing out my thoughts is very helpful when it comes to organizing my thoughts and even generating draft material. Additionally, I am fortunate enough to be working on my study with a team of researchers who all work together on a larger project. This gives me access to reliable individuals who understand my study and can help with sharing interview or other data collection responsibilities as well as work collaboratively with me on the coding and analysis required for my study. As such, I plan to collaborate with these individuals during data collection as well as data analysis to minimize the impact of my own bias.

Chapter 4: Findings

Purpose

The purpose of this study was to examine the impact of two different professional development programs, Immersion Professional Development (IPD) and Workshop Professional Development (WPD) on teachers' perceptions and practices related to inquiry based science. Further, implementations of the inquiry-driven, data analysis pedagogical skills highlighted in both professional development programs (Computer Supported Collaborative Science) was also analyzed. Teacher perception was measured through the use of open ended survey questions as well as focus groups and semi structured interviews. Teacher practice was measured using a combination of self-reported frequency data collected via survey at various points in the study, semi structured interviews, and artifact analysis conducted on sample lesson plans. Implementation of Computer Supported Collaborative Science (CSCS) was measured in a similar fashion to teacher practice using a frequency scale focused on various components of CSCS.

Research Questions

This study investigated the following research question as well as the three proceeding sub research questions.

What impact do two specific professional development (PD) delivery methods have on teachers' perceptions and practices related to inquiry based science?

- How do the different PD delivery methods in the two programs in the study impact teacher perceptions regarding inquiry based science?

- In what ways do these different programs impact teachers’ classroom practice as it relates to inquiry-based science?
- To what extent do participants from either program differ in their implementation of the CSCS data collection and analysis skills learned in the PD?

Participants

As presented in the previous chapter, the total number of participants included in this study is 81. This number represents participants from CSCS summer professional development in the summers of 2012, 2013, and 2014. Of these 81 participants, 19 were quoted directly, either from survey free response items, focus groups, or interviews. This group of 19 teachers is representative of the larger sample, both in terms of professional preparation as well as the nature of their quotes responses. As shown in Table 4, like the entire sample, a majority of the quoted teacher participants hold single subject science teaching credentials and work in SSD.

Table 4

Backgrounds of Teacher Participants Directly Quoted (*n*=19)

| Credential Type | | |
|------------------------|--------------------------|---------------------|
| Single Subject Science | Multiple Subject | |
| 14 | 5 | |
| District | | |
| SSD | Other Public | Private/Independent |
| 15 | 2 | 2 |
| Level | | |
| High School | Middle School | |
| 8 | 11 | |
| CSCS Experience | | |
| New to CSCS | Previous CSCS Experience | |
| 7 | 12 | |

Additionally, this group, like the entire sample, is fairly evenly split between middle school and high school teaching assignments. More detailed information on each of the quotes teachers, their background, training, and employment can be found in Appendix H: Participant Background Information.

Perceptions of Teaching Science

In order to address the first sub question, How do the different professional development (PD) delivery methods in the two programs in the study impact teacher perceptions regarding inquiry-based science?, teacher perception was measured using open ended survey questions as well as focus group transcripts. At multiple points throughout teachers' participation in the CSCS programs, participants were asked the following questions: "In your experience, what are the keys to good science teaching?" and "What do you think are the most important ideas or concepts for students to understand about the nature of scientific discovery and accumulation of scientific knowledge?" Data was collected in an open ended survey question at three time points in time for each year of participation, once in the early summer prior to the program, again in the late summer immediately after program participation, and then again in the winter approximately six months after program completion. Further, the same questions were also asked in a focus group of teacher participants immediately upon completion of each summer program.

Student-Centered Inquiry

Participants from both the IPD and WPD programs demonstrated a more defined view of the importance of student-centered scientific inquiry after participation in a CSCS program. Prior to program participation, responses did not include the actual term

inquiry. Table 5 shows the development of two teachers, one from each of the CSCS programs, whose responses were representative of the bulk of participants. These responses depict a shift toward student-centered inquiry upon completion of a CSCS PD program along with a continued emphasis on student learning into the school year.

Table 5

First Year CSCS Teacher Perceptions

| | Response 1 Prior to Program | Response 2 Immediately After Program | Response 3 Winter Following Program |
|-----------|---|---|---|
| Teacher A | Understanding that science is always changing based upon discovery of a testable hypothesis that has rigorously been evaluated. | Involving students in the reality of real science which involves discovery, inquiry and analysis | Continued learning and discovery of what there is to know and how to best share it with my students. The emphasis should be on STUDENT LEARNING with integrity, joy and enthusiasm of an interested facilitator. |
| Teacher B | Passion and understanding. Passion for the content and the need to understand the basis of science in the world. A teacher's passion is contagious, as is their apathy...A good teacher remembers that it takes time to learn a subject and some people will struggle with a subject... | Science should not be a subject that has right or wrong answers when it comes to scientific investigations. When students are engaging in investigations the focus should be on the process of discovery and argumentation with evidence... | Allowing students to make mistakes and not be "put down" for it. Often students are so afraid to be "wrong" that they change their hypothesis so they were "right the first time".... Allowing and encouraging mistakes and personal correction of those mistakes keeps the discovery part of the mind open which encourages science. |

Participant responses to the prompt “In your experience, what are the keys to good science teaching?”

When first asked, “In your experience, what are the keys to good science teaching?” both respondents gave answers that focused on the role of the teacher and the content. Initially, Teacher B placed a strong emphasis on the “passion” and “patience” of the teacher. Similarly, Teacher A, while referencing the scientific process, emphasized

content information that a successful teacher should know and convey to her students. Teacher A's reference to the scientific process is reminiscent of commonly held misconceptions presented in the literature, specifically the erroneous idea that scientific investigations must follow certain steps (Bybee, 2002).

After participation in their respective CSCS summer programs, both respondents provided further developed answers, both of which reference students engaging in scientific inquiry. Teacher A begins her answer with a powerful idea, and one that was absent from her first response, the idea of "involving students". Further, Teacher A goes on to explicitly cite "inquiry" as a key to good science teaching. Teacher B's response is similar in that it includes a student centered phrase, "when students are engaging in investigations". Like Teacher A, Teacher B did not reference students engaging in inquiry prior to participation in the CSCS workshop.

Not only do these responses indicated that both of these teachers demonstrate a shift in perception of what makes a good science teacher after participation in a CSCS program, this shift in beliefs held true six months later, after the teachers have returned to their school year classrooms, as demonstrated by each participants' third response. Both Teacher A and Teacher B maintain their emphasis on student inquiry in their third response. By the following winter, both participants reference "discovery", the basis for inquiry, as a key to good science teaching. Teacher A's claim that "the emphasis should be on STUDENT LEARNING" (respondent's emphasis) is even more encouraging.

In answering these questions, teacher participants from both programs demonstrated growth in their understanding of what is required for successful science teaching. While participants in both programs demonstrated a change in perception over

time, IPD and WPD participants differed in their areas of growth. Participants of both programs experienced a shift in thinking from a content driven philosophy toward a more student-centered approach to investigation. IPD participants tended to place more emphasis on student collaboration as a crucial element of scientific thought, while WPD participants tended to value critical thinking on the part of students. Further, it was also found that the more CSCS activities in which an individual had participated, particularly over multiple years, the more likely the individual was to include the role of pooling data, large data sets, and data analysis in his or her responses.

IPD Teachers

Of the 63 respondents enrolled in either IPD or WPD over two years (2013 and 2014), 15 participants mentioned collaboration when asked either “In your experience, what are the keys to good science teaching” or “What do you think are the most important ideas or concepts for students to understand about the nature of scientific discovery and accumulation of scientific knowledge?” of these 15 respondents, 73% (11/15) provided their response in a survey administered after completing the IPD program in either year. Zero respondents mentioned collaboration as an essential element to teaching science or understanding the nature of science in pre surveys. The quotes in Table 3 were selected based on their representative nature. These excerpts demonstrate widely held sentiments expressed by multiple respondents following participation in IPD.

Table 6

IPD Teacher Perceptions

| | Pre IPD Responses | Post IPD Response |
|-----------|--|--|
| Teacher C | Hands-on activities and labs and any chance to use technology in the lab | In any classroom, having an agenda, providing different ways for students to learn, being organized, and transitioning well between the different activities. Using technology for data collection and collaboration allows more time as a class to discuss and analyze what was done in the lab. |
| Teacher D | I think it is very important for students to do explorations. Once they discover and gain that knowledge they get very excited and very involved in more explorations. | The most important keys to good science teaching are to teach collaboration in collecting data and try to make lessons related to them (make it personal), and make sure that technology is widely used in good science classes. |
| Teacher E | Hands on experiences to supplement the lecture and text content. | Again, I need to place more emphasis on revision and collaboration. Usually, we do a lab, collect the data, write a short discussion and that's it. That's all we have time for. I was reminded that it is time well-spent when we discuss the findings in a collaborative nature and even do further experimentation on the same general topic. |
| Teacher F | The most important keys to good science teaching is to leave students genuine curiosity about the world around them and better problem solving skills. | That science isn't perfect. That there is no "right" answer. That science concepts help us better understand the world around us. And that collaboration with peers can be very rewarding and effective. |

Responses to the prompts “In your experience, what are the keys to good science teaching” or “What do you think are the most important ideas or concepts for students to understand about the nature of scientific discovery and accumulation of scientific knowledge?”

Responses from Teachers C-F, as presented in Table 6, all emphasize the idea that data collection, as a part of scientific inquiry, is a collaborative process. This sentiment is also supported by IPD participants in their reflections through focus groups conducted following 2014 summer programs. During one such focus group, first year IPD participants had a conversation about the role of CSCS in facilitating scientific inquiry.

Teacher B stated, “It's awesome that [the students] are really sharing their data like real scientists... Sharing with us. So that's cool.” This statement reflects the teacher’s understanding of collaboration, in this case by sharing data, as something that is integral to understanding science, as “real scientists” engage in this practice. During the same conversation, Teacher C added, “I think also in science, the fact that they are able to see the other group's responses, it kind of shows more insight into their answer. Like, ‘Oh, the other group thought this and we thought this.’ So that's totally science right there where they are collaborating...” The contribution of this second teacher reinforces the idea that scientific collaboration is centered around sharing data, in particular, an idea also presented in the survey results in Table 6.

In another focus group, consisting of experienced CSCS participants who had previously participated in CSCS professional development in one or more prior years and who had just completed a summer of IPD, the idea of collaboration was also raised. In this setting, experienced CSCS participants extended the idea of collaboration to not just include collaboration among students within one classroom, but to include sharing data across classes. Teacher G stated, “It’s about collaboration...Not just collaboration with many groups within the classroom, but collaboration between classrooms with data usage was just really powerful for students, because they see it's not just their classroom, it's other classes doing the same.” This statement demonstrates how experience can lead a teacher to take the idea of collaboration one step further.

Since beginning IPD teachers reference collaborating around data at the classroom level, while experienced IPD teachers build on this idea to present a more robust understanding of collaborating around data, this time at the school level, this

suggests that repeated participation in CSCS leads to a more developed understanding of inquiry. This is a theme that will be further explored in a coming section by examining the connection between CSCS experience and perceptions of inquiry.

WPD Teachers

WPD participants emphasized analytical thinking skills when they responded to the prompt, ‘In your experience, what are the keys to good science teaching?’ Their responses reflected their understanding of scientific inquiry by highlighting the analytical thinking skills necessary for students to be successful in a science classroom.

Additionally, WPD participants were the only respondents to explicitly cite NGSS (Next Generation Science Standards) in their discussion of what is necessary for successful science teaching. It is notable that these respondents referenced NGSS explicitly. This shows not only an understanding of the information set forth by this document, as reflected in the accuracy of their responses, but it also shows an understanding of importance of this document in informing classroom practice. Survey responses presented in Table 7 highlight these trends and serve as representative responses for WPD participants. While some participants quoted in Table 7 may have participated in both IPD and WPD over multiple years, the quotes included below were obtained immediately upon completion of the summer WPD program, thus linking the response to their most recent CSCS experience.

Table 7

WPD Teacher Perceptions

| Post WPD Responses | |
|--------------------|--|
| Teacher G | Data analysis, problem solving and critical thinking. Student need to develop those skills to gain a deeper understanding of science as well as other contents. Science is not memorization of facts, but understanding of processes. |
| Teacher H | I think the most important things lie in Dimension 1 of NGSS. I like the focus of analysis and evaluation. Oftentimes, students are so wrapped up in the memorization that they lose the big picture and the ability to think. I want my students to "think" about science and figure things out as they explore the curriculum with me. |
| Teacher I | Discovery learning. Analysis of data for NGSS cross-cutting concepts. |
| Teacher J | Motivate and create for real life applications or use. Try to create lessons that incorporate all the domains of the new NGSS. |
| Teacher K | Awareness of student personal and academic needs, and being flexible enough to meet them. I think we also need to be ready to adapt and modify our practice based on the feedback from our students, while challenging them academically. Good teaching prepares students to be independent seekers of knowledge, analytical thinkers and critical evaluators. |

Responses to the prompts “In your experience, what are the keys to good science teaching” or “What do you think are the most important ideas or concepts for students to understand about the nature of scientific discovery and accumulation of scientific knowledge?”

Responses from Teachers G-K, as shown in Table 7, demonstrate the repeated use of phrases which suggests an emphasis on critical thinking, a trend that replaces the content driven responses seen in many surveys administered prior to participation in WPD. For example, the terms “problem solving” (Teacher G), “analysis of data” (Teacher I), and “real-life applications” (Teacher J) show a tendency for WPD participants to value higher level thinking skills as a hallmark of their approach to student-centered inquiry. Teacher G and Teacher H also address the idea that thinking about science is not simply “memorization”, but a deeper level of thinking that leads to understanding.

Following the summer of 2014, WPD participants took part in a focus group reflecting on their experiences. In speaking about the role of critical thinking in science, Teacher P, new to the CSCS programs made the following statement,

I'm old school. I went to old school where you sat, they gave it to you, you wrote it down, you write it, you try to memorize as many dates and times that you could, and that was the way it was. It wasn't what if or how or why or what you think? We weren't allowed to think. We were told. And so I'm really expanding that 'what you think' aspect, so that it isn't right or wrong. Even in my quizzing and testing now, I'm seeing where the more obscure answers are the ones that I'll be exploring. So if they give me kind of an off-the-cuff or out-of-the-box, so to speak, answer, when I review, that might be something I'm going to use to throw out there to say, 'Okay, this came up. What do you think? How did this person come up with this?' rather than 'This isn't a right answer'.

Teacher P's statement corroborates the theme presented by the survey responses, critical thinking over memorization. Not only does this WPD participant reflect on the importance of critical thought, she reflects on how this is a shift from how she used to teach, as well as how she was taught as a student. Such an evolution is representative of the type of change in perception that results from CSCS participation.

While both IPD and WPD participants demonstrated an increased emphasis on student-centered inquiry after participation in a CSCS program, participants from each program provided differing responses on the specifics of what this student-centered inquiry should look like in the classroom. IPD participants were more likely to

emphasize collaboration among students as integral piece to effective science teaching while WPD participants tended to cite analytical thinking as a necessary component.

CSCS Experience & Data Pooling

Table 8 depicts representative responses of experienced CSCS participants both prior to their first summer and after their second summer. Prior to attending CSCS professional development, all respondents in Table 8 provided general responses to the question “What are the keys to good science teaching?” citing qualities including the ability to facilitate student engagement and a strong knowledge of content certainly contribute to good teaching, as do patient individuals who care for their students. For instance, Teachers L, M, and O mentioned relating scientific concepts to students in order to build context, which would be necessary for student understanding. These qualities, while useful to teachers, are not specific to teaching science as discipline. Instead, they are generalized qualities that would benefit teachers of most, if not all, disciplines.

After multiple years of CSCS professional development, teacher participants are more likely to include qualities specific to teaching inquiry-based science than they were prior to program participation. Both Teacher M and Teacher N both highlight the importance of data analysis over just the process of data collection in their responses collected after CSCS program participation. While Teacher L and Teacher O also mention data analysis, their inclusion of the need for a larger sample size further exemplifies a deeper understanding of collaborative data pooling.

Table 8

Veteran CSCS Teacher Perceptions

| | Pre Summer 2013 | Post Summer 2014 |
|-----------|--|---|
| Teacher L | 1) subject matter knowledge/ nature of science knowledge (i.e. research experience) 2) ability to explain concepts/problems clearly and succinctly. 3) love of science 4) love students | Because of my knowledge of CSCS I have re-experienced the joy of teaching through data based analysis (which is important for student inquiry and thinking like a scientist)...with CSCS students can analyze a large data pool instead of just their individual group's work. |
| Teacher M | 1. make the science concepts contextual (If students think the learning does not apply to them, they frequently shut down. A meaningful frame of reference does wonders to help students "buy-in" to their learning.) 2. make the science concepts fun for students to learn (This does not mean enable them...it does mean make the concepts accessible through creative means.) | 1. data analysis rather than just data collection 2. apply analysis to new situations/make connections |
| Teacher N | Patience! | Good science teaching requires that we get the student up to the higher levels of Bloom's taxonomy. Very important is the analysis of data. Collection of data is much less important. |
| Teacher O | Sparking interest is key and I think having students be able to wonder about things and try to figure things out. | My students like the hands-on aspects of the class including doing materials testing and collecting data and the technological data input... Analyzing the class data is useful in a whole group discussion because it allows students to see patterns, trends, outliers, etc.. |

Veteran CSCS Teacher Perceptions, Responses to the prompts “In your experience, what are the keys to good science teaching?”

This increased attention to data analysis, when paired with the emphasis on critical thinking and collaboration seen in first year participants, results in a more complete perception of inquiry than was demonstrated by participants in earlier years.

This shift in philosophy is embodied in the following quote from Teacher I’s focus group consisting of multi-year CSCS participants.

I think since we're getting a lot more towards the data analysis I kind of feel like yeah, my job is to teach you the facts but you're not going to be able to remember the facts. I want you to be able to remember how to figure things out together when you leave me because the facts will be gone.

This sentiment reflects a desire to leave a lasting impact on students, not just in terms of content knowledge, but in the form of analytical thinking skills, a feeling reflected in experienced CSCS participants.

While first year CSCS participants demonstrate differences in their perceptions regarding inquiry based science teaching, more experienced CSCS participants, regardless of whether they participated in IPD, WPD, or both programs, tend to have perceptions that converge on data analysis. Further, these perceptions represent a higher level of understanding of the role of data pooling as compared to less experienced participants

Practice of Teaching Science

The second sub research question in this study addressed teachers' practice as it related to teaching science. This question, "In what ways do these different programs impact teachers' classroom practice as it relates to inquiry-based science?" was analyzed through artifact analysis and self-reported classroom frequency data in closed ended survey questions. Further, this data was supported by interview transcripts during which teachers were asked to walk the researcher through the sample lesson plan submitted for artifact analysis.

Inquiry-based science teaching was examined through the lens of the Science and Engineering Practices set forth in Appendix F of the Next Generation Science Standards

(NGSS). These Science and Engineering Practices were examined in depth due to the role that they play in the instructional shifts required by the NGSS. In examining the NGSS, the content set forth by the document, while it may move from one grade level to another, is fairly representative of traditionally included science content. The Science and Engineering Practices, however, represent new methods of instruction that have not previously been enumerated by a standards document. Further, these practices align with the instructional philosophy and pedagogy represented by inquiry-based science teaching.

Implementation of NGSS Science and Engineering Practices

Ten teacher participants, five from IPD and five from WPD, were selected to submit lesson plans in the fall of 2014. Additionally, these participants were invited to take part in an interview during which they walked the interviewer through their submitted lesson plan. All lesson plans submitted were produced on the participant's own time following the summer 2014 professional development program. Each lesson was then implemented in the school year classrooms of participants in the fall of 2014. Lesson plans were evaluated using the Artifact Analysis Rubric found in Appendix F of this study. Artifacts were scored in each of the eight science and engineering practices set forth by the NGSS. Each lesson was scored on a scale of one to four, using whole numbers, with four being the most favorable score, for each of these practices. Artifacts were submitted by Teachers D, M, O, P, Q, R, and S, as well as three other teacher participants who are not directly referenced in the analysis.

Table 9

Artifact Analysis Results

| | Practice 1 | Practice 2 | Practice 3 | Practice 4 | Practice 5 | Practice 6 | Practice 7 | Practice 8 |
|------------|---------------|---------------|----------------|---------------------------|-----------------------------|--------------|---------------|--------------|
| First Year | 1.2 (.45) | 1.4 (.55) | 1.8 (1.30) | 2 (1.00) | 1.8 (.84) | 1.6 (.55) | 1.2 (.45) | 1 (0.00) |
| Returning | 2.25 (.50) | 1.75 (.50) | 2.75 (1.26) | 2.5 (.58) | 3.25 (.96) | 2 (1.15) | 1.75 (.96) | 1.5 (.58) |

Mean rubric scores with standard deviation for lesson plans submitted for each of the 8 NGSS science and engineering practices ($n=10$)

While there was not a notable difference in implementation of the NGSS Science and Engineering Practices in IPD participants as compared to WPD participants, there was a difference in implementation when participants were sorted according to their level of experience with CSCS. As shown in Table 9, implementation of all eight NGSS Science and Engineering Practices increased with experience. First year CSCS teachers scored highest on NGSS Science and Engineering Practice 4 while veteran CSCS teachers scored highest on NGSS Science and Engineering Practice 5.

NGSS Science and Engineering Practice 4, Analyzing and Interpreting Data.

NGSS Science and Engineering Practice 4, Analyzing and Interpreting Data, states,

As students mature, they are expected to expand their capabilities to use a range of tools for tabulation, graphical representation, visualization, and statistical analysis. Students are also expected to improve their abilities to interpret data by identifying significant features and patterns, use mathematics to represent relationships between variables, and take into account sources of error. When

possible and feasible, students should use digital tools to analyze and interpret data (NGSS Appendix F, p.9).

This practice was ranked on a scale from 1 to 4, using the Artifact Analysis rubric presented in Appendix F. Of the ten lessons submitted from ten different individuals, six were from first year CSCS participants and four were from returning participants. First year participants scored an average of 2 on this practice while returning teachers scored an average of a 2.5. Based on the rubric used, a score of a 2 represents the introduction of some level of data analysis in the lesson while a score of 3 requires students to consider causation or employ basic statistical analysis. Of the first year participants, a majority scored a 2 or higher in this category, thus making it the highest scoring practice for that group.

Teacher Q, a first year CSCS participant submitted a lesson in which sixth grade students conducted a hands-on investigation to examine the effect of heat energy in the atmosphere. This lesson is representative of the type of work submitted by most first year participants. This lesson is based on an investigation protocol provided in the course textbook. Teacher Q modified this assignment to include data collection in a cloud based form. Class data was then displayed to each class period on a spreadsheet. While conducting the experiment, which required students to hold a feather over a heat source, students were asked primarily qualitative questions. They were asked to describe their observations qualitatively at various intervals throughout the experiment. Upon the conclusion of data collection, students were asked, “Explain which variables you could change in this lab and how they might affect your results.” This final question demonstrates the inclusion of the topic of causation in this lesson, as students are

prompted to contemplate which variables contribute to the results. Examples of the artifacts submitted with this lesson can be found in Appendix I: Lesson Artifacts.

In discussing this lesson, the teacher also reflected on the fact that doing these types of labs represented a new practice for her. In her interview, this teacher stated, “Okay, this is the year we're going to start doing labs, because last year I didn't do any labs.” Participating in CSCS professional development gave this teacher the practice and skills necessary to not only begin implementing lab activities with her students, but to introduce data analysis as a critical component of the inquiry process.

Like with this example, this type of data analysis is typically a new skill for many first year CSCS participants. Another first year CSCS, participant, Teacher P, also explained this instructional shift in her interview.

As far as collecting data, that was new for me. Technology in the classroom seemed to be a means to an end. The presentation or something like that, a report but actually having them in real time, using it in a different way as they collect the data and the graph that changes and them having them analyze instead of them doing a graph on their own, and only their group's data versus seeing everybody, the whole classroom. And now they have the ability to analyze more than just their own. I found that actually amazing.

Here, this participant reflects on the newness of collecting data as a classroom activity. She also explains how using CSCS strategies, such as online graphing, can free up some time to focus on analysis, rather than investing valuable class time in tedious graphing by hand.

NGSS Science and Engineering Practice 5, Using Mathematics and

Computational Thinking. According to NGSS Science and Engineering Practice 5, Using Mathematics and Computational Thinking,

Computers and digital tools can enhance the power of mathematics by automating calculations, approximating solutions to problems that cannot be calculated precisely, and analyzing large data sets available to identify meaningful patterns.

Students are expected to use laboratory tools connected to computers for observing, measuring, recording, and processing data” (NGSS Appendix F, p. 10).

One of the hallmarks of this practice is the expectation that students use technology to identify patterns in large data sets. This practice was also ranked on a scale from 1 to 4, using the Artifact Analysis rubric presented in Appendix F. Of the four experienced CSCS teachers submitting lessons, two received ranking of 4, making this practice the highest ranked among returning CSCS teachers with an average score of 3.25.

One lesson submitted by an experienced CSCS participant, Teacher O, exemplifies the implementation level of this practice typical to such participants. The lesson, intended for sixth grade students, was used for the study of volcanoes. The class first views a video presenting a problem, students must make a recommendation as to where a millionaire should build a new home such that it will be safe from damage caused by volcano eruption. Students work in teams to collect and analyze data regarding volcano location and eruption patterns. Over the course of multiple years, this teacher has built a database of nearly 200 entries of data pertaining to various volcanos. Each time this project is assigned, students add to the collection of data, and then use an interactive map pinpointing volcano eruption patterns to make a recommendation as to

where it is safe to build a home. This lesson requires students to utilize a large data set to examine patterns in order to make and justify predictions, a level of application that is seen in lessons from CSCS participants with multiple years of experience. Examples of the artifacts submitted with this lesson can be found in Appendix I: Lesson Artifacts.

When veteran CSCS participants are asked why they continue to attend CSCS programs and implement these strategies in their classrooms, they often reference the ease of data analysis when supported by the CSCS technology. Below is one explanation from a veteran participant, Teacher R, explaining her lesson, which also scored four points as measured by practice five.

The best thing about [CSCS] is, well for me, the best thing about it is the kids are really engaged in it. The second best thing is they get it. They understand it better. Then, they can see more data if you present it with the whole class data, that they never saw in their life. Because usually, I mean it's fast. They like instant feedback. That's what I like about it too, because if I get it working correctly, then we could all see our result and they can quickly find, you know some weird result that's in the next. They can find the outliers and they're really good at spotting trends and stuff like that if you can get it all together.

Teacher R also highlights some of the challenges of implementing CSCS, specifically the challenges presented by getting the technology to function properly. These challenges and the need for continued support to overcome these challenges likely contributes to desire of veteran CSCS participants to return to the program for subsequent years.

Additionally, experience in handling these challenges likely contributes to the differences in implementation between first year and veteran participants.

Shift in Instructional Practice

Further evidence to support the implementation of these two particular NGSS Science and Engineering Practices was also reflected in the overall shifts in classroom practice as demonstrated by CSCS participants. CSCS teacher participants from both programs reported changes in classroom practice specific to the use of data analysis. Further, teacher participants new to either CSCS program have also demonstrated a decline in reliance upon traditional textbook and worksheet activities following their first year of CSCS professional development.

Frequency of Data Pooling and Graphing. CSCS participants in both IPD and WPD were asked “How often do you combine student data into a single spreadsheet and graph this data?” This question was posed at four intervals; prior to the summer programs of 2013, in the winter of 2013, prior to the summer programs of 2014, and again in the winter of 2014. Respondents were given the opportunity to report the frequency of this activity in their school year classrooms using the following scale. 0= Never, 1= Once or twice a semester (1-4 times), 2= Monthly (5-10 times), 3= Weekly (11-40 times), 4= Most days (more than 40 times). Responses were coded numerically and results from each program over each of the two years were graphed in Figure 5.

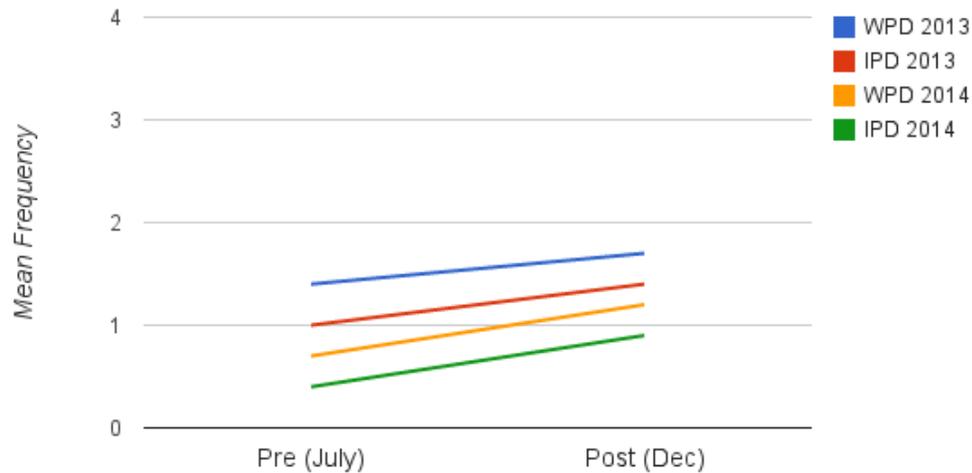


Figure 5. Frequency of Data Pooling and Graphing. Mean frequencies for IPD and WPD in 2013 and 2014 reported in response to the questions, “How often do you combine student data into a single spreadsheet and graph this data?”

In 2013, WPD participants reported a mean frequency of data pooling and graphing of 1.4 prior to program participation while IPD participants reported a mean frequency of 1. Following the 2013 program, both groups demonstrated an increase in mean frequency of use of data pooling and graphing with WPD participants reporting an average frequency of 1.7 and IPD increasing reported frequency to an average of 1.4. This trend continued in 2014. During the second year of the study, WPD participants reported a mean frequency of 0.7 prior to summer participation. Similarly, IPD participants reported a mean frequency of 0.4 in the pretest interval. After the summer of 2014, WPD participants and IPD participants both demonstrated an increase in frequency of data pooling and graphing with mean scores of 1.2 and 0.9 respectively.

When asked about implementing data pooling and electronic graphing, many teacher participants reflected on the benefits of using technology to facilitate the creation

of graphs. There was also discussion about the cumbersome process of having students graph by hand. Teacher O reflected,

The one other thing that I noticed was a lot of my students, probably especially the girls, liked to make [the graph] look pretty and everything, so they often get the job of doing the writing. If they don't know what they're doing, but they can still make a really pretty title, so they would spend a lot of time making bubble letters with polka dots and color coded. It was awesome, but they didn't have a clue what the heck they were doing with their numbers.

In this example, Teacher O highlights the tendency of students to use artistic skills to make a graph look nice, but also mentions the danger in this as there is no evidence that the student understand the trends in the data when using this method.

Teacher C also reflected on purpose of graphing,

but to me as long they know the basic of what's an x-axis, what's a y-axis, and how to read a graph, I think that's more important than them actually creating the graphs. It's like long division. Do you really want to show a kid long division, or do you want them to understand what long division is?

Here, Teacher C demonstrates an understanding of the application aspects of reading a graph, rather than just the mechanical skill of creating a graph.

Both of these excerpts reflect a shift in thinking, as they demonstrate they teachers' priorities when it comes to graphing. After participating in a CSCS program, teachers are more likely to value a conceptual understanding of patterns in data.

Therefore, they are more likely to implement data pooling and electronic graphing in their school year classrooms.

Use of Textbook and Worksheet Driven Activities. In addition to an increase in computer assisted graphing, CSCS teachers from both programs who were in their first year of CSCS, reported an increase in data analysis activities coupled with a decrease in textbook and worksheet driven activities. Participants were asked “How often did you have students read or complete assignments from the textbook or a worksheet?” and “How often did you have students analyze data in order to describe results or formulate explanations?” Both questions were asked at four points during the study; prior to CSCS programs in July of 2012, in a follow up survey in the spring of 2013, prior to summer workshops in July of 2014 and again in the winter of 2014. This question was not posed to participants of the 2013 summer cohort. Respondents reported the frequency of both activities on a scale of one to four. Responses were then numerically coded as follows: 0= Never, 1= Once or twice a semester (1-4 times), 2= Monthly (5-10 times), 3= Weekly (11-40 times), 4= Most days (more than 40 times).

Data from first year respondents’ pre and posttest responses in both 2012 and 2014 were combined. These results related to textbook and worksheet use are displayed graphically in Figure 6. Prior to participation in a CSCS program a majority of teachers, 58% (15/26), relied on a textbook or worksheet activity either once a week or on most days. After participation in one summer of CSCS professional development, this number dropped to 35% (9/26). Further, following CSCS participation, a majority of teachers, 65% (17/26) used a textbook or worksheet once a month or less.

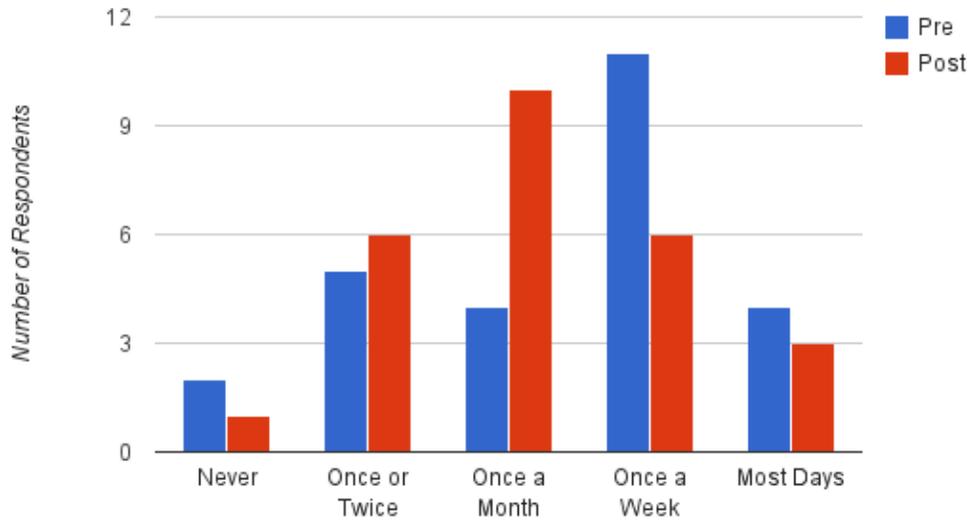


Figure 6. Frequency of Textbook and Worksheet Driven Activities. Response of first year CSCS participants to the question “How often did you have students read or complete assignments from the textbook or a worksheet?” ($N=26$)

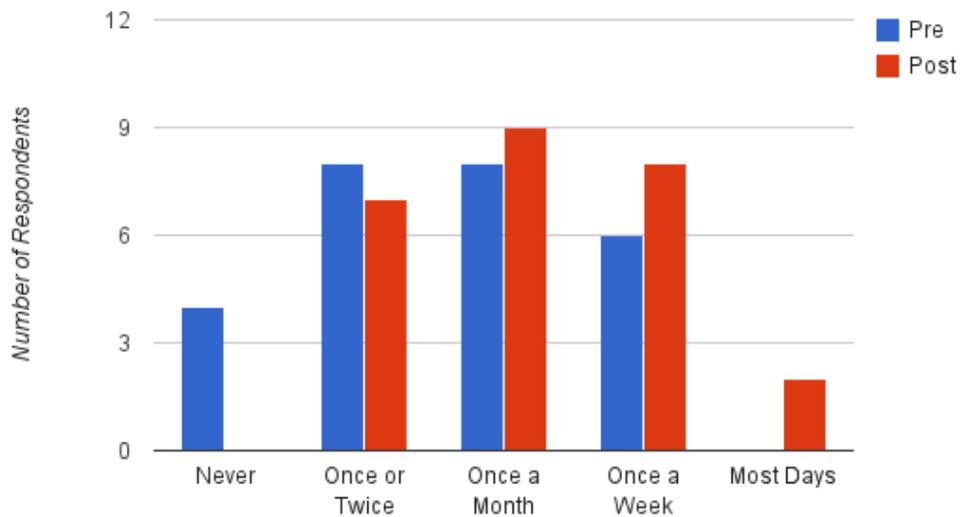


Figure 7. Frequency of Data Analysis Activities. Responses of first year CSCS participants to the question, “How often did you have students analyze data in order to describe results or formulate explanations?” ($N=26$)

Similarly, responses reporting frequency of data analysis activities are displayed graphically in Figure 7. Prior to attending a CSCS professional development program,

four teachers ($N=26$) never employed data analysis activities in their classrooms. Further, 46% (12/26) engaged in these activities once or twice or less. After completed one year of a CSCS program, 38% (10/26) of participants were utilizing data analysis activities once a week or more, a number that was up from 23% (6/26) prior to program participation. Notably, following CSCS professional development participation, all first year participants employed data analysis at least once in their school year classroom.

When asked to reflect on how participation in CSCS has changed teaching practice, IPD and WPD participants, both experienced and new, discussed a transition away from a text driven curriculum. Instead, they have started to rely on data analysis and conceptual understanding of patterns and trends to teach science.

A first year participant from the WPD group, Teacher P, reflected on her shifting instructional strategies.

[CSCS] opened up my eyes to not just giving the kids the information from the book... Previously, you know, I go through the vocabulary, you go through the book reading and you test kids. And when the opportunity arrives, you have them observe experiments, especially sixth-graders. Now, that I've had this opportunity and I see how much more they gain by doing more hands-on and getting them to talk, the hardest part I have right now is data analysis, because my kids, like all most kids coming up from the beginning, they are taught to listen and write, not discuss with each other. So the classes over the summer helped me be able to present questions, not that are yes, no, fill in the blank but critical, making them think.

This teacher also discusses some of the challenges of engaging students in data analysis. As she points out, not only is this a shift in educational practice for teachers, it is a shift in learning for the students. When students are accustomed to traditional forms of instruction, such vocabulary and reading as mentioned here, there is an adjustment period for students as well as teachers.

In a similar vein, an experienced IPD participant, Teacher S, discussed her transition in her approach to teaching science after multiple years of participating in CSCS activities.

To be honest, [CSCS] has really changed my program...when I first came in, I didn't know what to teach or anything like that. Many people mentioned standards but I didn't know what I was doing or anything so I just went off the book. Okay, chapter one, chapter two, chapter three... But, with [IPD] I started looking at consolidating concepts and not necessarily keeping them separate like they are in the book or separate like they're written in the standard. I started blending concepts...I think I got away from being so rigid and so strict in the structure and the order of ways things have to be taught...I don't necessarily have to focus on a particular concept but more about the real world problems that have to do with the concept.

Here, this teacher shares her journey away from a set order of instruction as prescribed by a text and toward a more integrated, conceptual approach to teaching science. Her commentary accurately reflects the data from new CSCS teachers who have not previously participated in the program. Many of these teachers are teaching a textbook,

one chapter to the next. It is only after multiple years of CSCS, and multiple opportunities to practice these skills, do CSCS teachers demonstrate this level of change.

Regardless of experience level or program enrollment, CSCS participants reported an increase in the frequency during which their students were engaged in data analysis activities after completing a CSCS professional development program. Overall, teachers from both IPD and WPD programs showed growth in Science and Engineering Practice 4, “Analyzing and Interpreting Data” and Practice 5, “Using Mathematics and Computational Thinking”.

Artifact analysis of lesson plans also demonstrated that lesson plans from first year CSCS participants were more likely to demonstrate proficiency in NGSS Science and Engineering practice 4 while veteran teachers, whose lessons also demonstrated proficiency in practice 4, also demonstrated proficiency in practice 5. Additionally, it was found that the level of experience that a teacher has with CSCS impacted the type and degree of growth observed. When examining the practices of first year CSCS participants from both programs, the increase in data analysis activities was paired with a decrease in the use of more traditional instructional strategies, specifically textbook and worksheet driven activities.

Implementation of CSCS

The third sub research question, “To what extent do participants from either program differ in their implementation of the CSCS data collection and analysis skills learned in the PD?” was addressed primarily through closed ended survey questions asked of participants at various points in the CSCS programs. Like the previous sections, teacher participants from both programs were surveyed three times for each year of

CSCS participation, once prior to the summer program, again immediately after completion of the summer program, and then again in the winter following one semester of school year implementation. Additionally, semi structured interviews were used to explore factors influencing school year implementation of CSCS.

Following each summer program, both in 2013 and 2014, IPD participants finished the summer with higher confidence levels and increased plans to implement CSCS as compared to their WPD counterparts. However, during the school year, the confidence level of IPD participants drops to mirror that of WPD participants. In looking at actual school year implementation, equal amounts of IPD and WPD participants had reached the desired model of CSCS implementation. Similarly, comparable numbers of participants from each group had not implemented any CSCS at all. Like the science teaching practice measured in the previous section, it is a teacher's experience with CSCS that lead to increased school year implementation. It was found that multiple years of CSCS involvement result in greater frequency of school year implementation. Finally, various factors impacting the teachers' ability to implement CSCS were investigated. Lack of support of the school site administration and lack of access to technology emerged as predominate themes impacting school year implementation.

Confidence Levels

Following both the 2013 and 2014 summer programs, participants were asked to describe their confidence with the CSCS teaching and technology tools for use during the coming fall semester. Over both years, IPD participants were more likely to report to that they were "Highly Confident" in their abilities to implement CSCS upon the conclusion of their summer program as compared to WPD participants.

As seen in Figure 8, in the summer of 2013, 80% (12/15) of IPD participants classified themselves as “Highly Confident” as compared with 39% (7/16) of WPD participants. Figure 9 depicts the responses from 2014 participants. Similarly, 68% (13/19) of IPD participants reported being “Highly Confident” in their ability to implement CSCS in the fall, as compared with 37% (7/17) of WPD participants. Over the span of two years, 73.5% (25/34) of IPD participants reported feeling “Highly Confident” in their abilities to implement CSCS in their school year classrooms as compared to 40% (14/35) of WPD participants when asked to describe their confidence in implementing CSCS at the end of each respective summer program.

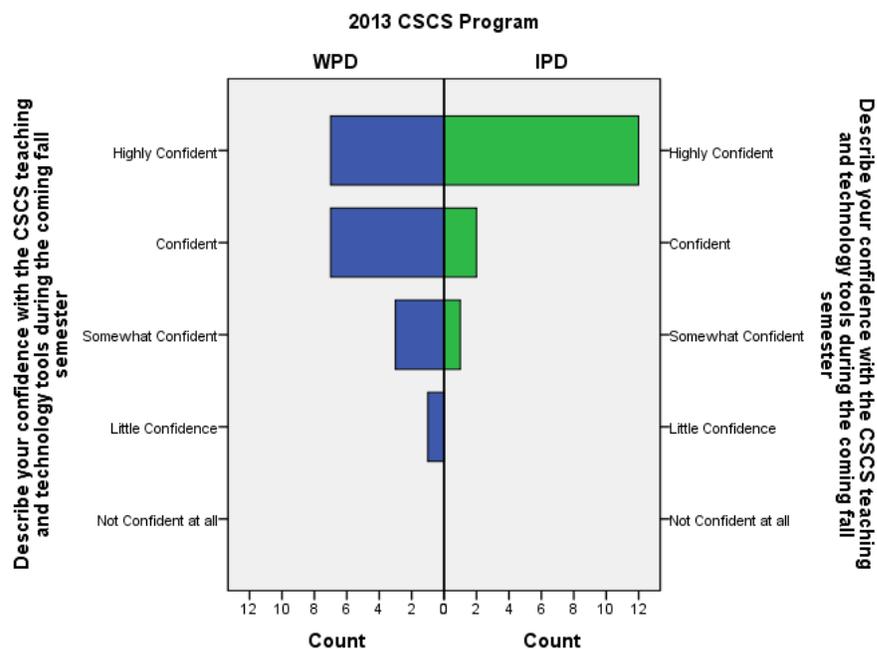


Figure 8. CSCS Implementation: Confidence Levels Post PD July 2013 (n=33)

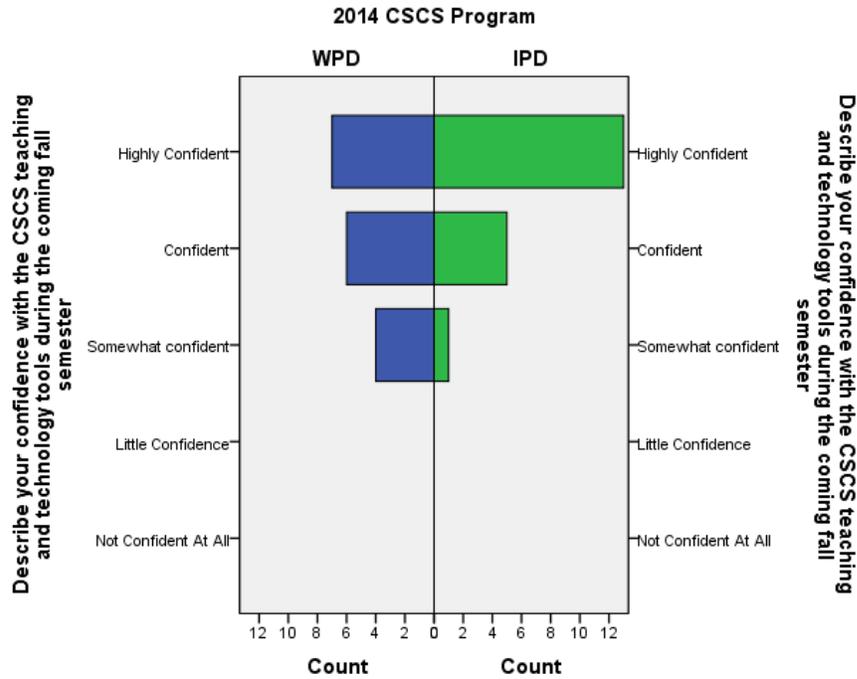


Figure 9. CSCS Implementation: Confidence Levels Post PD July 2014 (n=36)

While IPD participants reported higher confidence levels immediately upon completion of their summer program when compared to WPD participants, after a semester of school year implementation, IPD participants demonstrated a drop in confidence levels. Participants of both programs were asked to describe their confidence in their ability to implement CSCS in their school year classroom in the winter of 2013 and 2014. Responses are depicted in Figures 10 and 11. In the winter of 2013, 20% (2/11) of IPD participants reported feeling “Highly Confident” in their ability to implement CSCS in their school year classroom, down from 80% six months earlier. Of the original 18 WPD respondents, 16 responded in the winter and demonstrated a confidence level similar to that reported at the end of the summer program, with 37.5% (6/16) feeling “Highly Confident.” Results were similar for the winter of 2014. Only

one IPD participant, 17% (1/7) still expressed that she was feeling “Highly Confident”, again a decrease from 68% the previous summer.

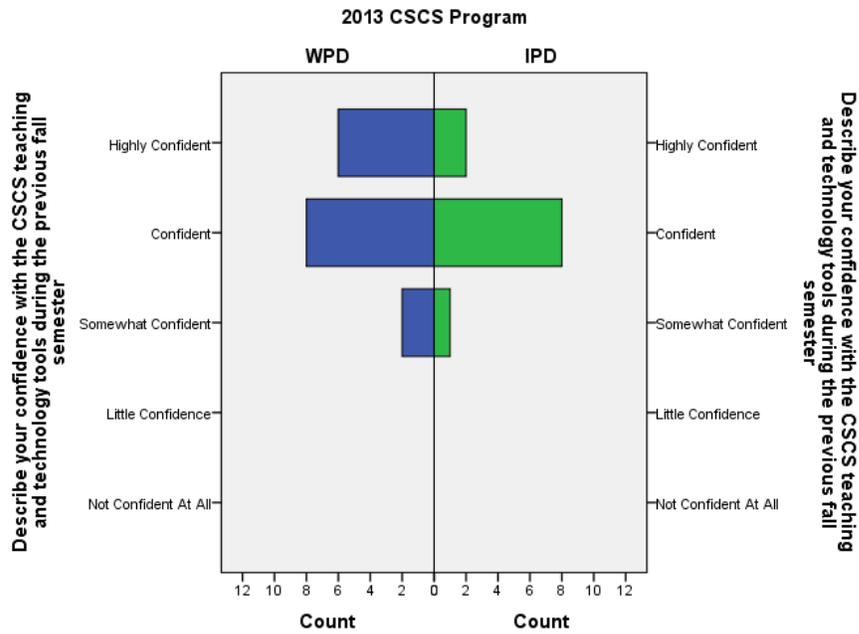


Figure 10. CSCS Implementation: Confidence Levels December 2013 (n=27)

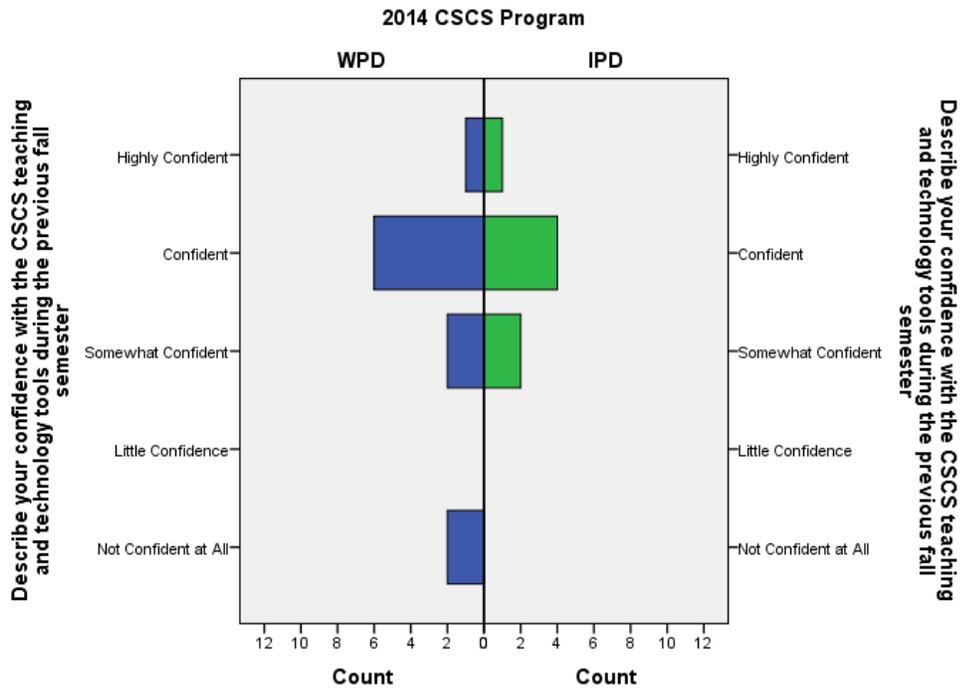


Figure 11. CSCS Implementation: Confidence Levels December 2014 (n=18)

Plans to Implement CSCS

Upon conclusion of the summer 2014 programs, participants of both the IPD and WPD program were also asked how often they were planning to implement CSCS in their school year classrooms. Results from this question are presented in Figure 12. While the majority of respondents from either program reported plans to implement CSCS on a monthly basis, 53% (10/19) for IPD and 65% (11/17) for WPD, IPD participants were more likely than WPD participants to have planned daily implementation of CSCS. In late July of 2014, 47% (9/19) of IPD participants reported that they planned to implement CSCS on “most days” during the coming school year, as compared to 17.5% (3/17) of WPD participants.

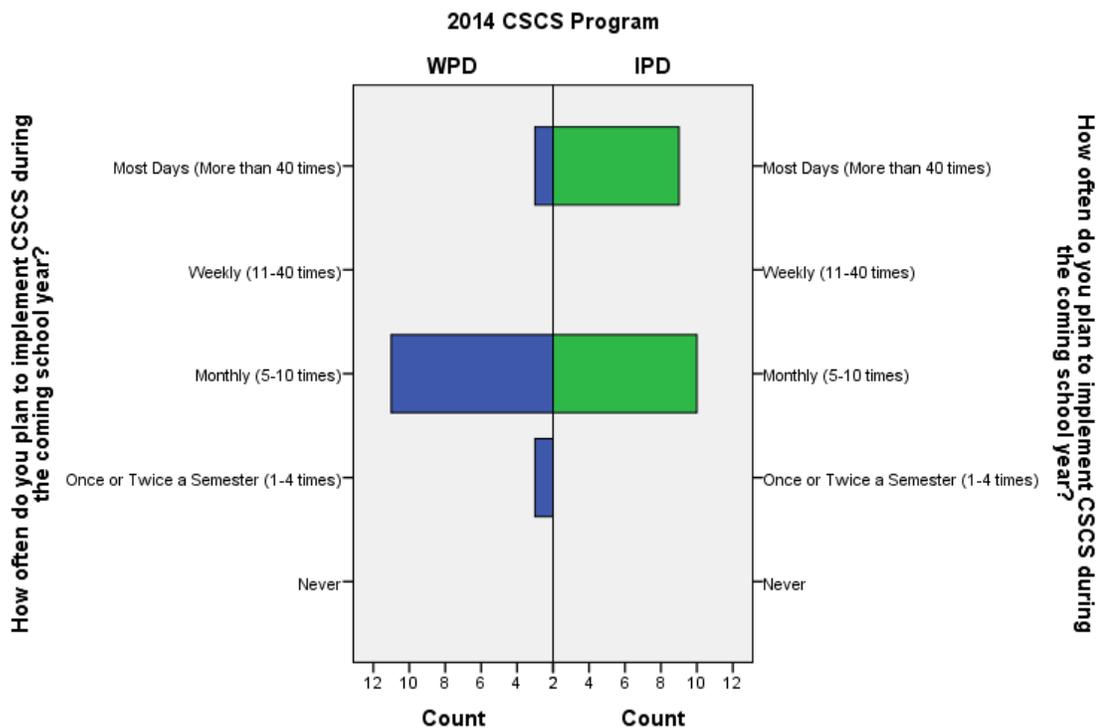


Figure 12. Plans to Implement CSCS Post PD July 2014 (n=36)

Type of Implementation

While IPD participants tended to conclude the summer with higher confidence levels and plans to implement CSCS with greater frequency than their WPD counterparts, the actual school year implementation of CSCS is similar for participants of both programs. In the winter of both 2013 and 2014, participants were asked to select a statement that best corresponded with their implementation of CSCS so far during the school year. Responses were then scaled based on their level of CSCS implementation and numerically coded as follows 0= I could not/did not use CSCS, 1= I used CSCS for the presentation of content (PowerPoint, video, external websites), 2= I used CSCS to create a class website for students to access agenda, information, or activities and created quick writes, 3= I used CSCS to create moderator, spreadsheets, charts, and graphs for student input and to analyze information, 4= Students used CSCS to create charts and graphs, reports, presentations, or multi-media products. Each category was then renamed to reflect the type of CSCS implementation. The distributions of responses to this question are displayed below in Figure 13.

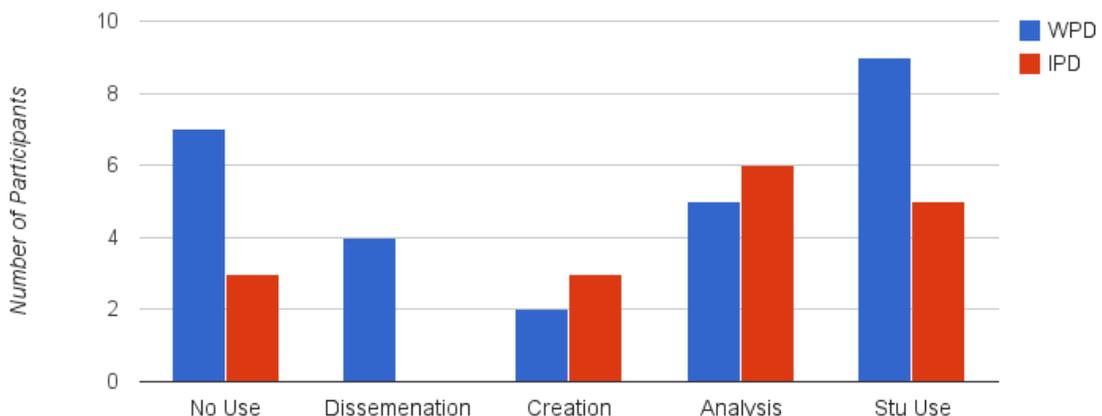


Figure 13. Self-Reported CSCS Implementation by Type ($n=44$). Data is combined from both December of 2013 and December of 2014.

Overall, approximately one third of participants from each group, 29.4% (5/17) from IPD and 33.3% (9/27) from WPD reported using CSCS as it is typically intended, for student use. In further examining the distribution of results, IPD participants slightly out performed WPD participants in type of CSCS implementation. Not only do IPD participants have a lower rate of “No Use” with 17.65% (3/17) versus 26% (7/27) for WPD, but no IPD participants report using CSCS solely for the dissemination of information. Instead, 35.4% (6/17) of IPD participants report using CSCS to engage students in analysis, as compared with almost half as many WPD participants at 18.5% (5/27). While IPD and WPD have almost equal percentages of participants employing CSCS for student use, of participants not engaging in this practice, the IPD group has a higher proportion of participants using CSCS in higher level applications.

Frequency of Implementation

In addition to asking participants to describe how they implemented CSCS in their school year classrooms, a composite CSCS implementation score was also calculated using multiple measures of implementation. All of the following activities can be considered part of CSCS implementation, using quick writes or clickers, engage in data pooling and electronic graphing, editing and creating collaborative texts, using Google Moderator or Edmodo for class discussions, and maintaining a class website. Participants were asked how frequently they engaged in each of these activities. Responses were numerically coded as follows 0= Never, 1= Once or twice a semester (1-4 times), 2= Monthly (5-10 times), 3= Weekly (11-40 times), 4= Most days (more than 40 times). Values for each of the six categories were then averaged. The resultant value served as the CSCS implementation score for each individual.

Participants were asked to report on the frequency of these activities before and after the summer programs of 2013 and 2014. Results from this calculation are displayed below in Figure 14. In each program, as well as in each year, participants demonstrated growth in their CSCS implementation score. While some programs started with higher pretest scores, for instance the WPD group in 2013, and other didn't have as much growth, like the IPD group in 2014, each subgroup increased their CSCS implementation after participating in a CSCS PD program.

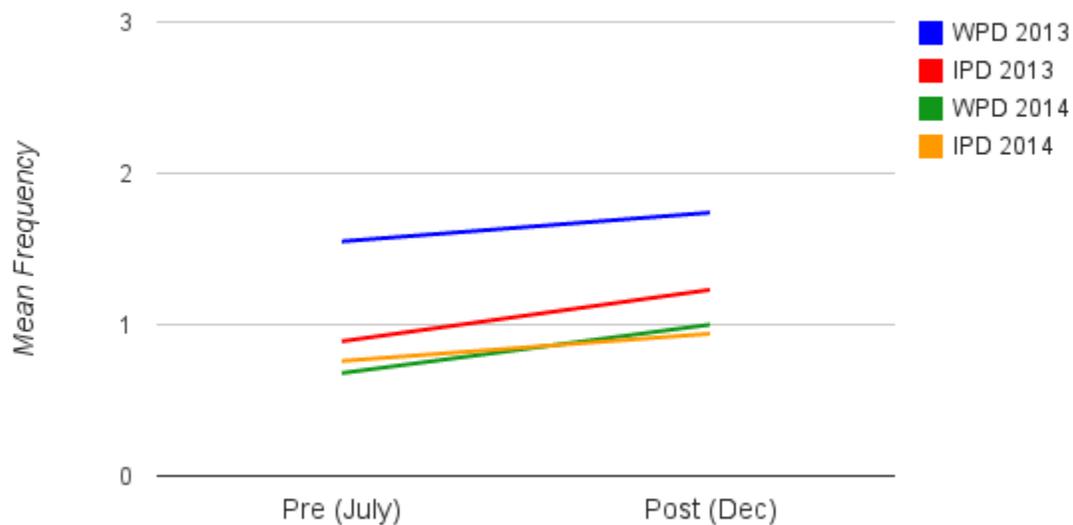


Figure 14. Average Self-Reported CSCS Implementation by Program

In addition to comparing CSCS implementation scores to program participation, CSCS implementation was also compared with experience with CSCS. CSCS experience was also determined numerically. A point system was applied to each CSCS participant, weighing their experience with various CSCS activities. This variable is referred to as CSCS Experience score. In establishing CSCS experience, participants were awarded one point for each summer CSCS program in which they participated (dating back to 2012). Participants who partook in dual sessions during the summer of 2013 were

awarded 2 points, one for each experience. Additionally, CSCS students who also participated in either of the two MA programs taught by CSCS faculty earned 2 points, 1 point for each year of coursework in the program. Finally, participants who also completed the CSCS Massive Open Online Course (MOOC) received an additional point. Points were calculated upon completion of the summer of 2014. Therefore, experience scores range from one point to five points.

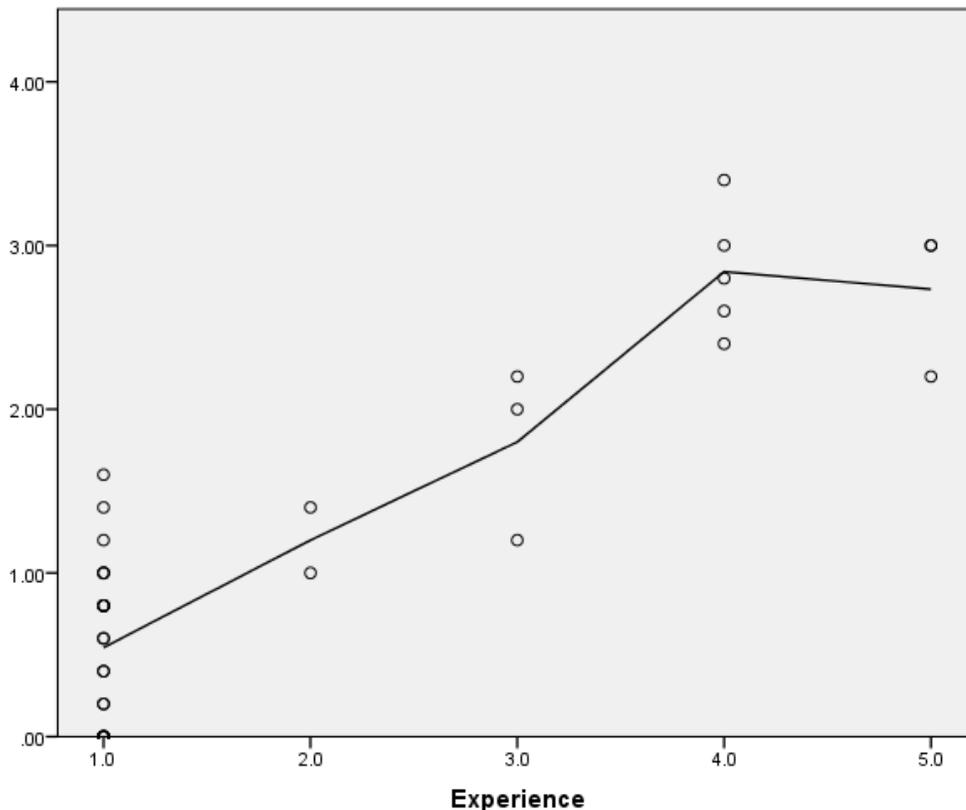


Figure 15. CSCS Implementation vs Experience.

When CSCS implementation scores were compared to CSCS experience scores, it was found that increased experience in the CSCS program tends to result in a higher frequency of CSCS in the school year classroom. The relationship between these two variables is depicted graphically in Figure 15. This corroborates earlier findings in which experience in CSCS was tied to more fully developed perceptions of teaching science, as

well as higher scores in implementation of the NGSS Science and Engineering Practices. It is also worth noting that retraining CSCS participants were invited to return based on their success in previous years. It is expected that these participants would outperform first year participants, as they had already demonstrated their ability to implement CSCS with some degree of success.

Factors Impacting Implementation

While experience, to a greater extent, and PD program, to a lesser extent, impacts a teacher participant's implementation of CSCS, there are also external environmental factors impacting implementation. During semi structured interviews in the fall of 2014, teacher participants from both programs commented on many barriers to CSCS implementation. In explaining the challenges of implementation, the themes of access to technology and administrative support became clear.

Access to Technology. For most CSCS teachers, outdated technology presents a challenge in their school year classrooms. While many have access to a few computers, they are often of poor quality or are not working at all. As Teacher L explains, "I have computers, but the computers were not good. Ninety percent of them were not working. One problem after another bug." Teacher O explains a similar situation,

So that's why I'm saying it's limited for me right now, because I don't have what I want. I did ask a few people if I could get...There's like a few old computers, like all we have are really old, like desktop computers they're I think from 2004 or something like that because that was the password, 2004. I think that was the year they were born (purchased) and there are two of them in our science room that we use.

Attempting to implement CSCS on a device that is over a decade old certainly presents challenges. Additionally, the second teacher above references having only two computers for her entire class of more than thirty students.

Even those who are working around the barrier of old or lacking technology comment on the time it takes to implement CSCS in an under outfitted environment.

Teacher Q explains how she uses CSCS in a one computer classroom:

I had them go up to the one computer in the classroom one by one and we made a list on the board and then they're little waiting for their turn. Then they'd go up there and take it and then they'd erase their name. Next kid. It only took like a day or two and they all had taken it because it's pretty quick.

Despite working with only one computer for a class of students, Teacher Q is still attempting to implement CSCS. From this quote, it is obvious that she has worked to develop a system that is passable, no matter how inefficient. She is even optimistic in her tone, stating that “It only took like a day or two.” Something as simple as data entry should be almost instantaneous with CSCS.

For others, even as late as November, the wait from the start of school back log continues. Teacher M explains, “I’m waiting on my computer guy on campus to come by and load the program because it's requiring a license key which I don't have. So that's going to make a big difference I think too.” In classrooms like this one, perfectly functioning computers sit idle, as teachers don’t have access to them.

Administrative Support. While most CSCS teachers report that their principals are aware of their work with CSCS, most teachers also mention that this knowledge has not helped them acquire the access to technology that they would like. In fact, many

teachers cite school site administration as one of the largest barriers to their implementation of CSCS.

In some cases, site administrators have put policy before student learning when it comes to using technology in the classroom. For instance, Teacher O explains,

What happened was while I was doing this in the lab, the principal walked in and I was like my kids are doing a little survey and he's like "ah that's good" and then he looked around and he looked around and then he left and then the very next day, he came out with this memo that we all have to have that A.U.P (acceptable use policy) form. So I think maybe that triggered it, because he saw they were using the internet.

While this teacher was not stopped from implementing her CSCS lesson, she felt that her principal's response was driven by fear of liability. This teacher later said that she would have felt better with just a few supportive words.

In other schools, policies about storing technology and preventing theft drastically impact the amount of instructional time that can be spent on CSCS. Teacher L explains, On minimum days or on those days that are short, I don't use [CSCS], because I know if I used it, there is not enough time. Ten minutes before [the bell] I collect all iPads making sure that iPads are safe. That's why I ended my lesson for using iPad ten minutes before, because I was told by my administrator to make sure that all iPads are placed ten minutes before... So thereby I cannot use it on those days that we have PD or minimum days.

In this case, the message is valuable; make sure that all iPads are accounted for before students leave, yet the ten minute requirement prevents this teacher from planning and executing complex lessons.

In other cases, school policies exist that prevent science teachers from accessing technology during a time and in a place that is conducive to the task at hand. In this case, Teacher O explains how her principal attempted to provide the technology she was requesting,

I've told [my principal], and he just nods. I don't think he's really seen [CSCS] in action or seen it working, so it's not really sinking in or it's not really a high priority. But when I ask for computer cart in a classroom, I was told that, because I teach an elective one period, so I was told I could go to a lab where we have a lot of Macs and we could do it there. But then I can't do the science there

Due to the principal's lack of understanding of the issue at hand, the desire to use computers in conjunction with a science activity, the teacher's request was not fully met. Now she spends valuable instructional time walking her students back and forth across a large campus in order to enter data into the computers.

Another CSCS teacher, Teacher S, has experienced lack of technology due to the structure of the school's scheduling.

There's a computer teacher who uses the computer lab for two solid periods and no one's allowed in the computer labs while he's teaching classes. Unfortunately, my biotech class which is also supposed to be getting credit for technology is during the same time period, so because he has the computer lab I don't get to use it during that same period. Then, we have two laptop carts and people are

supposed "reserve" the laptop carts for use. Then, I told the administration. They said, "Look. I've got this class and these kids are supposed to be getting technology integrated into this and I have no access to technology." It's not something that's guaranteed. If I come up with a lesson or plan, it's not guaranteed that I can walk in and have the kids do it because I've got to coordinate with all these other teachers to make sure that I have a cart for the kids.

Scheduling two technology classes at the same time, when there is only one computer lab available, is a problem that should be easily corrected. The solution to this shortage, to reserve a laptop cart, is obviously not a viable option, as this teacher also tells of many times when she has prepared a CSCS lesson and reserved the cart, only to find out on the day or period of her lesson that it will not be available.

It is worth noting that the CSCS team has purchased laptops available for participating teachers to sign out, the demand far outweighs the supply. While teachers cite the CSCS laptops as one of the sole reasons why they have been able to implement a few CSCS lessons, they also discuss long wait times. Additionally, there have been some issues getting the loaner laptops to work on the school's network. Some teachers have also met resistance from their administration, as site principals worried about security and theft of these loaner devices.

District. Not all of the commentary regarding implementation is negative. Teacher D tells of having "a mac, an iPad, and a chrome book for each student," while others talk of administrative support for not only the implementation of CSCS, but the sharing of the technique. More than one teacher mentioned that an interest in CSCS and a request to share CSCS with colleagues in a school or district supported forum.

The primary factor separating those participants reporting a positive implementation experience from those with a negative experience was found to be school district. As shown in Figure 16, when CSCS implementation score is compared to a participant's school district, the differences in growth are obvious.

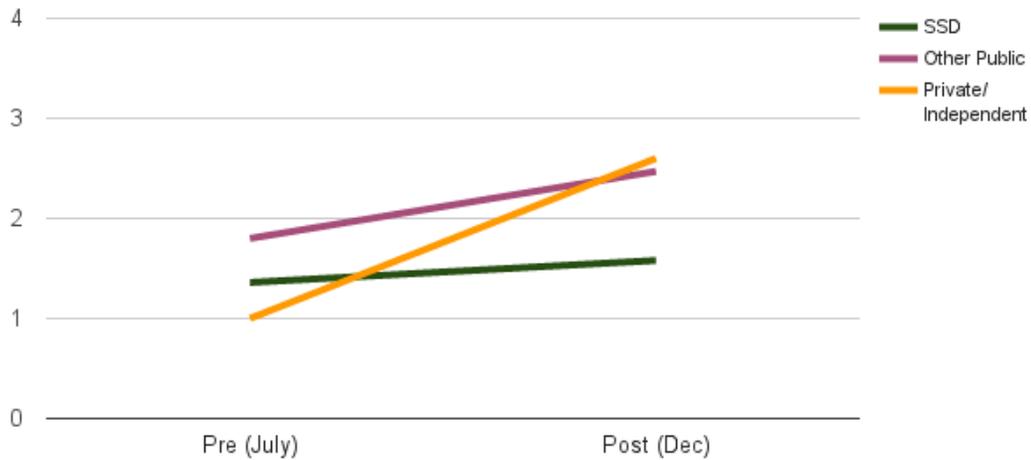


Figure 16. Average Self-Reported CSCS Implementation by District

Teachers in Southern School District (SSD) were more likely to report school site barriers to CSCS implementation and were also less likely to show growth in their CSCS implementation score. On the other hand, teachers at private and independent schools reported supportive school climates, ample access to technology, and showed the greatest increase in CSCS implantation. Other, smaller public school in the region demonstrated results in between these two extremes, and teachers at these schools reported moderate amounts of support at the school site.

Conclusion

In short, IPD and WPD are both effective methods of professional development, but both are more effective over the course of multiple years. In examining teachers' perceptions with regard to science teaching, it was found that experienced CSCS teachers, taking part in CSCS programs for a second year or more, more were likely to

include data pooling and large data sets in their definition of effective science teaching, as compared to first year CSCS participants. Similarly, the impact of IPD and WPD programs on teachers' practice of teaching science was positively influenced by increased experience in CSCS programs.

It was also found that more experienced CSCS teachers tended to implement science lessons that scored higher in all of the NGSS Science and Engineering Practices. In using the same measure, first year CSCS participants scored highest in practice 4, the area of data analysis. Interview transcripts support that this was an instructional shift for these teachers. Experienced CSCS teachers scored highest in practice 5, the area of mathematical and computational thinking, again placing value on teaching with large data sets. Additionally, it was found that teachers new to CSCS increased their use of data analysis in the classroom while simultaneously decreasing their use of textbooks and worksheets, thus shifting their emphasis toward inquiry.

In examining the impact of IPD and WPD programs on teachers' perceptions of teaching science, it was found that IPD participants are more likely to cite student collaboration as a key component of effective science teaching, whereas WPD participants are more likely promote critical thinking for students. In terms of implementation of CSCS, IPD participants tended to demonstrate more complex methods of implementing CSCS, but only slightly. Once again, it was experience with CSCS that was tied to increased implementation. Further, the school year barriers of lack of access to technology and lack of site based administrative support were identified. CSCS implementation saw the greatest gains in schools and districts outside of SSD.

While participation in either IPD or WPD can lead to differences in the way teachers think about and teach science, repeated exposure to either or both programs suggested a stronger connection to positive PD outcomes. Finally, the impact of professional development cannot be measured in a vacuum. Many factors, including school site leadership, district policies, and access to technology, have an impact on a teacher's ability to implement a new instructional strategy.

Chapter 5: Discussions and Conclusions

The discussion of this study's findings begins with a review of the purpose of the study as well as the guiding research questions. This chapter will then utilize the themes that emerged from data analysis along with the study's framework to report on each of the research questions. Next, recommendations for general professional development practices will be presented along with specific recommendations for the programs included in the study. Finally, implications for further research will be addressed.

Purpose

The purpose of this mixed methods study was to examine the impact of two professional development programs, Workshop Professional Development (WPD) and Immersion Professional Development (IPD) on teachers' perceptions and practices related to the teaching of inquiry-based science. Further, the degree to which teacher participants implemented the specific skills related to the content presented by both professional development (PD) programs; a pedagogy known as Computer Supported Collaborative Science (CSCS) was compared.

Research Questions

This study investigated the following research question as well as the three preceding sub research questions.

What impact do two specific professional development (PD) delivery methods have on teachers' perceptions and practices related to inquiry-based science?

- How do the different PD delivery methods in the two programs in the study impact teacher perceptions regarding inquiry based science?

- In what ways do these different programs impact teachers' classroom practice as it relates to inquiry based science?
- To what extent do participants from either program differ in their implementation of the CSCS data collection and analysis skills learned in the PD?

Discussion

While both IPD and WPD programs provided teacher participants with the opportunity to learn and practice the use of CSCS, primarily through clinical teaching opportunities, understanding the differences in these programs sheds light on the findings previously presented. IPD is truly an immersion experience for participants, as they take on the role of a summer school teacher for the length of their two week program. During this time, they plan lessons daily, collaborate with colleagues, and teach their students. Many of the day to day responsibilities of an IPD participant model those of a school year teacher. On the other hand, WPD participants have more frequent opportunities to take on the role of learner, rather than teacher. In the WPD program, participants receive direct instruction for a portion of the time and have the opportunity to plan and team teach one in depth lesson. When WPD teachers teach their lesson, which occurs twice during the two week program, they are a guest teacher in an existing class. Given this, they have fewer operational responsibilities as compared with IPD participants.

While the degree of clinical teaching varies by program, the inclusion of clinical teaching in both types of CSCS PD represents a commitment to allowing teacher participants to practice newly learned skills. As previously discussed, the use of clinical teaching for in service teachers is uncommon and makes both IPD and WPD unique programs. Additionally, CSCS, the specific pedagogy presented by both IPD and WPD

represents an innovative approach to science teaching. As such, multiple findings suggesting positive shifts in science instruction over time can be attributed to both the use of clinical teaching as well as the implementation of CSCS.

Perceptions

The first sub research question of this study focused on the change in teacher participants' perceptions regarding inquiry-based science after participation in the IPD and WPD program. In answering this question, "How do the different professional development (PD) delivery methods in the two programs in the study impact teacher perceptions regarding inquiry-based science?", it was found that while participants of both programs demonstrated changes in their perceptions, these changes in perception varied by program. WPD participants tended to value analytical thinking in inquiry based science teaching whereas IPD participants tended to emphasize collaboration among students. This was demonstrated by comments like that of Teacher D, who, after participating in IPD cited the keys to good science teaching as, "teaching collaboration in collecting data." Additionally, WPD participants, like Teacher G, who answered the same question by referencing "data analysis, problem solving and critical thinking."

Participants Model PD Process Factors

In referring to the framework for this study, presented earlier in Figure 2, it was found that the output of teacher perception is closely tied to the input of process factors. In other words, the process by which PD was delivered, either through WPD or IPD, impacted teachers' perceptions regarding inquiry based science. This finding is supported by the work of Borko (2004), who demonstrated that teachers, facilitators, and the PD program itself are all impacted by the context of the training. In this case, the

context set by each summer training, either WPD or IPD, impacted the changing perceptions of teacher participants.

Moreover, the delivery method of the PD in which participants were enrolled was also reflected in shifting perceptions of participants. Based on the findings of this study, it can be contended that teacher participants in nontraditional PD programs tend to value and emphasize the instructional practices with which the PD was delivered when it comes to their thinking about their own teaching. This is reflected by the type of values exhibited by participants of IPD and WPD. The process of delivering IPD is very collaborative. In this program, teachers participate in daily collaborative time with their colleagues. As a result of this PD delivery, IPD participants tend to cite collaboration among students as key to scientific inquiry. Similarly, the more independent, analytical nature of the WPD delivery is reflected in the tendency of its participants to include elements of analytical thinking when describing successful science teaching.

The connection between PD process components or delivery methods and teacher participants' perceptions regarding good teaching suggest that effective PD is that which models the instructional strategies that it seeks to pass along to teachers. The use of RTC in the IPD group allowed the facilitators to model peer collaboration, as the teacher participants in IPD collaborated with each other on a daily basis. Additionally, the direct instruction implemented in the WPD program created an environment in which teacher participants were able to engage in frequent critical thinking. Further, the clinical teaching components in both programs allowed participants the opportunity to apply the skills and practices they learned from both IPD and WPD.

Given that IPD participants engaged in daily collaboration themselves and then went on to value collaboration in their students and WPD participants engaged in daily problem solving as participants, while expecting the same of their students, it is suggested that teacher participants will model the PD delivery methods they experience when delivery content in the classroom. As such, when innovative instructional practices are listed among the goals of a PD program, the program will be more likely to achieve its goals if these same instructional strategies are modeled for teachers during the PD.

Changes in Perception are Lasting

In addition to perceptions reflecting the type of PD delivery participants experienced, it was also found that changes in participant perception were lasting in that changes that were reflected at the end of the summer session held true or even developed further at the midpoint of the school year. This is reflected specifically in the comments of Teacher A and Teacher B, who reflected on good science teaching both immediately after participating in summer PD and again after a semester of school year implementation. When asked about the keys to good science teaching, Teacher A responded in July, “Involving students in the reality of real science which involves discovery, inquiry and analysis.” Five months later, in December, Teacher A’s student-centered approach to teaching inquiry held true. This is reflected in her response to the same question, that in good teaching, “the emphasis should be on STUDENT LEARNING.”

Additionally, it was found that, regardless of the program in which a participant was enrolled, multiple years of participation in either PD program lead to more developed and equally lasting changes in perception. Participants in both programs showed a more

complete understanding of student centered inquiry as a component of good science teaching after participation in either program. Further, participants who returned for multiple years of PD tended to place increased value on data pooling as their time in either program increased.

This combination of lasting and developing perception change over time supports the findings of Lowden (2006) whose work establishes effective PD as that which is ongoing. Further, this finding suggests that the PD delivery in both IPD and WPD is effective, as participants in from either program, as well as those who partook in both programs over multiple years, demonstrated the same level of durable perception change. The role of repeated experience with CSCS PD, targeting successful teachers, is further explored in examining the classroom practices of teacher participants as described below.

Practices

In looking at teacher participants' classroom practice, as stated in the second research sub question, "In what ways do these different programs impact teachers' classroom practice as it relates to inquiry based science?", it was found that experience with CSCS PD programs, rather than either particular program, most impacted teachers' classroom practice. After one year of CSCS participation, classroom practices of participants shifted. In looking at first year CSCS participants, the frequency with which they engaged their students in data analysis increased in the semester of teaching following their participation in the program. Further, with this increase in data analysis activities came a decrease in more traditional instructional strategies, specifically those involving textbooks and worksheets.

Experience

While much existing research establishes short term, one time PD sessions as ineffective due to their lack of duration, few studies have establish a specific length of time that will result in lasting changes in teaching practice (Desimone, Porter, Garet, Suk Yoon, & Birman, 2002, Garet, Porter, Desimone, Birman, & Yoon, 2000, & Penuel, Fishman, Gallagher, Korbak, & Lopez-Prado, 2009). Those studies that have addressed the benefits of long term PD cite the need to revisit and practice skills, but do not provide a set duration for optimal benefits (Musanti & Pence, 2010). This study provides evidence that repeating a two week intensive PD program over multiple summers continues to result in increased gains in classroom practice over both two and three years of repetition, particularly when teacher participants are targeted based on successful implementation. This finding is reflected in the artifact analysis conducted on submitted lesson plans wherein returning CSCS participants' lessons scored higher on all eight NGSS science and engineering practices as compared to first year CSCS participants. This finding suggests that retention of participants from one year to the next is critical in maximizing the benefits of both the WPD and IPD programs.

Implementation

The final sub research question of this study, "To what extent do participants from either program differ in their implementation of the CSCS data collection and analysis skills learned in the PD?", focused on the implementation of the specifics of CSCS, rather than the more general topic of inquiry based science teaching. Like teacher practices, it was found that implementation of CSCS is increased with repeated CSCS experiences. In examining self-reported rates of CSCS implementation, multiple years of CSCS

participation, as well as participation in educational opportunities involving CSCS, led to increased implementation of CSCS.

Like teacher perceptions, it was found also that implementation of CSCS is heavily dependent upon context components. In this case, however, it is not the context of the PD program that impacts implementation, but the context and culture of the school site where the teacher is working during the school year. Context components of school sites, specifically access to technology and administrative support, were the determining factors in the success of participants in the implementation of CSCS. This phenomenon was exemplified by the comments of Teacher O, who encountered both technological issues, as well as a lack of administrative support in trying to mitigate these challenges. As she discussed, she feels that, for her site administrator, her efforts to implement CSCS as “not really a high priority.” As a result of this, she is currently dealing with “a few really old computers” dating back to 2004.

School Year Context

The importance of the role of school context in impacting PD outcomes is supported by the work of Guskey (2002), who found that the true outcomes of professional development programs are often difficult to measure as there are many confounding, external variables impacting implementation. Further, Guskey and Sparks (1996), include “administrator knowledge and practice” among the many factors that ultimately create the pathway from PD to student learning outcomes (Guskey, 2010, p.73). The role of administrative support in the success of implementing new programs suggests an increased need for communication between PD providers and school site and/or district level leadership.

Generalizability

While the findings from this study apply specifically to the IPD and WPD programs examined directly, many of the recommendations set forth for the CSCS PD programs can also be extended to other instances of non-traditional PD. Given that the participants in this study were secondary science teachers who volunteered to participate in an intensive transformational PD program, it is likely that these findings and recommendations are applicable to similar individuals in similar programs. Additionally, given the clinical teaching component of both IPD and WPD, findings from this study are likely to be applicable to other PD programs using clinical teaching for in-service teachers. Further, findings from this study, combined with the detailed description of IPD and WPD may also serve as a blueprint for other organizations wishing to incorporate clinical teaching into their existing PD programs.

It is not likely, however, that findings from this study would apply to traditional PD programs nor are they likely to apply to mandatory PD. In both traditional and mandatory PD programs, participants are more likely to feel that they are facing corrective action and will likely be less open to receiving new information when compared to voluntary participants in non-traditional programs (Musanti & Pence, 2010). Such beliefs are inconsistent with the philosophy and practice of the greater CSCS PD program and are not accounted for in this study of voluntary participants.

Recommendations

Based on the successes of the CSCS PD programs, it is suggested that transformational PD programs model the instructional practices they seek for participants to implement, repeat intensive programs across multiple years to maximize results, and

offer supports at the school site level to increase the chances of successful implementation. In order to maximize results, it is important for reform PD programs to invest in their participants in the form of ongoing support and continued opportunities. Rather than solely working to expand the number of teachers reached by a particular program, leaders of transformational PD are reminded to continually develop their existing participants.

Modeling

Given the fact that teacher participants are likely to value and perpetuate the types of instructional strategies they receive during transformational PD, it is important that such programs effectively model the instruction that they wish to transfer to teachers. This practice is especially important when it comes to PD delivery for science teachers. The unique nature of inquiry based instruction, paired with the importance of proper, complete implementation of the pedagogy, requires careful dissemination of proper practice. As such, modeling complete inquiry for science teachers is necessary to convey the idea successfully.

Further, the use of clinical teaching is vital to the facilitator's ability to monitor the impact that this modeling is having on participants. Clinical teaching allows PD facilitators to coach and guide participants in a setting that closely reflects the instructional environment those participants will return to during the school year. When facilitators wish to observe skills presented during PD in the school year classroom, clinical teaching provides a much needed opportunity for participants to practice new skills, thus increasing the odds of successful implementation.

Duration

The increase of inquiry-based instruction seen in participants after multiple years of participation in the PD programs reinforces both the need for follow up after the initial PD program as well as the need for the opportunity for participants to take part in the PD more than once. When it comes to the duration of successful PD, a component of ongoing follow up, paired with repeated opportunities for intensive sessions, is likely to yield the greatest outcomes in terms of classroom practice. Given this, it is not only necessary to offer these follow and repeated experiences, it is critical that PD leaders take step to retain teachers over multiple years.

Support

Teachers who were most successful in implementing the new skills they learned during PD when they returned to a school environment that was supportive of their implementation efforts, thus emphasizing the need to foster collaboration between PD programs and local schools. It is up to the leaders of PD programs to communicate with local schools to determine how the two groups can best work together to support their teachers. Further, partnerships between school site leadership and those providing professional development will increase the odds of successful implementation.

CSCS

In addition to the general recommendations above, this study has also yielded several recommendations specific to the two CSCS programs under investigation, IPD and WPD. By altering both existing policies and practices, the CSCS team can work to improve outcomes for teacher participants while still maintaining the original values of the program. Additionally, implementing a strategic action plan for success will allow

the team to better conduct a focused effort to invest in existing teachers while still expanding their reach to new individuals interested in participating in CSCS PD.

Changes in Policy. From its inception, CSCS was founded based on the belief that offering voluntary PD to interested teachers would serve as a grassroots effort to insert increased amounts of quality instruction into local schools. Encouraging teacher participants, rather than school administrators, to refer their colleagues to this program worked to further this thinking. While the teacher-first aspect of this philosophy has been successful and is worth preserving, these teacher participants need to be viewed as part of a dynamic school community, rather than in isolation. In order to best support teacher participants in their school year classrooms, the CSCS team is advised to reach out to local district and site administration, not as barriers to implementation, but as partners in the success of the teachers shared by both the CSCS program and the school sites.

Changes in Practice. In order to progress toward this partnership, the CSCS team will need to take the first steps by reaching out to SSD leadership. In doing this, they will first create awareness of the opportunity that CSCS PD offers. Additionally, they will begin the journey of fostering site based supports that are necessary for the successful implementation of CSCS. This change in practice does not need to replace their outreach program to local educators. Instead, contact with school and district leadership can serve as an additional form of community outreach.

Next Steps. In moving forward, the CSCS team is advised to reexamine the PD offerings and delivery methods for the coming year. Instead of offering both IPD and WPD, the team may want to consider offering one program where the primary delivery method is inquiry-based. Based on findings from this study, using inquiry to deliver PD

should increase the use of inquiry-based instruction by PD participants. Further, the team should seek to recruit a majority of returning participants while opening a few spots to new members. Based on the classroom practice outcomes of returning teachers, investing in current participants ought to maximize outcomes.

It is also suggested that the team create an informational publication that can be used both for recruitment as well as informing local district and site leadership of the CSCS program, its goals, and its offerings. Using the findings from this study, the CSCS team can use their offerings to appeal to local districts' need for support in implementing the Next Generation Science Standards. Additionally, the team can capitalize on their existing ability to provide technology to classroom teachers in order to garner support.

As the team begins to meet with school site leadership, they may wish to begin with school sites where long term CSCS PD participants are teaching. This will allow them to forge relationships at sites where CSCS implementation is already taking place. In doing this, they will be able to provide an overview of the program for site administration and possibly take site administrators to see the program in action in their own classrooms. In time, they will then be able to use these school sites as success stories in appealing to additional sites.

Implications for Future Research

The findings of this study highlight two areas of interest for future research. First, in order to generate the greatest gains from the investment in these PD program, it is suggested that study teacher retention and motivating increased number of teachers to repeat CSCS PD programs would result in desirable results. Additionally, the findings from this study provide evidence of both changes in teacher perception and practice after

participating in CSCS PD. This lays the groundwork necessary to begin investigating the impact that this PD has on the students in the school year classrooms of participating teachers.

Teacher Retention

It is now known that multiple years or cycles of exposure to either CSCS PD program result in increased use of inquiry in the secondary science classes of participants. At the same time, CSCS PD, as it currently exists, has more new teachers each year than it does returning teachers. Given this, a more concentrated effort ought to be made to investigate what factors contribute to teacher retention in this and similar PD programs. Additionally, it would be advantageous to track and entice teacher participants to return to the program for multiple years. A research based plan to support returning teachers will work to extend and protect the initial investment in their professional development.

Student Outcomes

Initially, student engagement and student achievement were beyond the scope of this study. Prior to this study, the impact that CSCS PD had on teachers was not known, and neither was the rate of CSCS implementation. Now that program participation has been tied to changes in teacher participants' perceptions and practices regarding science teaching, as well as attempted implementation of skills learned, the question of student outcomes arises. Future research on CSCS PD in particular, or on transformational PD in general, may include student outcomes. Given the nature of inquiry-based instruction, it is suggested that these outcomes include student engagement, student self-efficacy, and

students' desire to enroll in advanced science courses in addition to traditional measures of academic achievement.

Summary

In compiling the findings in this study, several themes emerged. As suggested by the guiding framework for this study, the process of PD delivery, or the manner in which the PD was deployed, impacted teachers' perceptions. More specifically, it was found that participation in either WPD or IPD impacted the type of perception changes demonstrated by teacher participants. The findings of this study support the following PD delivery practices, modeling the instructional strategies the teachers are expected to emulate, providing ongoing opportunities to participate in continued professional development, and offering continued support for participants throughout the school year.

Further, it was found that the role of experience impacted teacher participants' perceptions as well as classroom practice. Multiple repetitions of either PD over multiple years, regardless of whether this PD was WPD, IPD, or some combination of the two, lead to an increase in inquiry-based classroom practices. Finally, multiple barriers to implementation presented. These barriers to implementation include limited access to technology and lack of administrative support. Such barriers were found to be dependent upon the context of the school site where the teacher participants worked during the school year. These barriers were also found to limit school year implementation at school sites where they were reported.

Based on these findings, the providers of CSCS PD are advised to consider the explicit use of inquiry in PD delivery. They are also encouraged to expand their PD

offerings for returning teachers. Finally, the CSCS team is advised to work with local district and site leadership to promote support for PD participants working to implement CSCS in their school year classrooms.

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Appendix A: Research Invitation

Professional Development for Science Teachers: Research Invitation

DESERT STATE UNIVERSITY

Dear Teacher,

I am writing to inform you about a dissertation study that is being conducted at Desert State University (DSU) regarding the impact of professional development programs on science teachers. Kelly Castillo, a doctoral candidate, is conducting the study as part of the Ed.D. degree requirements.

The purpose of Kelly Castillo's dissertation study is to compare the impacts of two professional development programs on the way science teachers think about and teach science. This study will add new knowledge to existing information regarding the effectiveness of different types of professional development. Your participation in this study would mean participating in three separate surveys over the course of the study as well as written reflections and a focus group during your participation in the professional development program. Finally, participants may be asked to complete one 30 minute interview during the fall of 2014.

Any personally identifiable characteristics, such as your name or school, will not appear in the study. Participating in this study is completely voluntary and you may withdraw at any time.

Your time investment in this study is greatly appreciated. If you would like to participate, please contact Kelly Castillo at [REDACTED] or [REDACTED]. Thank you in advance for considering participation in this study.

Best,
Kelly Castillo

Appendix B: Informed Consent Form

California State University, Northridge CONSENT TO ACT AS A HUMAN RESEARCH PARTICIPANT The Impact of Professional Development on Teachers' Perceptions and Practices Regarding Inquiry-Based Science

You are being asked to participate in a research study. The Impact of Professional Development on Teachers' Perceptions and Practices Regarding Inquiry-Based Science, a study conducted by Kelly Stellmach Castillo as part of the requirements for the Ed.D. degree in K-12 Educational Leadership. Participation in this study is completely voluntary. Please read the information below and ask questions about anything that you do not understand before deciding if you want to allow your child to participate. A researcher listed below will be available to answer your questions.

RESEARCH TEAM

Researcher:

Kelly Stellmach Castillo
Department of Educational Leadership and Policy Studies (ELPS)
18111 Nordhoff St.
Northridge, CA 91330- 8265
Kelly.Castillo.42@my.csun.edu

Faculty Advisor:

Dr. Brian Foley
Department of Secondary Education
18111 Nordhoff St.
Northridge, CA 91330- 8265
bfoley@csun.edu

PURPOSE OF STUDY

The purpose of this research study is to compare the impacts of two professional development programs on secondary science teachers' perceptions regarding the implementation of inquiry-based science and the impact these programs have on instructional practice.

SUBJECTS

Inclusion Requirements

You are eligible to participate in this study if you are a secondary science teacher participating in either ISE professional development program (IPD or WPD) and plan to teach secondary science in the fall of 2014.

Time Commitment

This study will involve approximately 15 hours of your time during the two week professional development program during the summer of 2014 as well as approximately five hours of your time during the fall of the 2014-2015 school year.

PROCEDURES

The following procedures will occur: You will complete a survey prior to beginning the summer professional development program. You will then complete daily written reflections during the program. On the last day of the program, you will complete another survey and may participate in a focus group. During the school year, you will be asked to post lesson plans to the website you created as part of the professional development program. You will also be asked to complete another survey during the school year. You may also participate in a 30 minute interview in the fall of 2014.

RISKS AND DISCOMFORTS

This study involves no more than minimal risk. There are no known harms or discomforts associated with this study beyond those encountered in normal daily life.

BENEFITS

Subject Benefits

The possible benefits you may experience from the procedures described in this study include the opportunity to reflect on your own practice as an educator.

Benefits to Others or Society

Participation in this study will contribute to a greater understanding of how professional development experiences for science teachers can be improved.

ALTERNATIVES TO PARTICIPATION

The only alternative to participation in this study is not to participate.

COMPENSATION, COSTS AND REIMBURSEMENT

Compensation for Participation

You will not be paid for your participation in this research study.

Costs

There is no cost to you for participation in this study.

Reimbursement

You will not be reimbursed for any out of pocket expenses, such as parking or transportation fees.

WITHDRAWAL OR TERMINATION FROM THE STUDY AND CONSEQUENCES

All teachers who receive training must agree to participate in the research. You are free to withdraw from this study at any time. **If you decide to withdraw from this study you should notify the research team immediately.** The research team may also end your participation in this study if you do not follow instructions, miss scheduled visits, or if your safety and welfare are at risk.

CONFIDENTIALITY

Subject Identifiable Data

All identifiable information that will be collected about you will be removed and replaced with a code. A list linking the code and your identifiable information will be kept separate from the research data.

Data Storage

All research data will be stored electronically on a secure cloud account that will be password protected.

The audio recordings will also be stored on a secure cloud account that will be password protected. The recordings will be transcribed and retained with the other research data. No information derived from this research project that personally identifies you will be released or disclosed without your separate consent, except as specifically required by law.

Data Access

The researcher and faculty advisor named on the first page of this form will have access to your study records. Any information derived from this research project that personally identifies you will not be voluntarily released or disclosed without your separate consent, except as specifically required by law. Publications and/or presentations that result from this study will not include identifiable information about you.

Data Retention

The researchers intend to keep the research data in a repository indefinitely. Other researchers will have access to the data for future research.

Mandated Reporting

Under California law, the researcher(s) is/are required to report known or reasonably suspected incidents of abuse or neglect of a child, dependent adult or elder, including, but not limited to, physical, sexual, emotional, and financial abuse or neglect. If any researcher has or is given such information, he or she may be required to report it to the authorities.

IF YOU HAVE QUESTIONS

If you have any comments, concerns, or questions regarding the conduct of this research please contact the research team listed on the first page of this form.

If you have concerns or complaints about the research study, research team, or questions about your rights as a research participant, please contact Research and Sponsored Projects, 18111 Nordhoff Street, California State University, Northridge, Northridge, CA 91330-8232, or phone 818-677-2901.

VOLUNTARY PARTICIPATION STATEMENT

You should not sign this form unless you have read it and been given a copy of it to keep. **Participation in this study is voluntary.** You may refuse to answer any question or discontinue your involvement at any time without penalty or loss of benefits to which you

might otherwise be entitled. Your decision will not affect your relationship with California State University, Northridge. Your signature below indicates that you have read the information in this consent form and have had a chance to ask any questions that you have about the study.

I agree to participate in the study.

I agree to be audio recorded

I do not wish to be audio recorded

Participant Signature

Date

Printed Name of Participant

Researcher Signature

Date

Printed Name of Researcher

Appendix C: CSCS Survey

Professional Development for Science Teachers CSCS Survey

Name:

Participation in DSU Science Education Programs

DSU provides a number of ways for science teachers to hone their craft, including the programs this summer. In most of our programs we talk about CSCS or Computer Supported Collaborative Science. It is a way to use computers to make science activities more effective through collaboration.

Please select the program you are participating in this summer:

IPD

WPD

Have you participated in any of the following programs through CSUN?

IPD Summer 2012

IPD Summer 2013

WPD Summer 2010

WPD Summer 2011

WPD Summer 2012

WPD Summer 2013

Science Education Master's Cohort

Ed. Tech. Master's Cohort

Why did you decide to participate in this summer teaching and training program?

(Free response)

Use the following scale for the next two questions:

- Not at all confident
- Little confidence
- Somewhat confident
- Confident
- Highly confident

Describe your confidence with the google tools you are learning about (we call CSCS) – How confident are you that you can implement CSCS tools successfully in your summer 2014 teaching? (Pre Test Only)

Describe your confidence with the google tools you are learning about (we call CSCS) – How confident are you that you can implement CSCS tools successfully in your 2014-15 school year classroom? (Pre Test and Post Test Only)

What other recent training have you had in teaching with technology in recent years?
(Free response)

Please use the following scale for the next sets of Likert scale questions.

- Never
- Once or twice a semester (1-4 times)
- Monthly (5-10 times)
- Weekly (11-40 times)
- Most days (More than 40 times)

PROFESSIONAL DEVELOPMENT:

Thinking about your professional development from last year: how often did you engage in the following:

I participated in institutes, workshops or in-service training related to science or science education during the previous school year

Thinking about your professional development from last year: how often did you engage in the following:

I participated in professional development activities with most or all of the teachers from my school.

Thinking about your professional development from last year: how often did you engage in the following:

I participated in professional development activities with most or all of the teachers from my department or grade level.

Thinking about your professional development from last year: how often did you engage in the following:

I participated in lesson design or planning activities with most or all of the teachers from my department or grade level

Thinking about your professional development from last year: how often did you engage in the following:

I reflected on my science teaching with most or all of the teachers from my department or grade level

Thinking about your professional development from last year: how often did you engage in the following:

I examined student work or assessment data with most or all of the teachers from my department or grade level

Free Response:

Briefly describe what topics or activities were emphasized most during this professional development.

TECHNOLOGY USE

Thinking about your teaching from the previous school year, how often did you employ the following technology-assisted instructional activities with students in your classroom? - Quickwrite (short answers in collaborative document / spreadsheet); clicker style

Thinking about your teaching from the previous school year, how often did you employ the following technology-assisted instructional activities with students in your classroom? - Data pooling and graphing (combine student data into a single spreadsheet)

Thinking about your teaching from the previous school year, how often did you employ the following technology-assisted instructional activities with students in your

classroom? - Collaborative text (shared document, report, wiki) for students to write collaboratively

Thinking about your teaching from the previous school year, how often did you employ the following technology-assisted instructional activities with students in your classroom? - Collaborative presentation, drawing, video for students to present their knowledge

Thinking about your teaching from the previous school year how often did you employ the following technology-assisted instructional activities with students in your classroom? - Google moderator or discussion boards (e.g. edmodo forums)

Thinking about your teaching from the previous school year, how often did you employ the following technology-assisted instructional activities with students in your classroom? - Dynamic class website (how often did you use or update the website)

Thinking about your teaching from the previous school year, how often did you employ the following technology-assisted instructional activities with students in your classroom? - External websites, simulations, videos, brainpop, or other instructional material

Thinking about your teaching from the previous school year, how often did you employ the following technology-assisted instructional activities with students in your classroom? - Powerpoints or other non-collaborative technology to present information to students

Thinking about your teaching from the previous school year, how often did you employ the following technology-assisted instructional activities with students in your classroom? - Students post homework or assignments online

Thinking about your teaching from the previous school year year, how often did you employ the following technology-assisted instructional activities with students in your classroom? - Students do online research or access online materials for class from home

Thinking about your teaching from the previous school year, how often did you employ the following technology-assisted instructional activities with students in your classroom? - How often did you employ ANY technology-assisted instructional activities with students in your classroom?

Free Resonse:

What technology tools worked best with your students, and why do you say that?
What difficulties, if any, have you had using technology in your science classes?

SCIENCE INSTRUCTION:

Thinking about your teaching last year, how often were your science students engaged in the following activities? - Read or complete assignments from the textbook or worksheet

Thinking about your teaching last year, how often were your science students engaged in the following activities? - Write a report or prepare a presentation from a laboratory activity, investigation, experiment, or a research project

Thinking about your teaching last year, how often were your science students engaged in the following activities? - Open-ended expression of results, evidence, explanations, or reasoning (oral or written)

Thinking about your teaching last year, how often were your science students engaged in the following activities? - Ask and discuss testable science questions

Thinking about your teaching last year, how often were your science students engaged in the following activities? - Analyze data in order to describe results or formulate explanations

Thinking about your teaching last year, how often were your science students engaged in the following activities? - Provide feedback to classmates (peer review activities)

Thinking about your teaching last year, how often were your science students engaged in the following activities? - Engaged in science investigations, labs, or other hands-on activities

Thinking about your teaching last year, how often were your science students engaged in the following activities? - Work in collaborative groups (pairs and/or small groups)

Free Response:

For which activities did students in your classes work in collaborative groups (pairs and/or small groups)?

What do you think are the most important ideas or concepts for students to understand about the nature of scientific discovery and accumulation of scientific knowledge?

In your experience, what are the most important keys to good science teaching?

Discuss potential advantages to pooling data for an experiment across groups or classes.

CSCS: (Post & Delayed Post only)

Please use the following scale for the next three questions:

- Negative effect
- No noticeable improvement
- Slight improvement
- Significant improvement
- Excellent improvement

What effect have CSCS tools had on student learning in Science, Technology, Engineering or Math (STEM) subjects? - Student motivation towards STEM learning when you employ CSCS in your teaching?

What effect have CSCS tools had on student learning in Science, Technology, Engineering or Math (STEM) subjects? - Student self-efficacy in STEM learning when you employ CSCS in your teaching?

What effect have CSCS tools had on student learning in Science, Technology, Engineering or Math (STEM) subjects? - Student accountability towards their own learning when you employ CSCS in your teaching?

Appendix D: CSCS Focus Group Protocol
Professional Development for Science Teachers
CSCS Focus Group Protocol

I. Pre-focus group Session: Introduction/Background

Welcome and introduction:

Good morning/afternoon/evening. Thank you for taking the time to talk with me today. Before we begin the focus group session, I'd like to give you the opportunity to read and sign the Consent to Participate in Research.

Purpose of the focus group:

As we discussed, this focus group will be used collect information for a research study that examines professional development for secondary science teachers. During the focus group, we will talk about your experience with this summer's professional development program. Then we will talk about how you might implement some of the ideas from the summer in your school year class.

Confidentiality:

Any information you share with us today will be used for research purposes only. You will not be identified by name, department or office, position, or any other personally identifying information in any report or document. Today's focus group session will be audio-recorded. I will also be taking notes of the conversation. The audio recordings may be transcribed for analysis. The audio recorded file, transcribed file, and notes will be stored securely in a password-protected cloud account of the evaluator until completion of focus group analysis. Upon completion of analysis, files and notes will be destroyed. Only the researchers identified in the Consent to Participate will have access to the files and notes. The files and notes will be accessed and analyzed in strict confidentiality. Finally your name or personally identifying information will not be used in any published or public reports.

Informed consent:

This consent notice summarizes some information from the Consent to Participate in Research and communicates the procedures, potential risks and discomforts for subjects, potential benefits to subjects, payment to subjects for participation, participation and

withdrawal, and rights of research subjects. Procedures in this focus group are limited to semi-structured personal focus group sessions. Because the study deals with issues that are sensitive, some focus group questions may involve issues of a personal nature. You may feel uneasy about answering some of these focus group questions. You may elect not to answer any of the questions with which you feel uneasy and still remain as a participant in the study. You may not benefit personally from your participation in this study. However, findings from this study may lead to improvements in professional development programs for other teachers and may contribute to our knowledge on the subject. Your participation in this focus group is voluntary. You are not obligated whatsoever to answer or respond to any question or to discuss anything that you are not inclined to answer or discuss. You can skip any question, or any part of any question, and will not face any penalty for answering, or not answering, any question in any way. You may ask that the audio recording be stopped at any time and/or may leave the focus group at any time for any reason without consequences of any kind. You may withdraw consent at any time and discontinue participation without focus group. You can halt your participation in the focus group at any time. You are not waiving legal claims, rights, or remedies because of your participation in this focus group.

Identification and contact information of principal investigator:

If you have questions regarding your rights as a research subject, the details of this study, or any other concerns please contact Kelly Castillo at the mailing address: Department of Educational Leadership and Policy Studies, California State University, Northridge, 18111 Nordhoff Street, Northridge, CA 91330. Alternatively, you may Kelly via telephone at [REDACTED] or via email at Kelly.Castillo.42@my.csun.edu.

Timing:

Today's focus group will last approximately 60 minutes. Are there any questions before I get started?

II. Focus group Session

Main Questions

First, I will ask you some questions about the professional development program you completed this past summer as well as some questions about teaching science in general.

1. Describe the Computer Supported Collaborative Science (CSCS) program that you participated in this past summer.
 - a. How would you explain this program to a middle school science teacher who had not heard of it before?

2. Tell me about how you spent a typical day while enrolled in this program.
 - a. What components of this program make it unique, or different from other teaching experiences you've had?
 - b. How would you describe our daily meeting time? How did you usually spend this time?
 - c. In what ways was this time similar or different to your professional development time during the school year? Or any other PD you have been involved in?
3. How would you characterize the use of technology in this program?
 - a. How was the use of technology different this summer than in your regular classroom?
4. How would you describe the approach to science teaching in this program?
 - a. In what ways does this align with your personal philosophy of science teaching?
 - b. In what ways does it differ?
5. How has your teaching of science been different during this summer as compared to how it has been in the past?
6. Will your approach to science teaching be different in the future based on your experiences this summer?
 - a. If so, in what ways?
7. What about the use of technology in your classroom?
 - a. How might that aspect of your teaching change in the future?
8. What is something that you've done this summer that you are most proud of?
9. If you could improve one aspect of your time and experience this summer, what would it be? (and why?)
10. Think of a lesson that you usually teach during the school year. Explain how you might integrate technology into this lesson based on your experience this summer.
11. For those of you who participated in this program before, Tell me about previous experience you've had with CSCS. (IPD or WPD)
 - a. How has this summer been similar to those experiences?
 - b. In what ways has this summer been different?

Closing Questions

I would like give you a final opportunity to help us examine these issues. Before I end today, is there anything that I missed? Do you have anything else to add at this time? Have you said everything that you wanted to say but didn't get a chance to say? Have you shared everything that is significant about these interactions with me? If there's

anything else that you recall after our focus group session, I invite you to share it by contacting me.

III. Post-Focus group Session: Debriefing and Closing

Thank you for participating in today's focus group session. I appreciate your taking the time and sharing your ideas with me. I also want to restate that what you have shared with me is confidential. No part of our discussion that includes names or other identifying information will be used in any report or document. Finally, I want to provide you with a chance to ask any questions that you might have about this focus group. Do you have any questions at this time? May I contact you in the future should I have any follow-up questions or find that I would like additional information?

Appendix E: CSCS Interview Protocol

Professional Development for Science Teachers CSCS Interview Protocol

I. Pre-interview Session: Introduction/Background

Welcome and introduction:

Good morning/afternoon/evening. Thank you for taking the time to talk with me today. Before we begin the interview session, I'd like to give you the opportunity to read and sign the Consent to Participate in Research.

Purpose of the interview:

As we discussed, this interview will be used collect information for a research study that examines professional development for secondary science teachers. During the interview, we will talk about your thinking about teaching science. Then we will take a look at a lesson that you posted on your class website. Finally, I will ask you a few questions about your classroom and your teaching.

Confidentiality:

Any information you share with us today will be used for research purposes only. You will not be identified by name, department or office, position, or any other personally identifying information in any report or document. Today's interview session will be audio-recorded. I will also be taking notes of the conversation. The audio recordings may be transcribed for analysis. The audio recorded file, transcribed file, and notes will be stored securely in a password-protected cloud account of the evaluator until completion of interview analysis. Upon completion of analysis, files and notes will be destroyed. Only the researchers identified in the Consent to Participate will have access to the files and notes. The files and notes will be accessed and analyzed in strict confidentiality. Finally your name or personally identifying information will not be used in any published or public reports.

Informed consent:

This consent notice summarizes some information from the Consent to Participate in Research and communicates the procedures, potential risks and discomforts for subjects, potential benefits to subjects, payment to subjects for participation, participation and withdrawal, and rights of research subjects. Procedures in this interview are limited to semi-structured personal interview sessions. Because the study deals with issues that are sensitive, some interview questions may involve issues of a personal nature. You may feel uneasy about answering some of these interview questions. You may elect not to answer any of the questions with which you feel uneasy and still remain as a participant in the

study. You may not benefit personally from your participation in this study. However, findings from this study may lead to improvements in professional development programs for other teachers and may contribute to our knowledge on the subject. Your participation in this interview is voluntary. You are not obligated whatsoever to answer or respond to any question or to discuss anything that you are not inclined to answer or discuss. You can skip any question, or any part of any question, and will not face any penalty for answering, or not answering, any question in any way. You may ask that the audio recording be stopped at any time and/or may leave the interview at any time for any reason without consequences of any kind. You may withdraw consent at any time and discontinue participation without interview. You can halt your participation in the interview at any time. You are not waiving legal claims, rights, or remedies because of your participation in this interview.

Identification and contact information of principal investigator:

If you have questions regarding your rights as a research subject, the details of this study, or any other concerns please contact Kelly Castillo at the mailing address: Department of Educational Leadership and Policy Studies, California State University, Northridge, 18111 Nordhoff Street, Northridge, CA 91330. Alternatively, you may Kelly via telephone at [REDACTED] or via email at Kelly.Castillo.42@my.csun.edu.

Timing:

Today's interview will last approximately 60 minutes. Are there any questions before I get started?

II. Interview Session

Main Questions

First, I will ask you some questions about the professional development program you completed this past summer as well as some questions about teaching science in general.

- I. Describe the Computer Supported Collaborative Science (CSCS) program that you participated in this past summer.
- II. Tell me about how you spent a typical day while enrolled in this program.
 - a. What did you spend most of your time doing?
 - b. What were your favorite activities in this program? (or, which activities did you forward to the most?) Why?
 - c. What were your least favorite activities? (or, which activities did you look forward to the least?) Why?
- III. In what ways has your participation in this program changed the way you think about teaching science?
 - a. Before starting this program, what was your philosophy on teaching science?
 - b. What is your current philosophy on teaching science?
 - c. How is this similar to different to your current philosophy on teaching science?
 - d. To what do you attribute these changes? Can you give me a specific example?

In this next section, I will ask you some specific questions about a particular lesson that you posted on your class website.

- IV. Walk me through this lesson.
 - a. What learning goals did you have for your students?
 - b. What activities did you do?
 - c. How did you decide on these activities?
 - d. What was the outcome of this lesson?
- V. What was the main topic or problem of this lesson?
 - a. Who identified this problem? (Did the teacher identify it, did the students identify it, or did students and teacher work together on this?)
 - b. What questions, if any, did students have to ask as a part of this lesson?
- VI. Did the students refer to or create any pictures or images during this lesson?
 - a. How were these pictures used in the lesson?
 - b. Can you show me an example of this?
- VII. Did students carry out an investigation as a part of this assignment?
 - a. Walk me through the process that the students followed.
 - b. How (and by whom) were these steps determined?
- VIII. What role did data play in this lesson?
 - a. What data was collected?
 - b. Who collected this data?
 - c. How was data displayed?
 - i. Talk me through how the data or the graph was analyzed in class.
 - ii. What questions did you pose to the students? How did they respond?
- IX. Did students need to use math as a part of this lesson?
 - a. If so, what did they need to do?
 - b. Can you show me an example of this?
- X. What conclusions did students draw from this lesson?
 - a. How do you know this?
 - b. Were these the results that you expected?
- XI. How did you assess student learning during this lesson?
 - a. What parts of this lesson were graded?
 - b. Did students work alone or in groups?
 - c. What was the final product?

Thank you for reflecting on this particular lesson. Now I am going to ask you a few questions about your teaching in general. These next questions are not necessarily related to the lesson we just discussed.

- XII. How would you say that you spend most of your time teaching in your school year classroom?
 - a. What activities do you do the most?
 - b. The least?
 - c. Why do you say that?

Closing Questions

I would like give you a final opportunity to help us examine these issues. Before I end today, is there anything that I missed? Do you have anything else to add at this time? Have you said everything that you wanted to say but didn't get a chance to say? Have you shared everything that is significant about these interactions with me? If there's anything else that you recall after our interview session, I invite you to share it by contacting me.

III. Post-Interview Session: Debriefing and Closing

Thank you for participating in today's interview session. I appreciate your taking the time and sharing your ideas with me. I also want to restate that what you have shared with me is confidential. No part of our discussion that includes names or other identifying information will be used in any report or document. Finally, I want to provide you with a chance to ask any questions that you might have about this interview. Do you have any questions at this time? May I contact you in the future should I have any follow-up questions or find that I would like additional information?

Appendix F: Artifact Analysis Rubric

Title of Lesson: _____ Grade Level: _____
 Lesson ID: _____

| | 4 | 3 | 2 | 1 |
|--|--|---|--|---|
| Practice 1: Asking Questions and Defining Problems | Students specify relationships between variables AND clarify arguments or models. | Students specify relationships between variables OR clarify arguments or models. | Students begin to specify relationships between variables. | The lesson contains little to no evidence of this practice. |
| Practice 2: Developing and Using Models | Students develop, use, AND revise models to describe, test, AND predict. | Students develop, use, OR revise models to describe, test, and predict. | Students develop, use, OR revise models to describe, test, OR predict. | The lesson contains little to no evidence of this practice. |
| Practice 3: Planning and Carrying Out Investigations | Students conduct investigations that use multiple variables and provide evidence to support explanations or solutions | Students conduct investigations that use multiple variables. | Students conduct investigations that use single variables. | The lesson contains little to no evidence of this practice. |
| Practice 4: Analyzing and Interpreting Data | Students distinguish between correlation and causation, and employ basic statistical techniques of data and error analysis. | Students distinguish between correlation and causation, OR employ basic statistical techniques. | Students engage in minimal data analysis or data analysis in primarily qualitative or descriptive. | The lesson contains little to no evidence of this practice. |
| Practice 5: Using Mathematics and Computational Thinking | Students identify patterns in LARGE data sets and use mathematical concepts to support explanations and arguments. | Students identify patterns in SMALL data sets and use mathematical concepts to support explanations and arguments. | Students identify patterns in data sets but do not draw from data to support or establish arguments. | The lesson contains little to no evidence of this practice. |
| Practice 6: Constructing Explanations and Designing Solutions | Students construct explanations AND design solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. | Students construct explanations OR design solutions supported by MULTIPLE sources of evidence consistent with scientific ideas, principles, and theories. | Students construct explanations OR design solutions supported by a SINGLE sources of evidence. | The lesson contains little to no evidence of this practice. |
| Practice 7: Engaging in Argument from Evidence | Students construct a CONVINCING argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s). | Students construct an argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s). | Students attempt to support or refute a claim. | The lesson contains little to no evidence of this practice. |

| | | | | |
|---|--|---|--|---|
| Practice 8: Obtaining, Evaluating, and Communicate Information | Students evaluate the merit AND validity of ideas AND methods. | Students evaluate the merit AND validity of ideas OR methods. | Students evaluate the merit OR validity of ideas OR methods. | The lesson contains little to no evidence of this practice. |
|---|--|---|--|---|

Appendix G: Codes

The following hierarchal codes were developed:

- I. CSCS
 - a. NGSS- references to Next Generation Science Standards by name or lists one of the Science and Engineering Practices explicitly.
 - b. “CSCS-ify”- an emic term referring to the act of taking an existing lesson and adding CSCS components.
 - c. Data Analysis- discussion regarding the use of CSCS to analyze data in an instructional setting.
 - d. Graphing- discussion regarding the use of CSCS to graph data in an instructional setting.
- II. PD Type
 - a. WPD- references to the Workshop Professional Development program, also known as WPD.
 - b. IPD- references to the Immersion Professional Development program, also known as IPD.
 - c. Traditional PD- discussion of professional development that may be one time, mandatory, or administered in a top down, traditional setting.
 - d. Comparing PD- discussion comparing two or more of the types of PD listed above.
- III. Perceptions- comments reflecting the way teacher participants view or feel about science teaching, including ideologies and practices that they value.
- IV. Practices- comments reflecting instructional activities in which teacher participants engage in their classrooms with their students.
 - a. Changes in Practice- any reflection on a change or shift in practice (as defined above).
- V. Implementation- commentary regarding the use of CSCS in a classroom setting.
 - a. Summer Implementation- discussion about the use of CSCS in the clinical teaching setting of either program.
 - b. School Year Implementation- discussion about the use of CSCS in the school year classroom of the teacher participant.
 - i. Barriers to School Year Implementation- discussion of the factors that prevent or challenge successful use of CSCS in the school year classroom.
 1. Access to Technology- comments with regard to broken, outdated, or inaccessible technology in a manner that contributes to challenges in implementation of CSCS in a school year classroom.
 2. Administration- comments with regard to lack of administrative support and/or enforcement of school site or district policies in a manner that contributes to challenges in implementation of CSCS in a school year classroom.
 - ii. Forms of School Year Implementation- discussion with regard to CSCS activities implemented in a school year classroom.

1. Data- discussion of pooling data or analyzing data, when assisted by Google tools.
 2. Form- discussion of the use of a Google form to collect information (qualitative and/or quantitative) from students.
 3. “Quickwrite”- a CSCS term used to refer to having students record answers to questions in real time, usually using a Google spreadsheet.
 4. Website- reference to a teacher built and/or maintained website using Google sites.
- iii. Students- any conversation relating to student’s responses to using CSCS in the school year classroom, including student behaviors as they contribute to or hinder implementation.

Appendix H: Participant Background Information

| ID | Level | Science Taught | District | Credential | CSCS PD Experience | Other CSCS Experience |
|----|-------|---------------------------------|-----------------------|-----------------------------------|----------------------------------|-----------------------|
| A | HS | Biology | Other Public | SS Biology | 2013 WPD | |
| B | MS | Physical Science | SSD | SS Biology | 2014 IPD | |
| C | MS | Earth Science | Private / Independent | SS Biology | 2014 IPD | |
| D | MS | Earth Science, Life Science | SSD | Multiple Subject | 2013 WPD 2014 IPD | MOOC |
| E | HS | Earth Science, Physics, Biology | SSD | SS Biology SS Physical SS Geology | 2013 IPD | |
| F | MS | Physical Science | SSD | SS Biology | 2013 IPD 2014 WPD | |
| G | HS | Biology | SSD | SS Biology | 2012 WPD 2013 WPD 2014 IPD | MA |
| H | HS | Biology, Chemistry | Private / Independent | SS Biology | 2012 WPD 2013 WPD | MA |
| I | HS | Biology | SSD | SS Biology | 2012 WPD 2013 WPD 2014 WPD | MA |
| J | MS | Earth Science | SSD | Multiple Subject | 2013 WPD | |
| K | HS | Earth Science, Astronomy | Other Public | SS Geoscience | 2013 WPD 2014 IPD | MA |
| L | HS | Earth Science | SSD | SS Geoscience | 2013 WPD 2014 IPD | MA |
| M | MS | Earth Science | SSD | SS Biology | 2012 WPD 2013 WPD 2014 WPD | MA |

| ID | Level | Science Taught | District | Credential | CSCS PD Experience | Other CSCS Experience |
|----|-------|----------------|----------|------------------|----------------------------------|-----------------------|
| N | MS | Marine Science | SSD | SS Biology | 2013 WPD 2014 WPD | |
| O | MS | Earth Science | SSD | Multiple Subject | 2011 WPD 2013 IPD 2014 IPD | |
| P | MS | Earth Science | SSD | Multiple Subject | 2014 WPD | |
| Q | MS | Earth Science | SSD | Multiple Subject | 2014 WPD | |
| R | MS | Life Science | SSD | SS Biology | 2012 WPD 2013 WPD 2014 WPD | |
| S | HS | Chemistry | SSD | SS Chemistry | 2013 IPD 2014 IPD | MA MOOC |

Appendix I: Lesson Artifacts

The images below represent artifacts from Teacher Q's lesson. The student directions (hosted on the teacher's website) along with the online form on which students recorded their observations were submitted along with this lesson.

Student Directions:

QL Heat Energy

This lab will explore the effects of heat in the atmosphere.

Directions:

1. Gather supplies (feather, 24 inches of thread, ruler).
2. Determine responsibilities in group (timekeeper, data recorder).
2. Complete initial responses in your Interactive Notebook.
3. Conduct experiment.
 - a. Turn on heat plate to warm up.
 - b. Prepare feathers by tying them onto rulers.
 - c. Observe feather in cold air, record observations.
 - d. Hang feather over heat plate and make observations.
 - e. Return feathers when completed.
4. Share data among group members.
5. Answer questions in Interactive Notebook.
6. Record data in computer using [response form](#).

Response Form:

75 Cold *

Observation at 75 seconds of cool air feather.

Explain how this lab relates to flow of energy in atmosphere? *

Variables? *

Explain variables you could change and how they would affect your results.

The images below represent artifacts from Teacher O's lesson. The online form on which students recorded their observations along with a sample of student responses were submitted along with this lesson.

Form:

Volcano *

Type the name of the volcano. Remember to capitalize and spell correctly.

Latitude *

Northern latitudes are positive; southern latitudes are negative. Use the - on the key next to zero for negatives.

Longitude *

Type of Volcano

- shield
- cinder cone
- composite
- stratovolcano
- other

Status

- dormant
- active

Current Elevation in Feet *

Current Elevation (in Meters) *

Student Responses:

| Volcano | Latitude | Longitude | Type of Volcano | Status | Current Elevation in Feet | Current Elevation (in Meters) | Last Eruption |
|--------------------------|--------------|------------------|-----------------|---------|---------------------------|-------------------------------|-------------------|
| Sakurajima, Japan | 31°35'N | 130°39'E | other | active | 3,665Ft | 1,117 meters | 2013 |
| Mount Agung | -8 20'27"S | -115 30'12"E [1] | stratovolcano | active | 9944 | 3031 | 2/18/1963 |
| Mount Fuji | 21', 39" | 43', 39" | stratovolcano | dormant | 12,388' | 3.776metr | December 16, 1707 |
| Chaiten Volcano | -45° | -72° | other | active | 3,681 feet | 1,122 meters | May 2nd 2008 |
| Popocatepetl | 19 01"120 "n | 98"37 40"w | other | active | 17802 | 5426 | 2001 |
| Hoodoo Mountains | 47.03306 | -116.48583 | stratovolcano | dormant | 6070 | 1850 | 5101 B. C. |
| Puyehue, Chile | 40.583192 | 72.112198 | other | dormant | 7,336 ft. | 2,236 meters | 2011-2012 |
| Mount Lamington | -8° | +148° | stratovolcano | dormant | 5512 feet | 1680 meters | 1956 |
| lassen peak | 402917N | 1213018W | other | active | 10457 | 5229 | 5/22/1915 |
| Mammoth Mountain Volcano | 37.6486°N | 118.9719°W | other | dormant | 11,059Ft | 3,371 m | 1260 years ago |
| Mount Krakatoa | 6.152738 | 105°.26',9.946 | stratovolcano | active | 2,667 feet | 813 meters | 9/11/2012 |
| Makushin | 53 53 11"n | 166 55 52"w | stratovolcano | active | 6680 | 2036 | 1995 |