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Rural High School Chemistry Teachers' Views and Implementation of Inquiry-Based Laboratory Instruction as Set Forth in the Georgia Standards of Excellence

A Dissertation

Submitted to the
Faculty of Kennesaw State University
Bagwell College of Education
in partial fulfillment of
the requirements for the degree of
Doctor of Education
Department of Secondary and Middle Grades

By

Robert D. Bice Jr.
Kennesaw State University
Kennesaw, GA

2020

Dedication

This dissertation is dedicated to my two sons, Caleb and Dylan. Push through when things get tough, never stop learning, and put your all into every endeavor, whether for man or for God.

Acknowledgements

Growing up I always wanted to be a doctor, but I never envisioned earning it in teaching or learning the methods I would employ in completing it. I would not have completed it or be here today if it were not for Dr. Kimberly Cortes. Her roles in my life are varied, but no less important. She first spoke to me about KSU's graduate programs at science conferences almost a decade ago now. The interest sparked then led to my enrolling in the program years later, accepting a position as a graduate assistant under her guidance, taking classes she taught, and having the honor of having her serve as my advisor and committee chair. I am not the easiest student to work with, yet she never gave up on me, and I will always be indebted to her for the support she has shown me.

Two more Kennesaw State University faculty that played a large role in my completing my doctorate are Dr. Michael Dias and Dr. Megan Adams. Although I never took a class with either of them, their support, guidance, and constant reminders to push my thinking helped me complete the process. You accepted me when you did not know me and agreed to help me out on this journey that would take us through COVID-19 and many other challenges. I want to thank them for being on my committee and encouraging me throughout the way.

Many colleagues have passed through my life in the various courses I have taken at KSU and all of them hold a special place in my heart. However, Ashley Deason is the one colleague and friend who stands out among the rest. We started in the same cohort one summer and instantly bonded through sarcasm and a strong desire for excellence in academic endeavors. There were times that I wanted to quit but Ashley would not let me. We took every class together in our time at KSU and her desire to continue in her education motivated me to do the

same. In addition, she has been an invaluable resource in helping to read and provide commentary on my dissertation, and every other paper I wrote while pursuing this degree.

Thank you, my friend.

My coworkers at my current school and former schools have all contributed and I thank them for their help and support. However, my friends and family outside of KSU deserve more than the praise I can give. I am happy that I can now spend more time with my friends and, more importantly, family. Caleb and Dylan will finally get their father back on a full-time basis. Their patience and understanding have been immense and much more than I should ask of two boys in elementary school. I can only hope that they see this as an example of what it looks like when you do not give up and continue to push through even when things are tough.

To my wife, who has generously supported me with time, energy, and motivation since 2006, goes my biggest praise. What do I say to someone who has supported me every step of the way by making me comfortable, providing distractions when I needed them, running kid interference when getting work done was critical, and been there for emotional support when I felt less than worthy? Nothing I do can repay you for the love, self-sacrifice, and hours of looking at my papers. You are an exemplary mother, wife, and best friend, and I do not know what I would do without you. I am not sure what you saw in me years ago in that dance class at Berry College, but I am beyond glad that you agreed to go on a date with me. My life was forever changed that day, and I would have been wrong if asked where I saw myself in 10 years. Marrying you and raising a family has been the most rewarding adventure of my life. Anne, I love you!

Abstract

Inquiry-based instruction within science has been a growing field for decades. The foundation of inquiry is constructivism; that students must *do* science in order to understand it. Instruction using inquiry is something that has been written into the Next Generation Science Standards along with many state standards, like the Georgia Standards of Excellence (GSE). Teaching inquiry within a rural public high school chemistry setting has its own set of challenges unique to the rural context. Research is needed to give those educators a voice regarding teaching inquiry. This study utilized a mixed-methods design of survey and interviews to allow these rural public high school chemistry teachers a platform to weigh in on the feasibility of teaching standards through inquiry, methods of teaching concepts that require students to plan and carry out investigations, and their access to supplies, technology, planning, and professional development required to teach an inquiry-based unit including laboratory activities. Almost two-thirds of Georgia's rural public high schools had at least one participant who completed the survey. Participants from the survey were then chosen to complete an interview to further discuss their experiences. The survey data showed that the majority of participants used inquiry in their classrooms in some form but desired more time and resources to implement inquiry-based instruction. Methods used to integrate inquiry in the classroom and lab varied, as expected. One finding showed that many interview participants seemed to perceive students planning and carrying out investigations as reserved for wet labs. Interview data also emphasized how much time and personal funds teachers spend on their classrooms for labs and professional development. A desire for chemistry-specific professional development resonated among survey and interview participants. The findings brought forth in this dissertation can be used to inform policies regarding professional development and continued support for rural public high school teachers. Georgia Department of Education can also use the data to help meet the expressed needs of teachers in the state. Additionally, other states can use the data presented here to begin discussions about their own rural teachers and how they can best be supported to teach chemistry using inquiry-based instruction.

Keywords: Inquiry, Inquiry-Based Instruction, Rural Education, Chemical Education, Place-Based Education, Next Generation Science Standards, Professional Development, Constructivism, Social Cognitive Theory, Planning and Carrying Out Investigations, Equity, Standards, Georgia Standards of Excellence

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Chapter 1: Introduction

Statement of the Problem

Rural life has its own set of challenges as does teaching high school chemistry in a rural public school (Corbett & Gereluk, 2020). Regardless of location, the Next Generation Science Standards (NGSS) is the most recent push by educators toward STEM education that is largely inquiry-based. Designing and implementing laboratory experiences that include the type of inquiry stressed within the NGSS requires training, professional development, monetary resources, and planning time to properly shift toward inquiry. Issues that rural public chemistry educators face, especially at smaller schools, are loss of dedicated planning time by teaching multiple course preparations (Goodpaster, et al., 2012), isolation from others who have detailed knowledge of the specific content matter (Flinders, 1988; Hanushek, et al., 2005; Rockoff, 2004), and lack of receiving the same funding for professional development as subjects such as math and English/language arts. The present study aims to highlight the voices of chemistry teachers who are implementing this reform-based science teaching within their rural public high school classrooms to determine whether those issues are pervasive or benign.

Curriculum Standards

Teaching in the public education sector now carries with it the implied requirement of having standards in a curriculum document that governs what is taught in the classroom. The development of standards is something that only really took hold in the United States in the past half century (The National Commission on Excellence in Education, 1983). In 2020, all states have their own science standards, with six states developing their own, 20 others adopting the NGSS, and 24 states adopting standards based on principles used to make the NGSS (NSTA,

2014). The creation of the NGSS was part of a multi-state collaboration that included educators of all levels, members of the business community, scientists, and leaders in industry (NSTA, 2014). The authors of the NGSS included science practices that were to be taught or fostered within students in all science courses (NGSS Lead States, 2013).

Application of NGSS to High School Chemistry

The present study focuses on several of the practices within the NGSS that specifically concern laboratory activities within the high school chemistry classroom including Practice 3: Planning and carrying out investigations, Practice 4: Analyzing and interpreting data and Practice 6: Constructing explanations and designing solutions (NRC, 2012, p. 42). Georgia's own state standards, Science Georgia Standards of Excellence (GSE), include these three practices embedded within 14 of 36 elements of the six main standards for high school chemistry (Georgia Department of Education [GaDOE], 2016). The remainder of the practices found in the NGSS can be found in the remainder of the elements and standards within the GSE. This is important because even though Georgia was one of the lead partners in developing the NGSS (NGSS Lead States, 2013), it is one of many states that chose to develop its own set of standards rather than to implement the NGSS (NSTA, 2014). These standards are based, officially, on the *Benchmarks for Science Literacy* and the *Framework* (GaDOE, 2016). With this in mind, the GSE and NGSS were both informed by the *Framework* and should therefore be similar. The practices are not specifically listed in the same way, but GSE and NGSS use some common language with regard to practices. Table 1 shows the NGSS practices grouped into three categories: investigating practices, sensemaking practices, and critiquing practices (McNeill et al., 2015).

Table 1*NGSS Science Practices*

Science Practices	Investigating Practices	Sensemaking Practices	Critiquing Practices
	1. Asking questions	2. Developing and using models	7. Engaging in argument from evidence
	3. Planning and carrying out investigations (PCOI)	4. Analyzing and interpreting data	8. Obtaining, evaluating, and communicating information
	5. Using mathematical and computational thinking	6. Constructing explanations	

All of these are necessary for science, but the practice that I will focus on with greatest emphasis will be “planning and carrying out investigations” (PCOI). It is the one that seems to invoke the greatest overlap with performing laboratory experiments and subsequently requires resources and inquiry-based instruction. The Instructional Leadership for Science Practices (ILSP) has a rubric for evaluating teachers that contains the eight practices (McNeill et al., 2015). Table 2 highlights just the PCOI portion of the rubric.

Table 2*Science Practices Continuum – Students' Performance*

	Level 1	Level 2	Level 3	Level 4
Planning and carrying out investigations	Students do not design or conduct investigations.	Students conduct investigations, but these opportunities are typically teacher-driven. Students do not make decisions about experimental variables or investigational methods (e.g. number of trials).	Students design or conduct investigations to gather data. Students make decisions about experimental variables, controls or investigational methods (e.g. number of trials).	Students design and conduct investigations to gather data. Students make decisions about experimental variables, controls and investigational methods (e.g. number of trials).

Note: Only the Investigative Practices listed for PCOI included in this table.

Considerations with changing standards.

The specific interest in planning and carrying out investigations (PCOI) exists because it is a new demand placed upon teachers with the GSE. These demands were not previously part of the Georgia Performance Standards (GPS), which were the standards in place prior to GSE. The GPS grouped science subject-matter into two categories, or co-requisites; content and characteristics of science, which was further broken down into habits of mind and the nature of science (science practices). However, neither of these categories specifically required students to plan and carry out investigations. In addition, these standards were developed in 2006 on the heels of federally mandated state testing. K-12 testing and accountability were developed as part of the 2002 education legislation No Child Left Behind (NCLB), which was legislation that increased federal oversight in holding schools accountable using test scores and other factors as

criteria, with science testing being mandated in 2007 (Moore, 2005). Under NCLB states maintained control of their own testing. When it was first developed, testing in Georgia focused almost exclusively on the content most readily tested, instead of the practices or characteristics of science. The GSE changed from the previously used GPS by specifically stating that teachers were to have students involved in doing science through PCOI (GaDOE, 2019). Even though PCOI will be focused on throughout this research it is important to note that it is not the only way to involve students in science nor is it the best in every situation. However, PCOI is the practice that most relates to inquiry as described in the NGSS and *Framework*. This is specifically a concern because, contrary to documents stating that inquiry is one of the best methods for teaching science to students (NRC, 2012), there may be teachers who spent years developing a teaching practice with little attention to inquiry-learning. A continuum may be the best way to view it where on one extreme lies teachers who are resistant to change and may refuse to change teaching styles for one reason or another. The other end of the spectrum contains many who simply have not learned inquiry-based practices (Capps, et al., 2012; Cullen, 2015).

Purpose and Research Questions

The purpose of this research is to determine whether a disparity exists between inquiry-based instruction, as described via the NGSS and earlier documents, and the pedagogy being utilized in the rural public high school chemistry classrooms. In addition, it remains to be seen whether teachers report that districts are providing the resources (funds for professional development, planning, and supplies) in order to properly implement the teaching strategies

required by the GSE, especially if those strategies are different than those the teachers learned in their teacher education program.

The research questions guiding this study are:

RQ1: What are Georgia rural public high school chemistry teachers' views of the feasibility of teaching GSE High School Chemistry through inquiry?

RQ2: What are rural chemistry teachers' methods of teaching the concepts that have explicit inquiry or PCOI in the standard?

RQ3: What access do rural public high school chemistry teachers have to supplies, technology, planning, and professional development required to teach an inquiry-based unit including laboratory activities?

Conceptual Framework

The lens through which this entire study is viewed begins with equity. The National Science Foundation defines equity as the “reduction in attainment differences between those traditionally underserved and their peers” (Zucker et al., 1998, p. 37). It is not my intention to exclude urban and suburban areas from any inequity that occurs within those areas, but rather to bring attention to what is a lack of equity in rural areas or a need for social justice (Eppley, 2017). Areas of research and concern often include gender, ethnicity, and poverty, or socioeconomic status (SES). While extensive research has been done looking at equity as it relates to gender (Campbell et al., 2000; Grigg et al., 2006; Haslanger, 2000; Maehr & Steinkamp, 1983; Scantlebury, 1994), ethnicity (Aikenhead, 1997; Chapin, 2006; Grigg et al., 2006; Peng & Hill, 1995; Rakow, 1985; Rodriguez, 1998), and poverty (Arambula-Greenfield,

1999; Hewson, et al., 2001; Lynch, 2000; O’Sullivan et al., 2003; Rodriguez, 1998) one area that remains less charted is the equity of place.

There is a failure to recognize spatial inequity, or equity of place, as a distinct disadvantage (Roberts & Green, 2013). Stereotypes about rural people being “backwoods”, “redneck”, or “simple” are used in the media without regard for the inherent worth of people in rural areas. With comments by former U.S. President Barak Obama about rural citizens being “bitter” about loss of jobs and economic stimulus in their areas it is no wonder that the stereotypes of rural people exist and are pervasive in today’s society (Seelye & Zeleny, 2008). Students in rural areas have worth and require the just distribution of education resources (Eppley, 2017). This just distribution of education resources includes professional development related to standards-based teaching, especially, for this study, as it relates to the teaching of chemistry standards in rural high schools.

Urban schools are placed within hubs of larger groups of people while many rural schools are in the outskirts, by the very definition of rural. While urban schools have their own set of issues to deal with, rural schools have not typically been popular recipients of philanthropy (Beeson & Strange, 2000; Howley et al., 2009; Martin, 2010; Sherburne, 2016). Combine this with the cuts in education that have occurred in the past two decades and there is a real problem in the rural American education system (Ansalone, 2004). No Child Left Behind (NCLB) did very little to advance and help rural districts and schools (Jimerson, 2005). Every Student Succeeds Act (ESSA) has done much more to ensure that states include rural funding initiatives, studies, and formulas for funding into their plans, but still so much more needs to be done since there has been an equity gap for so long (Brenner, 2016).

Part of the equity gap that exists is due to the brain drain in these areas. This is what is referenced when intelligent people are either encouraged to leave or leave of their own accord to pursue more intellectual or monetarily lucrative positions in bigger cities elsewhere (Howley, et al., 2009). The cultivation of these minds and their subsequent exit from the area means that the area is left with smaller amounts of highly intelligent people. Previous research has also shown that rural students are at a distinct disadvantage because of the lack of proximity to corporations and large events that attract talent. Combine this with the brain drain and the documented results that show teachers in rural areas teach more preps, have less specialized education, and make less money than their urban or suburban counterparts and there exists a recipe for a diminished education on the part of the rural student (Deck, 2001).

There is a need to look at how the standards teachers are required to teach their students may be, in and of themselves, inequitable (Roberts & Green, 2013). Are the standards poorly written or do school districts need to step up and fund what they have voted in as appropriate standards of learning for the students? Are teachers misreading or misinterpreting the standards (Eppley, 2015)? In addition, professional development is also typically lacking in quantity or quality in these rural districts because the money isn't there to attract people who really grab attention or who are working on cutting edge pedagogy or technology (Reese & Miller, 2017). Smaller districts have a tough time attracting the talent for themselves and their professional development (Dunac & Demir, 2017). More research is needed to determine teacher views of this from a particularly rural public high school viewpoint in a specific field such as chemistry.

The results of this study should help to inform the rural education research, particularly the research into rural science education. If there are feelings of inequity among the teachers of

rural students, then it will need to be addressed quickly. All data was analyzed through an equity lens in hopes of determining whether it exists just in the minds of only a few teachers or whether it is a pervasive feeling among rural chemistry educators.

Organization of Study

The remainder of this dissertation is comprised of four chapters. Chapter 2 provides a comprehensive review of literature on the development of national and state science standards, pedagogical reform efforts, the shift toward teaching inquiry and laboratory instruction, and rural education. In Chapter 3, the research methodology with specific details on how the study was conducted is discussed. Chapter 4 presents a detailed description of the research findings and analysis. Finally, Chapter 5 focuses on an interpretation of the findings along with implications and areas for future research.

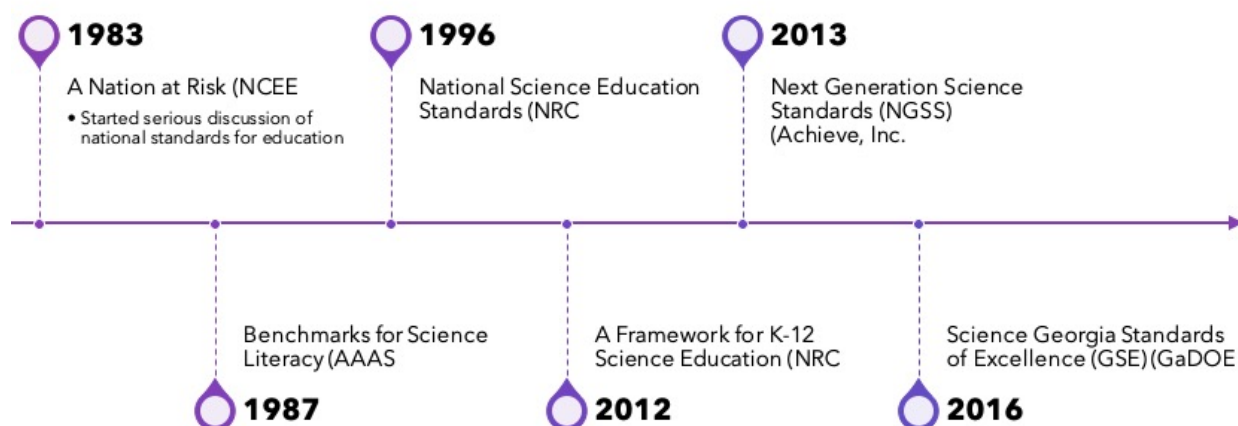
Chapter 2: Literature Review

Introduction

The practice and art of teaching science has been under improvement for decades in the United States. One major development in standards-based curriculum was the publication *A Nation at Risk* (The National Commission on Excellence in Education, 1983; Figure 1).

Figure 1

Development of Science Standards in the United States



This resulted in a nationwide movement toward creation of standards for all subjects to move away from the “rising tide of mediocrity” (Llewellyn, 2013 p. X). In the United States curricula is set at the state and/or local level. The standards referenced were standards put out by organizations set out to be agents of change. Recommendations for national math standards were developed first in 1989, while the other subjects lagged just behind it (Delandshare & Petrosky, 2004). The development of these standards made the learning expectations of what students should be taught and understand clear to both students and teachers (Miskel & Ogawa, 1988).

Once science standards, including chemistry, were put forth in the 1990s via the *Benchmarks for Science Literacy* (Project 2061, 1993) and National Science Education Standards (NRC, 1996), there was a movement toward accountability with NCLB (2002) and its high-stakes standardized testing. Then, the nation saw a large shift toward more teachers focusing solely on content and rote memorization which produced results on standardized tests while, in the process, abandoning the scientific practices that were truly important in developing students into the kind of thinkers needed in STEM careers (Cawelti, 2006; Flinders, 2005; Guilfoyle, 2006; Marx & Harris, 2006; Vogler & Virtue, 2007). Part of this shift was due to the double-edged sword that is NCLB, in which the positive aspects of states being held responsible for the learning outcomes of students, but negative in that the high stress environment moved many teachers to teach to the test to avoid school and district scrutiny (Coburn, et al., 2016; Diamond, et al, 2004; Firestone, et al., 1999; Firestone, et al., 1998; Heilig & Darling-Hammond, 2008; Jennings, 2010; McNeil, 2002; Valenzuela, 2005; Wilson & Floden, 2001; Llewellyn, 2013, p. 190). There was finally accountability for teaching students specific content standards, but NCLB left the writing and adopting of standards up to the states. This left the possibility of vastly different ways of assessing students and a variety of standards across the 50 states responsible for their education. It is at this point that *A Framework for K-12 Science Education* (NRC, 2012) was released and changed the trajectory of science education in the United States.

The *Framework* attempted to address shortcomings of the U.S. education system specifically stating that the system “[was] not organized systematically across multiple years of school, emphasize[d] discrete facts with a focus on breadth over depth, and [did] not provide students with engaging opportunities to experience how science is actually done” (NRC, 2012, p.

1). It is upon this *Framework* and the desire to reform existing standards (which varied from state to state), that the NGSS were based (Achieve, Inc., 2013). These standards are a result of the collaboration of 26 lead states which included Georgia until the standards came to adoption. Even the 24 states who did not adopt the NGSS, like Georgia, did adopt an “NGSS-informed” version of their own design, which is based on the *Framework* (NSTA, 2014). The NGSS emphasize assessment of students’ abilities to demonstrate proficiency in scientific practices (Achieve, Inc., 2013). This is built on the concept of inquiry-based learning, which is described in the *Framework* as necessary for students to comprehend scientific practices by “experiencing those practices for themselves” (NRC, 2012, p. 30).

Next Generation Science Standards

The practices embedded within the NGSS were specifically listed as “practices” instead of “skills” for the reason of “emphasiz[ing] that engaging in scientific investigation requires not only skill but also knowledge that is specific to each practice” (NRC, 2012, p. 30; NGSS Lead States, 2013). There are eight specific science and engineering practices (SEP) that are embedded within the NGSS from the *Framework* (NRC, 2012):

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

8. Obtaining, evaluating, and communicating information

These SEPs for science are designed to give students an understanding for “how scientific knowledge develops,” and how to apply this to “investigate, model, and explain the world” (NRC, 2012, p. 42). The NGSS, in which the SEPs can be found, were written with the *Framework* as the foundation. The authors of the *Framework* specifically state that anyone in education who may attempt to only teach students skills and facts needed for scientific labor without adequately fostering an understating of the development of those facts or anyone who ignores applications of science in the world as being someone who “misrepresents science and marginalizes the importance of engineering” (NRC, 2012, p.43). With this in mind, the SEPs explain student performance expectations without listing curriculum, teaching methods, or pedagogy for teachers to follow. However, the NGSS do list progressions for how the practices should build across four distinct grade bands: Grades K-2, Grades 3-5, Grades 6-8, and Grades 9-12. Essentially, the SEPs are not distinct for just one grade band, but they are something that should be structured or built upon and experienced throughout the entire academic lives of students.

The content associated with PCOI within the Chemistry GSE can be found as part of the standards and elements SC2a, SC3b, SC3e SC4a, SC5a, SC6b, and SC6h (GaDOE, 2016, p. 2-4). In science, the GSE are setup in a way such that the symbol represents the subject area of science (S), content area of chemistry (C), standard number (1, 2, etc.) and the element (a, b, c, etc.). The elements of the standards are as follows in Table 3.

Table 3*PCOI as Evidenced in the Georgia Standards of Excellence (GSE)*

Standard Identifier	Standard Wording
SC2a	Plan and carry out an investigation to gather evidence to compare the physical and chemical properties at the macroscopic scale to infer the strength of intermolecular and intramolecular forces.
SC3b	Plan and carry out an investigation to determine that a new chemical has been formed by identifying indicators of a chemical reaction (e.g. precipitate formation, gas evolution, color change, water production, and changes in energy to the system).
SC3e	Plan and carry out an investigation to demonstrate the conceptual principle of limiting reactants.
SC4a	Plan and carry out an investigation to provide evidence of the effects of changing concentration, temperature, and pressure on chemical reactions. (Clarification statement: Pressure should not be tested experimentally)
SC5a	Plan and carry out an investigation to calculate the amount of heat absorbed or released by chemical or physical processes. (Clarification statement: Calculation of the enthalpy, heat change, and Hess's Law are addressed in this element.)
SC6b	Plan and carry out an investigation to evaluate the factors that affect the rate at which a solute dissolves in a specific solvent.
SC6h	Plan and carry out an investigation to explore acid-base neutralizations.

The elements in Table 3 show the content areas of chemistry that are specifically PCOI as being physical and chemical properties, intramolecular and intermolecular forces, evidence of chemical reactions forming a product, limiting reactants (stoichiometry), Le Chatelier's

Principle, enthalpy, Law of Conservation of Energy, Hess's Law, and acid-base neutralizations. These concepts are also mirrored in the Physical Science DCI (disciplinary core ideas) of the *Framework*. As Table 1 illustrates, the juxtaposition of the GSE and the closest NGSS for the elements or standards within high school chemistry identified as involving PCOI shows that the GSE has many more PCOI standards than the NGSS for the same content area.

Even though the chemistry GSE is quite narrow in its focus and has much fewer points in common with NGSS upon first glance it is worth stating that the design of NGSS is to cover the "most essential material for students to know and do," and not to "define advanced work in the sciences" (NGSS Lead States, 2013, p. XVII). The discretion of advanced STEM courses, such as chemistry, lies with the educators and curriculum writers within each state. Even so the NGSS classifies the science content into four categories or Disciplinary Core Ideas (DCIs): Life Sciences, Physical Sciences, Earth and Space Sciences, and Engineering Design. Chemistry content is placed in the high school Physical Sciences DCI and, even though Georgia did not adopt NGSS outright, one can see the influence of NGSS within the GSE when looking at similar standards or performance expectations (PE) in Table 4.

Table 4*PCOI as Represented in GSE and NGSS*

Science Georgia Standards of Excellence (GSE)	Next Generation Science Standards (NGSS) Performance Expectations
SC2a. Plan and carry out an investigation to gather evidence to compare the physical and chemical properties at the macroscopic scale to infer the strength of intermolecular and intramolecular forces.	HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.
SC3b. Plan and carry out an investigation to determine that a new chemical has been formed by identifying indicators of a chemical reaction (e.g. precipitate formation, gas evolution, color change, water production, and changes in energy to the system).	None
SC3e. Plan and carry out an investigation to demonstrate the conceptual principle of limiting reactants.	HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.
SC4a. Plan and carry out an investigation to provide evidence of the effects of changing concentration, temperature, and pressure on chemical reactions. (Clarification statement: Pressure should not be tested experimentally)	HS-PS1-5. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. HS-PS1-6. Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.
SC5a. Plan and carry out an investigation to calculate the amount of heat absorbed or released by chemical or physical processes. (Clarification statement: Calculation of the enthalpy, heat change, and Hess's Law are addressed in this element.)	HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends on the changes in total bond energy.
SC6b. Plan and carry out an investigation to evaluate the factors that affect the rate at which a solute dissolves in a specific solvent.	None
SC6h. Plan and carry out an investigation to explore acid-base neutralizations.	None

Inquiry-based Instruction

The move toward inquiry-based learning is one that is deeply rooted in research, amid much debate about the precise meaning of inquiry (Hayes, et al., 2016; NRC, 2012, p. 30). In particular, the ambiguity has been with the portions of inquiry-based learning, such as modelling, critiquing models and explanations, and argumentation within science (NRC, 2012, p. 44). One of several purposes for developing the *Frameworks* was to make clear what comprised the different parts of inquiry, and to differentiate between inquiry in science and engineering (NRC, 2012). The *Frameworks* state that inquiry includes planning investigations, reviewing what is already known in light of experimental evidence, using tools to gather, analyze and interpret data, and proposing answers, explanations and predictions (NRC, 2012). Scientific inquiry is important for learning science because “it recognizes science as a process of discovery and invention that involves engagement, exploration, explanation, application, and evaluation” (Fang, et al., 2010, p. 3). Inquiry-based learning has been shown to be effective in helping students score higher on knowledge-based science tests, and in developing more positive attitudes toward the subject matter than students taught using traditional methods of instruction, such as lectures, labs from a lab manual, and other methods of teacher-centered instruction (Chang & Mao, 1999). Shifting away from teacher-centered instruction primarily utilizing lecture towards inquiry-based practices can be aided by viewing inquiry as existing on a continuum (Capps, et al., 2012; Cullen, 2015). The alternative to inquiry-based learning in the minds of many teachers is to use direct instruction with emphasis on lecture or transmission of information, which has been shown to reduce effectiveness in critical thinking, self-regulation, and elaboration, when compared to learning science by inquiry (Schraw, et al., 2006).

Diametrically opposed to an information transmission mode of direct instruction is inquiry-based instruction where student formulation of explanations of phenomena and exploration of concepts precedes formal explanations provided by the teacher (Bransford, et al., 2000; Bybee, et al., 2006; Marshall, et al., 2017). Pedagogical approaches like inquiry and others that focus on the learner have also invoked the term “student-centered” (Bybee et al., 2006; Marshall, 2013; Windschitl, 2008). This student-centered approach of inquiry has resulted in significant positive student attitudes toward science (Cheng, et al., 2014); some studies have even shown that inquiry learning may narrow the achievement gap within science (Geier, et al., 2008; Marshall & Alston, 2014).

If inquiry-based teaching and scientific literacy is important in science as a whole, then it should be especially important in a subject largely based on the atomic level of matter (Dale & Dale, 2018). Chemistry is one of the two subjects that students often list as being uninteresting or boring (Hofstein, et al., 2011). In order to engage students, they must be involved with the planning and carrying out of investigations (PCOI) in order to activate student interest (Stuckey, et al., 2013). The material must be relevant to the students; immersing them in inquiry-based instruction helps to make the material more relevant to them (Hofstein & Eilks, 2015).

Chemistry presents quite a daunting teaching task because students must understand everything from the subatomic level to the macroscopic physical properties of a substance. One example of a way to address some of the difficulties in teaching chemistry is presented by Sanger’s (2005) use of particulate drawings to evaluate student understandings of balanced equations and stoichiometric ratios. The findings of a study into the effectiveness of this technique showed that students may be able to work stoichiometric problems and balance

equations, but they “may not understand the underlying concept or its application in practicing chemistry in a laboratory or in industry” (Kimberlin & Yeziarski, 2016). Science courses with a heavy laboratory component, like chemistry, often get a reputation for relying on mostly lecture-based instruction within the classroom. However, lecture must have its place even within a classroom where a high degree of inquiry-based instruction is occurring, but this should not be the dominant learning approach within the classroom. This idea further emphasizes the need for inquiry-based learning to overcome these misconceptions and allow for efficient use of learning modes within the classroom.

The study by Kimberlin & Yeziarski (2016) shows how the integration of inquiry-based lessons and modeling can be used to positively affect high school students’ understanding of underlying chemistry concepts. Inquiry-based instruction has been shown to positively reverse pervasive student misconceptions in chemistry (Bridle & Yeziarski, 2012). Correcting the common misconceptions that often exist is part of the ongoing science education reform efforts in the United States (NRC, 2012, p. 25). While a focus on student misconceptions may seem like a deficit view of learners, conceptual change can be accomplished with effective science instruction that allows students to engage in argumentation, “targeted instructional interventions,” and communication (NRC, 2012, p. 96).

In order for effective reform to occur in chemistry and all STEM classrooms across the country, effective professional development (PD) focused on inquiry-based lessons and evaluations must occur and continue (Yeziarski & Herrington, 2011). Science and math teachers who received reform-based pedagogical education during teacher preparation programs were found to increase their use of inquiry-based instruction (Sawada, et al., 2002). However, PD and

development of highly rated lesson plans will not solve all problems; these strategies “will likely only translate into high-quality science instruction if teachers possess the content and pedagogical content knowledge to support student connections among...[and] within those materials” (Bancroft, et al., 2019, p. 405). If teachers have not been trained to deliver this pedagogical knowledge, then this means that states and districts will need to provide appropriate PD in order to effectively change how concepts are being taught in chemistry classrooms.

Planning and Carrying Out Investigations

In addition to content knowledge that highly qualified teachers attempt to help students construct, many of the skills and scientific practices that students must be able to do involve scientific investigations. One key phrasing imbedded in the NGSS is that students will “plan and carry out an investigation (PCOI).” PCOI involves students, instead of teachers, being the ones to both plan and to carry out a scientific investigation. This is important because it introduces students to how scientists and engineers work things out within the confines of the natural world. Moving toward a more student-centered approach will enable students to more clearly connect being a scientist with doing science (Edwards & Head, 2016). One key component that students must understand is that “PCOI has many steps involving numerous decisions and frequently requiring repeated attempts” (Duschl & Bybee, 2014). Guiding students to do so should allow them to share their ideas with others, accept criticism, share lessons learned, and perhaps revise and improve their experiment (Duschl & Gitomer, 1997; Engle & Conant, 2002). Students need the opportunity to come up with their own investigations, and they need this from an early elementary level on through 12th grade (Lehrer & Schauble, 2000). The synthesis of the literature is that students learn science best when they are actively engaged in doing science,

which results from, essentially, inquiry-based instruction. However, this change involves considerable time and is concerning to many teachers due to the difference in what they are asked to teach and in how they are being assessed in a different way at the state level on state-mandated high-stakes standardized testing (Haag & Megowen, 2015; Hayes, et al, 2016; Wellington & Osborne, 2001).

Even though this active and student-centered instruction is the most effective method, it also comes at a time when current education budgets are being cut; all while many states have yet to see relief from the previous circa 2008 reductions (Zumeta, 2010). Teachers who wish for their students to PCOI must have the class time do this as well as the money, or resources, from their school to fund student-centered investigations. One of the stated visions for the NGSS was that they “be explicit about resources, time, and teacher expertise” (NRC, 2012). Learning progressions listed in the NGSS regarding time and grade-band expertise are present, but the resources required to enact reform-based science teaching as is listed in the NGSS is lacking. Expenses associated with laboratory experiments have been cited by teachers as a hindrance to conducting hands-on activities (DeMeo, 2007; Penker & Elston, 2003), but money is not the only hindrance teachers face when it comes to including laboratory activities in their chemistry curriculum. Teachers also report high-stakes standardized testing (Trautmann, et al., 2004), student attitudes (Cheung, 2011), and loss of instructional time (Cheung, 2008; Deters, 2005) as barriers to conducting activities requiring consumable materials and laboratory equipment at the level required by the chemistry curriculum (ACS, 2012). One recent mixed-methods study showed that the expense of laboratory activities does not particularly dissuade teachers from performing labs, but it does significantly influence the decision as to which labs are performed

(Boesdorfer & Livermore, 2018). This means that money may influence a teacher's decision to use a more or less pedagogically effective lab based on which is more affordable. Another finding from the literature is that teachers' personal ideas and beliefs have a great deal to do with choosing whether to perform hands-on activities (Crawford, 2007; Keys & Bryan, 2001; Roehrig & Kruse, 2005). It should be noted that the findings of many of these studies do not necessarily indicate the alignment of a laboratory activity with NGSS and/or whether it was effective in advancing student understanding.

Types of Inquiry and Methods of Delivery

Advancing student understanding has been reported in several trends in chemistry instruction, which help students gain meaning and include Argument-Driven Instruction (ADI), guided-inquiry mini-journal labs, process-oriented guided inquiry learning (POGIL) activities, and virtual simulations (Barthlow & Watson, 2014; Davenport, et al., 2018; Zhao & Wardeska, 2011). ADI helps to convey the content and develop students' ability to critique others' claims and has been hybridized as a type of inquiry-based instruction, or guided-inquiry, that fosters students' making claims, citing evidence, and then reasoning through them (Jimenez-Aleixandre, 2007; Sampson & NSTA, 2015). Using mini-journal labs students generate questions that they then investigate through a hands-on laboratory activity, which combines inquiry with PCOI, gives students scaffolding for completing this investigation to help students who are just starting out PCOI. Even while there is some emphasis of getting students to PCOI, ADI is more of a method of arguing for a particular concept or idea and not so much the planning or carrying out of an investigation (Walker & Sampson, 2013). POGIL was developed around 1994 for the purpose of helping college chemistry students to understand concepts and has since proven to

increase achievement for this age group (Farrell, et al., 1999; Hanson, 2013; Hinde & Kovac, 2001; Spencer, 1999). The effectiveness of POGIL for high school students is still a growing research field (Schwartz, 2009). Even so, the skills that the innovative lab techniques are attempting to foster are those that get the students involved with actually doing science in a way that mimics what they would do if they, themselves, were scientists. The skills of critical thinking, lab practices, defining variables, running an experiment, analyzing the data, and then determining what to do next are what the NGSS and GSE were designed to have students do, that is mainly PCOI.

Most PCOI requires coming up with some degree of hypothesis on the part of the student. Many activities can be made into inquiry activities; classification of activities as inquiry would depend on the instructor's wording within the assignment (Sanchez, 1988). Planning and coming up with investigations are not the only forms of inquiry. Inquiry exists as a continuum with distinctions on how much guidance the teacher provides and how much information students are provided (Banchi & Bell, 2008).

Types of Inquiry

The inquiry continuum includes five essential features within variations of student autonomy as shown in Table 5 (NRC, 2000, p. 29). The most self-directed version has the learner communicating and justifying explanations as opposed to the teacher giving the learner steps and procedures for communication (NRC, 2000, p. 29). Banchi and Bell (2008) agree and identified four levels of inquiry: confirmation, structured, guided, and open.

Table 5*Inquiry Continuum*

Essential Feature	More ←-----Amount of Learner Self-Direction -----> Less Less ←----Amount of Direction: Teacher or Material Variations-->More				
1. Learner engages in scientifically oriented questions	Learner poses a question	Learner selects among questions, poses new questions	Learner sharpens or clarifies question provided by teacher, materials, or other source	Learner engages in question provided by teacher, materials, or other source	
2. Learner gives priority to evidence in responding to questions	Learner determines what constitutes evidence and collects it	Learner directed to collect certain data	Learner given data and asked to analyze	Learner give data and told how to analyze	
3. Learner formulate(s) explanations from evidence	Learner formulates explanation after summarizing evidence	Learner guided in process of formulating explanations from evidence	Learner given possible ways to use evidence to formulate explanation	Learner provided with evidence and how to use evidence to formulate explanation	
4. Learner connects explanations to scientific knowledge	Learner independently examines other resources and forms the links to explanations	Learner directed toward areas and sources of scientific knowledge	Learner given possible connections	Learner given all connections*	
5. Learner communicates and justifies explanations	Learner forms reasonable and logical argument to communicate explanations	Learner coached in development of communication	Learner provided broad guidelines to use to sharpen communication	Learner given steps and procedures for communication	

* Statement not in original document. Adapted from page 29 of NRC (2000).

Confirmation inquiry is more in line with the way most labs have been taught in high school. The student is given the procedure, knows what the result should be, and then the data from the lab confirms what is expected. This is useful in that it helps to reinforce an idea or concept from a lecture or reading. These can also be used to hone students' laboratory or measurement skills. More student-centered instruction is structured inquiry where students are still provided questions and procedures, but the students must come up with explanations from their data. The instructor has provided most of the material throughout the first two types, but guided inquiry is where the teacher takes an even larger step back and allows the students to design their own procedure to test the prediction for the provided research question. Finally, the form of inquiry providing the most student autonomy is open inquiry. It is quite as its name implies, open to whatever the students would like to do. The students must come up with the research question, procedure to test it, and then communicate their results. This is very similar to designing and running a science fair project. While it may seem that the teacher becomes more and more hands-off, which is somewhat true, the fact remains that the teacher must be there to guide the instruction and serve as a sounding board for ideas from students. Students are responsible for the research, but the teacher must be a voice of reason and ask probing questions to spark curiosity among the learners.

Facilitating Inquiry

This curiosity can be easily fostered if there is access to technology through virtual representations. Virtual representations using current technology are ways to help teachers facilitate inquiry with students, especially with atomic or molecular, intermolecular and intramolecular, force concepts (Davenport, et al., 2018). There are a number of these online or

virtual environments that are compatible with a variety of platforms or operating systems. These may help students in the creation of models of events that may be unobservable in the lab (Donnelly, et al., 2013; Winberg & Berg, 2007; Yaron, et al., 2010). Students have been shown to increase learning through inquiry and problem solving, as well as PCOI, in most computer simulations but must work within the confines of the programming (Davenport, et al., 2018). However, the virtual presentation of inquiry activities requires technology, which may be a barrier to some schools.

Activities presented to teachers to implement with their students are not always like the ones listed previously. My high school's current chemistry books are copyrighted in 2002, and they contain labs and hands-on activities that were popular during the mid to late 1990s (Davis, 2002). Of the 28 laboratory activities found in the Davis textbook (2002), only the first lab had any PCOI or inquiry in it. The remainder of them were "cookbook" labs with very prescribed procedures and students should all get the same results if they follow the procedural steps. Another example of the type of experiment is found in a 1995 *J. Chem. Ed.* article regarding stoichiometry and acid-base neutralizations (Hayes, 1995). This investigation has little inquiry and is on par with the experiments listed in much of the curriculum found by textbook manufacturers in the late 1990s and early 2000s. A survey of 571 teachers in 2006 found that 55% taught at least three inquiry labs, where students designed the procedure, per semester (Deters, 2006). Even with three inquiry labs being taught per semester, that does not fully satisfy the amount of inquiry or PCOI required for the standards and elements in the GSE.

Also, the more innovative laboratory activities, such as inquiry, POGIL, computer simulations, or virtual labs, require the high school chemistry educator to invest time into

perfecting the teaching craft, as well as money for the copyrighted materials and technology for computer simulations. For experienced educators it will require their time outside of the classroom in order to incorporate these types of learning into the curriculum. Leaders in education must respect this, and make sure that teachers know how the program or innovation will fulfill the jobs they are trying to get done (Arnett, 2018). Pre-service teachers should be receiving the education and professional development within their teacher education programs; this will ensure that they come into the classrooms ready to begin engaging their students, especially when it comes to PCOI. However, the status quo of teaching practices student teachers experience within their student teacher placement constrains progressive pedagogy even if taught within the pre-service experience.

Pedagogical Shift and Challenges

While changing how pre-service teachers are educated will help those new teachers, changing how a subject is taught takes considerable effort on the part of the educator but is also not something that is without reward. If nothing else, the GSE explicitly states how teachers should teach many of the standards and elements by placing the emphasis on PCOI. The GSE places such an emphasis on PCOI that out of the elements that deal with the focused laboratory SEPs, 50% of them have students engaged in PCOI (GaDOE, 2016). The involvement in and preparation for PCOI has roots in inquiry-based instruction. Structured hands-on activities, semi-structured activities, and completely open inquiry activities can all be used to involve students in PCOI as long as the activities do not focus on the teacher as the only one that interacts with laboratory equipment (Boesdorfer & Livermore, 2018). However, there are teachers that cite cost (DeMeo, 2007; Penker & Elston, 2003) and time (Cheung, 2008; Cheung,

2011; Deters, 2005; Trautmann, et al., 2004) as reasons why they cannot or do not teach using a more inquiry-based pedagogy. Is expense truly something that prohibits chemistry teachers from involving their students in PCOI explicitly stated in the GSE as the minimum level that students should be receiving within the confines of their high school chemistry course? Boesdorfer and Livermore (2018) note that the concept of cost with laboratory activities was more complicated, and one particular area of interest within that complexity is the role that location of schools plays within the dynamic of teachers choosing whether or not to engage students in PCOI.

College Board (CB) states that an Advanced Placement (AP) Chemistry course “requires that 25 percent of the instructional time engages students in lab investigations.” In addition, CB also requires a “minimum of 16 hands-on labs (at least six of which are inquiry based)” (College Board, 2017, p. 1). If high school courses, or pre-AP courses, are designed to prepare students for the actual AP courses, then they should mirror the requirements (Boesdorfer & Livermore, 2018). With this in mind, teachers engaging their students in PCOI should be of utmost importance. Not all of the PCOI needs to be lab-based but being able to successfully plan and carry out an investigation is, inherently, a laboratory skill needed to be successful in any STEM field to make sense of real-world situations.

Regardless of the concept, students in high school are interested in topics that are relevant to them and their unique contextual understanding of the world (Bybee & McRae, 2011; Matthews, 2007; Schreiner & Sjøberg, 2005). Hands-on activities and laboratory activities are other ways to gain student interest while imparting understanding of chemical concepts and practices (Sampson & NSTA, 2015). However, these activities must be structured in ways that are appropriate for the students to construct their own meaning from the experiences and not

simply get what they were supposed to get by following the directions in what are commonly called “cookbook” labs (Garnett, et al., 1995; Walker & Sampson, 2013). Teachers should be mindful that students take away little to nothing in regard to meaning with performing these labs (Domin, 1999; Hofstein & Lunetta, 2004).

Rural Education

Being mindful of one’s students requires that each teacher keep in mind the needs of each student. Just as each student is unique, so too is each school. Despite contextual differences, schools can be grouped based on certain criteria, such as location. The National Center for Education Statistics (NCES) breaks down rural into the following three categories for funding under the Rural Education Achievement Program (REAP): 41 - Rural, Fringe, 42 - Rural, Distant, and 43 - Rural, Remote. Their distance to urban areas defines these categories (Geverdt, 2015).

Schools that are farther away from urban areas have trouble finding teachers, and there is also a trend in gifted education to try and set the sights of motivated students toward getting out of the rural area they grew up in and to pursue careers elsewhere (Howley, et al., 2009, Lawrence, 2009). This has been termed “brain drain” and has been propagated by corporations and mass media (Howley, 2009). The cultivation of these minds and their subsequent exit from the area means that the area is left with smaller amounts of critical thinkers fostered by the public education system. Previous research has shown how there is a disparity between money given to urban versus rural schools (Howley, et al., 2009). Previous research has also shown that rural students are at a distinct disadvantage because of the lack of proximity to corporations and large events that attract talent. Combine this with the brain drain and the documented results that

show teachers in rural areas teach more course preparations, have less specialized education, and earn less money than their urban or suburban counterparts, and you have a recipe for a diminished education on the part of the rural student (Deck, 2001).

This idea of being rural, or from a rural area, is something that greatly impacts teaching in areas of both pedagogy and funding (Martin, 2010; Sherburne, 2016). Rural education has been often overlooked and people living in rural areas subject to popular stereotypes, such as “backwoods”, “racist”, or “redneck” (Eppley, 2010; Howley, 2009). In reality, these areas make up over 25% of the schools in America and 50% of the school districts (Jimerson, 2005). No Child Left Behind (NCLB) did very little to advance and help rural districts and schools (Jimerson, 2005). Every Student Succeeds Act (ESSA) has done much more to ensure that states include rural funding initiatives, studies, and formulas for funding into their plans, but still so much more needs to be done since there has been an equity gap for so long (Brenner, 2016).

There is a need to look at how the standards teachers are required to teach their students may be, in and of themselves, inequitable. Are the standards poorly written or do school districts need to step up and fund PD for the standards of student learning that the state has decided appropriate? Professional development is also typically lacking in quantity or quality in these rural districts because the money is not there to attract people who really grab attention or who are working on cutting edge pedagogy or technology (Reese & Miller, 2017). Smaller districts have a tough time attracting the talent for themselves and their professional development (Dunac & Demir, 2017). More research is needed to determine teacher views of this from a particularly rural public high school viewpoint in a specific field such as chemistry.

Theoretical Framework

Constructivism is a learning theory that holds that knowledge is not transmitted from the teacher to the learner in the same form but is constructed through active learning by the learner (Wheatley, 1991). This is done in large part by building upon the foundation of already established prior knowledge and experiences. Experiences and prior knowledge, themselves, shape the knowledge that is constructed by the learner. The theory itself, as it relates to the cognitive capacity to learn and pedagogy, has its foundation in the works of Piaget, Bruner, von Glaserfeld, Dewey, Stanley, Gesell and Vygotsky (Stone, 1996; Vanderstraeten, 2002). Piaget (1972) described how learners would pass through various stages in their lives. The stages presented a sort of limitation to the learners with regard to abstract thought, or mental capacity, especially when looking at children actively involved in science education (Shayer & Adey, 1981). Vygotsky agreed in principle but emphasized the social aspect of construction of knowledge, and implied that there was a connection between the psychological processes and the environment inhabited by humans (Vygotsky, 1929). Combinations or semblances of these tenants of constructivism can be found through science education, in particular The Next Generation Science Standards and Framework, which shows how the constructivist ideology influenced governments' educational policy (Bell, et al., 1995; Railean, et al., 2016; Taber, 2010).

The progression of understanding complex concepts and expectations throughout the NGSS and GSE is evidence for a constructivist understanding of knowledge construction by the writers of the standards. The inquiry-based instruction explicit in the NGSS and Framework, upon which the GSE are based, includes the social aspect of constructing knowledge with other students, which is why Vygotsky's social constructivism pairs well when delving into research

into inquiry. The researcher espouses a social constructivist understanding of knowledge formation upon which the methodology and data analysis will be built. Teachers are charged with helping to facilitate learning and understanding within their students and between their students. However, there is no strange instant acquisition of knowledge as portrayed in *The Matrix* (Wachowski & Wachowski, 1999) where Neo instantly understood Kung Fu after receiving a memory card download of the knowledge into his memory banks. No, information must be learned and constructed through experience. Students are able to do this by co-constructing knowledge through the incorporation of inquiry and laboratory activities in the classroom. Through these they are actively engaging, building, and sharing information which allows them to construct the knowledge. Additionally, students do not acquire the knowledge, but rather construct it based on data observed through activities and even more so those that they have taken ownership, whether that be by themselves or as a group.

However, ownership does not come from simply engaging in an activity, but it is synthesized through students engaging their real-world experiences and existing knowledge, hypothesizing, testing those hypotheses, and then drawing conclusions from their findings. Jonassen (1994) describes the learning outcomes as not predictable and that “instruction should foster, not control, the processing of the learner.” Learning occurs when the students tap into their curiosity about the world, how it works, and try to understand it (Olusegun, 2015). One way in which this curiosity is also piqued is through reflection (von Glasersfeld, 1995). Reflection allows for self-regulation and abstraction. This is especially important when critical thinking is involved, which is often where constructivist concepts are given great credence (Tam, 2000). Critical thinking is part of knowledge construction and interpretation within a community

of learners (Confrey, 1995). This community of learners is built around the ways in which scientists use language, behave, and conduct investigations (Shotter, 1995). Driver (1995) stated that students needed to “be initiated into this scientific culture” to learn science. However, in order to be initiated into this culture a student must value the same kinds of discourses as the classroom teacher or the student may feel especially disenfranchised (Moje, 1997). Teachers are often unaware of their own biases and how their pedagogy has been socially constructed along with the drive to change people’s lives as a manifestation of their own institution and culture (Gee, 1996).

Synopsis

Teaching in rural public schools, especially small ones, is challenging and often requires teachers to teach multiple preps without any colleagues teaching the same or similar subjects. This means that teachers must receive professional development or be part of a professional organization that allows them to grow. Not all districts pay for these organizations or professional development, like workshops, so the teachers may not be delivering content or assessing in ways that the standards, either NGSS or GSE, demand. Research rarely specifically addresses how rural public high school chemistry teachers view inquiry-based instruction, methods of teaching the concepts, and also determining whether or not they feel like there is a lack of funding for their professional development to be able to deliver such content. One of the goals of this study was to determine whether this is a pattern of teachers feeling that they cannot teach the way the standards are worded. Another goal was to determine what methods rural public high school chemistry teachers are using to teach standards that are inquiry-based, such as those that require laboratory investigations for the students to master the concepts, according to

the standards. In addition, a final goal was to see what resources these teachers have access to, either on their own or with the help of their school districts, through the lens of equity.

Chapter 3: Methodology

The present study utilizes a mixed methods approach that is described in this chapter. The research questions are introduced followed by the rationale for a mixed methods design. Following that is detailed information on the survey instrument, interview protocols, participant selection, data collection and analysis.

Research Questions

The research questions guiding this study are listed below:

RQ1: What are Georgia rural public high school chemistry teachers' views of the feasibility of teaching GSE High School Chemistry through inquiry?

RQ2: What are rural chemistry teachers' methods of teaching the concepts that have explicit inquiry or "plan and carry out the investigation" in the standard?

RQ3: What access do rural public high school chemistry teachers have to supplies, technology, planning, and professional development required to teach an inquiry-based unit including laboratory activities?

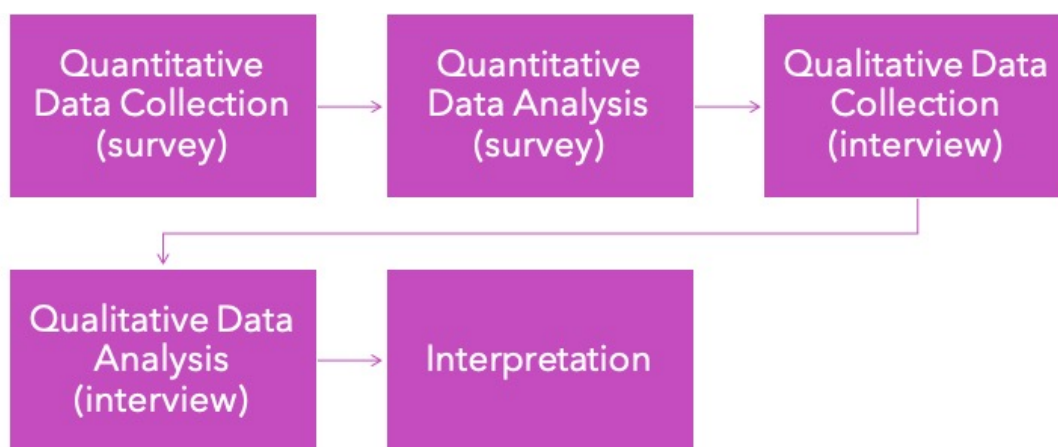
Rationale for Mixed Methods Design

The ultimate goal of this study is to accurately understand and voice the views of the participants. One way to do this is through a mixed method design. It allows the researcher to take data from both quantitative and qualitative instruments and combine them for a more complete analysis of the phenomenon (Creswell, 2005; Tashakkori & Teddlie, 2003). Design methods employing only one data collection method would be lacking in what the other could offer. The qualitative without the quantitative would not yield the rich data that is sought. On the other hand, quantitative without the qualitative would not give enough depth. For the

purposes of trying to gather both rich data and depth in conjunction with balancing the valuable time of the participants a mixed methods design has been utilized. Creswell (2003) describes the decisions a researcher undergoing a mixed methods design must make as the following: how data will be implemented, which research approach will have the dominant priority, how data collection and analysis will be integrated, and which theoretical framework will guide the study. A semi-concurrent implementation was utilized in the present study with the quantitative survey followed by qualitative interviews while drawing on a sequential explanatory design as shown in Figure 2.

Figure 2

Sequential Explanatory Design Strategy (Creswell, 2003)



The design of the present study is semi-concurrent, because while the quantitative survey was given first to inform the qualitative interview it continued to be given while interviews were being conducted. In that way the interview guide became dynamic in response to changes in data from the survey. This dynamic nature allowed for more in-depth analysis and questioning based on the close-ended survey responses. Interviews expanded the breadth and depth of the

survey (Towns, 2008). Also, keeping in mind the human and personal nature of the interviews and participants, the semi-concurrent nature allowed for convenient scheduling of interviews around events that occurred in schools, such as virtual teaching, COVID-19 quarantine, graduation, and teacher planning days. Research design typically has the dominant approach utilized first, but both approaches provide equal contribution in the present study.

The overall goal of the study was to give a voice to rural teachers. A higher response rate allowed for more validity in the results. The time required for this gives further reasoning for a semi-concurrent implementation. Past experience by the researcher regarding a pilot study attempted during summer 2019 showed that beginning research with teachers over summer is simply not wise, as teachers are 10-month employees and they are not required to work during the summer, and many do not check their email.

Rationale for Survey

Surveys are best used if the data cannot be observed directly or is not available in previous research literature (Jann & Hinz, 2016, p. 105; Phillips, 2017). They are most effective in investigating opinions and emotions, or human phenomena (Artino, et al., 2014). Taking these factors into account, the design of the survey is important but depends entirely on the research design intended by the researcher. A cross-sectional design was used for the clearly defined population of rural public high school chemistry teachers in Georgia and only occurred once at a specific point in time. This was an appropriate design because it allowed for the collection of data while taking into account the valuable time of the participants. A cross-sectional design was used to explore potential causal relationships which could not be done if a descriptive design was used (Jann & Hinz, 2016, p. 112-113).

Rationale for Interview

Face-to-face interviews are considered to be the most flexible in terms of complexity of the questionnaire, coverage, and even assistance of the interviewer (Leeuw & Berzelak, 2016, p. 144). These face-to-face interviews, in conjunction with surveys, allowed for a rich texture of data. The idea of using multiple modes dates back as far as the 1960s and includes mailed surveys with follow-up phone interviews, which helped to reduce nonresponse and kept costs down (Dillman & Tamai, 1988). However, knowing when, or if, to use a new survey is critical to its effectiveness. Sending a questionnaire through the mail is often met with a large expense with very little response rates, especially in today's technologically advanced society, which makes it less than ideal for answering the research questions (Duhan & Wilson, 1990). In the scenario of conducting research into the opinions and teaching methods of those educators from rural areas it is quite difficult, if not impossible, to observe all of them directly. This makes a survey conducted online the most feasible mode of gathering the data required to answer the research questions. A survey method with personal interviews and a mixed-methods approach, with the majority of data being qualitative from the interviews interspersed with quantitative data from the survey, helped answer the research questions appropriately.

Survey Instrument

The survey itself was developed in a manner to encapsulate as many research questions as accurately possible (and can be found in Appendix A. Questions were selected from Ladd's (2011) survey instrument that measured teachers' perceptions of their working conditions. Several of Ladd's 5-point Likert-style questions were used to probe teacher perceptions of their resources, support, and access to resources. Questions were then added regarding use of a

constructivist mindset in the participant's classroom, which might correlate to a teacher's adherence to the largely constructivist push for inquiry-based instruction. In addition, some questions were added that specifically dealt with lab supplies. The entire survey by Ladd was not used, particularly the questions relating teacher job satisfaction with retention. In effect, the questions taken from Ladd's survey helped to answer RQ2 and RQ3.

RQ3 was given further attention by utilizing questions from the *Teacher Perspectives on Factors Influencing Effectiveness* survey instrument by the Center on Great Teachers & Leaders along with The National Network of State Teachers of the Year (Behrstock-Sherrat, et al., 2014). Question 36 on the *Teacher Perspectives on Factors Influencing Effectiveness* survey instrument was used to develop the professional development portion of the present study's survey instrument. The question asked specifics that were relevant to the present study. The portions of question 36 that dealt with National Board Certification and co-teaching were not used as the information was outside the scope of the present study. The entire instrument was not used as it was much longer than the researcher's target of a 10-15-minute survey completion time. This helped to determine the professional development and involvement in professional organizations to which the participants have access.

RQ1 and RQ2 were addressed using questions taken and modified or condensed from the survey *Inquiry Beliefs and Practices* used by Jeanpierre (2006), which was developed and modeled after Burry-Stock's (1999) expert science teaching educational evaluation model (ESTEEM) survey. The version by Jeanpierre asked more specific inquiry type questions of the participants in order to discover the inquiry beliefs and teaching techniques used. The survey

comes from a constructivist theoretical framework and attempts to determine whether the social cognitive theory is put into practice within the classroom.

Questions regarding inquiry labs taught, number of inquiry labs taught, number of labs taught in general, teacher demonstrations, and whether inquiry labs were taught at all answered RQ1 and RQ2. These data were used to determine the degree to which the participants utilized inquiry labs and labs in general. Participants who reported not completing labs on a regular basis were asked to discuss this during the interview phase. Participants who utilized a large percentage of inquiry labs were also sought after to discuss the topic during interviews. The determination of how these differ is discussed in the determination of a link between funding, professional development, and the number and types of labs performed.

Basic demographic information is asked at the beginning of the survey to determine eligibility based on the requirements for participation set forth in the next section of this chapter. There is also a question that seeks to determine technology access for students in the school. Other questions involve schedule of classes, perceived location of school (rural, suburban, or urban), courses taught by the participant, and years taught with level of education. The perceived location of the school was checked after the survey to determine whether the school truly was rural and was added to determine if there was a difference in participant response based on the perception. These aspects could have an impact on the data. The more demographic information collected the more likely rich connections will be able to be made during the analysis of the data. With survey research there is only one chance to get the questioning correct, so making sure to have the proper questions listed was critical.

Context of Study & Participants

The sample for this study consisted of rural public high school chemistry teachers in Georgia. These teachers were currently teaching chemistry or had taught it in the last three years to allow for schools which are so small as to have to alternate subjects taught and for high turnover in rural areas (Ansalone, 2004; Deck, 2001; Monk, 2007). The aspect of three years means they may have taught three years ago under the Georgia Performance Standards as the state began rolling over to the GSE. The participants varied in terms of gender, race, and years of experience, but all were at least 18 years old to legally consent to participate in the study. All held a valid teaching license from the State of Georgia or recognized by the State of Georgia through Georgia Professional Standards Commission (GAPSC). The participants may have been in current administrator roles and eligible for the study if they did teach chemistry within the past three years. Each participant must also be teaching, or have taught, at a rural school with at least grades 9-12, which was checked using the school name against the National Center for Education Statistics (NCES) database of schools in Georgia. The grades are explicitly stated because some rural schools include grades 6-12 or more. For the purposes of this study, town and rural areas, according to the NCES, were grouped together as they face similar challenges and are often both referred to colloquially as rural (NCES, 2018).

Survey Sample

A total of 171 participants began the survey instrument. Of those 171, only 153 were deemed as eligible participants and completed the survey per the parameters set out in chapter 3. This includes the exclusion of 10 participants for schools that did not qualify as being public or were suburban or urban schools as well as 8 participants who did not correctly answer the internal test of validity embedded within the Likert-scale responses which asked participants to

select the option “somewhat disagree” as a response in the Likert-style questions. Of these 153 participants, 128 unique rural public high schools were represented out of the 202 total high schools that fit the research parameters in Georgia. The education level of the participants varied as shown in Table 6 with teachers with a master’s degree making up the greatest portion of participants at 47.7% compared to 44% of teachers in the state of Georgia who hold a master’s degree (GOSA, 2020, p. 2). Even though only 12.4% of participants indicated a doctorate or equivalent degree, 83.0% had a degree beyond a four-year bachelor’s degree.

Table 6*Education Level of Survey Participants*

Factor	Total Sample	Percent
Education		
n	153	n/a
Bachelor’s degree	26	17.0
Master’s degree	73	47.7
Specialist degree	35	22.9
Doctorate degree	19	12.4
Total	153	100

A bit more information about the survey participants that helps to add to the context is the years of chemistry teaching experience due to teaching chemistry under both the Georgia Performance Standards (GPS) and GSE. Table 7 lists the frequency and percentages of the groupings of experience.

Table 7*Survey Participants Years of Chemistry Experience*

Years of Experience	Frequency	Percent
1 – 5 Years	60	39.2
6 – 10 Years	40	26.1
11 – 20 Years	33	21.6
More than 20 Years	20	13.1
Total	153	100

The majority of survey participants, 65.3% ($N=100$), were in their first 10 years of chemistry teaching experience, and 86.9% ($N=133$) of participants had 20 years or less of chemistry teaching experience. While the percentages of participants in their first 10 years of chemistry teaching experience is close to the percentage who held a bachelor's or master's degree, 65.3% and 64.7%, respectively, they cannot be assumed as being the same individuals; for example, one of the interview participants, Eleanor, had more than 20 years of experience while holding a bachelor's degree as her highest level of education.

Similar to the variety of education levels and years of experience among survey participants, there was also a variety in the class schedules being utilized at participants' schools. Table 8 shows the frequencies and percentages of those on certain schedules. The type of schedule was defined in the survey question as follows: Traditional refers to six or seven-period days, with classes lasting approximately 60 minutes; block schedule (full year) is often described as a 4x4 block, where students go to A classes one day and then B classes the next with classes

typically meeting for 90-minutes every other day; block semester schedule only meet for a single semester with the typical 90-minute class like block whole year, but these classes meet each day; finally, a hybrid schedule is some combination of block and period, and it varies from school to school. An example that has been used in several schools is where students are on a traditional schedule for three days out of the week and then on a block schedule for the other two days. This type of schedule has the potential to allow for laboratory experiments to be performed in a timely manner on these days, while still maintaining an optimal amount of seat time for the students.

Table 8*Course Schedule of Survey Participants*

Schedule	Frequency	Percent
Traditional	46	30.1
Block (Full-Year)	7	4.6
Block (Semester)	92	60.1
Hybrid (Mix of Block & Traditional)	8	5.2
Total	153	100

The participants were overwhelmingly on a non-traditional schedule with 69.9% of participants ($N=107$) selecting one of the types of block schedule or the hybrid schedule. The semester-long block schedule was the most common choice of participants with 60.1% ($N=92$) selecting this schedule. Teachers who are on block schedule must teach the entire chemistry course to students

in 18 weeks of a high school semester rather than having 36 weeks utilized by the other schedules.

Interview Participants

In all, survey participants represented 128 unique rural public high schools with some duplications at some high schools for a total of $N=153$ participants whose responses met the internal validity test. From this population, eight participants consented to an interview during the survey portion of the study and gave pertinent contact information to accompany their response. As described earlier in this chapter, all participants' identities remain confidential and pseudonyms were given to each to avoid identification and possible fear of retribution for their comments.

Participant Selection

Purposeful sampling was used to select participants based on their answers during the survey portion of the study. Since a large portion of this study centers around teachers and their use of inquiry when teaching chemistry, the participants were chosen in order to maximize the variety of answers and to highlight teacher voices as to whether inquiry was taught, percentage of labs that were inquiry, and number of labs in general with regard to high school chemistry. The interviewed population is described in Table 9. The survey did not measure gender as part of the demographic information, but gender determination by names traditionally associated with gender showed that less than 20% of participants had a traditionally male name, which is contrary to data that shows that 75% of STEM teachers identified as male (National Science Board, 2018). Greater gender diversity in the interview participants was desired but attempts to bring in more male participants were not successful.

Table 9*Interview Participant Information*

Pseudonym	Gender	Reason for Selection
Alice	Female	Expressed interest in helping, smaller rural school, low lab number, 10% inquiry
Bridgette	Female	Low labs; lots of commentary; pros and cons
Cathryn	Female	90% inquiry; only 4 labs
Daisy	Female	Block schedule, interesting clarification statements, low lab numbers, 20% inquiry, struggled with low income multiple preps
Eleanor	Female	Disagrees with the way the State is mandating PLCs and how district and school are implementing them.
Felicia	Female	Rural; 80% inquiry; trouble with students planning investigations.
Gladys	Female	Low lab numbers; poor school; isolation
Hugh	Male	Male; no other chemistry teachers; new teacher; second career; low inquiry on survey; no PCOI

Context of Interview Participants*Scheduling*

The interview participants included three on a traditional schedule with 45 to 60-minute periods and five on block schedule with classes lasting only a semester with 90-minute periods each day. Typically, the traditional schedule yields classes between 45 and 60 minutes whereas block schedule is often 90 minutes or more.

Experience

Experience not only refers to years of teaching but also to those spent in industry, life experience, and experience in other jobs. The interview participants together had an average of 9.6 years of experience with three having 15 years or more of experience and one having more than 25 years. Comparatively, three participants only had either one or two years of experience, and five out of the eight had between one and ten years of experience.

Education

Education can be considered a substitute for experience for some jobs, such as those at the federal level. Of the participants in this study, four reported having a bachelor's degree, two reported having a master's degree, and two reported having a specialist degree. However, only one of the participants went to college intending to teach, and that participant is the only one with a bachelor's degree in education. All of the other seven participants have bachelor's degrees in subjects other than education as well as a Bachelor of Science in a scientific discipline. There were no participants in the interviews with a doctorate degree of any type, although they were not specifically excluded from participating.

Data Collection

IRB approval for the study is provided in Appendix B. Kennesaw State University IRB Board approved the study and designated it Study 19-596. Data collection of surveys was completed using Qualtrics and quantitative data analysis using SPSS. A link, or QR code, was provided to educators via business card, photo, social media post, or email (whichever was preferred by the educator taking the survey at the time). The cards were given out by the researcher to teachers at chemistry sessions at the Annual Conference for the Georgia Science Teachers Association. The GSTA conference is held each year and is open to anyone who pays

registration and desires to contribute or learn from the scientific community of educators. Permission to distribute surveys was obtained from the GSTA President at the time of the study, Judy Ward. GSTA District Directors were also given the link to send out to their districts, with a specific list of schools in their district that are eligible to complete the survey. In addition, Facebook, Instagram, and Twitter were used to get the information out to rural educators in Georgia. Regional Educational Service Agency (RESA) representatives in the various areas in Georgia were contacted and made aware of the research and asked to distribute to those they know in the rural schools in their areas. A list of schools and districts in each RESA area that fall into the guidelines for this study was sent out to each RESA representative in the initial email. IRB approval from districts was not required as personal emails and contacts were used. No student work was collected. All information was strictly concerning the adult participant(s) and their views of teaching the chemistry standards.

From the participants for the survey, 8 teachers were chosen to interview from rural public high schools in Georgia. Purposeful sampling was employed when choosing the participants. The first aspect was unique or intriguing answers to the survey that the researcher wished to know more about. The second factor, and most common, was the choosing of teachers who represented a wide array of rural public schools; small schools, large schools, etc. There is a question within the survey that asked for consent to contact those willing to participate in the interview. Only those who indicated a willingness to participate in the interviews were considered. The semi-structured interviews helped to give insight to the survey answers as well as develop personal trust between the participants and the researcher. The interview guide can be found in Appendix C..

The interview times ranged from 45 to almost 120 minutes and were completed virtually. The ideal time was set for 30 to 90 minutes, but many of the participants expanded on views and gave great detail in answering the questions. Participants felt comfortable discussing the topics with a fellow chemistry teacher even though the interviews were recorded using Zoom Pro. The interviews were transcribed and then coded using Atlas.ti (Barry, 1998). While a face-to-face interview would have definitely yielded personal results and helped in connections with the participant and researcher, online computer mediated interviews using Zoom have been shown by researchers to yield similar results as face-to-face interviews (Handgraaf, et al., 2012).

In-person interviews were not possible during the spring and summer of 2020 due mainly to the COVID-19 pandemic that spread throughout the United States and the rest of the world. This pandemic shut down the in-person or face-to-face component of schools through the country and were formally shut down by Georgia's Governor Brian Kemp from March 16th through the rest of the school year as part of his continuation of a state of emergency (Exec. Order No. 04.01.20.01, 2020). The U.S. Department of Education further waived all mandated standardized testing for the spring (GaDOE, 2020). Due to the shelter in place order in-person interviews were not possible. Schools implemented the remainder of the semester in a variety of ways. Video conferencing and online meetings were several methods implemented by schools and districts across the nation. The combination of teachers already being comfortable with video conferencing along with the amount of time they were spending checking email and being available online led to a greater willingness to participate in both the survey and interviews. Teachers who participated in the interviews were contacted after the original data was coded and analyzed to utilize member checking, which is described in detail later in this chapter. Further

implications of COVID-19 and the economic impact on education and chemistry budgets are discussed in Chapter 5.

Incentives for Survey and Interview

The survey included an optional incentive drawing of ten \$25 Amazon gift certificates for those who completed it and wished to enter the drawing. Each participant who opted in the drawing was assigned a number based on timestamp of completion of the survey. A random number generator online was used to determine the ten winners. The winners were then contacted via the method they chose within the survey, either email or phone call. In addition, each interview participant was given a \$25 Amazon gift certificate to compensate the individuals for their valuable time.

Data Analysis

Analyzing the data involved using open, axial, and selective coding. Open coding is a form of coding that involves describing and defining phenomena under investigation and occurs during the data analysis portion of the study. Codes were assigned while analysis was being done, which aimed at answering questions regarding the underlying issues, main actors involved and roles being played, context of place, intention or purpose, and how the phenomenon occurs in the first place. After these codes were identified axial coding was used to group them together into larger groups. This essentially assigns meaning to the codes and helped to determine relationships or commonalities between them. The interview transcripts were read multiple times to allow for these common ideas to develop into codes. Finally, selective coding was used to gather the big ideas and tie all the data together. A list of codes and sub-codes that were used to navigate through the data generated by the qualitative interview is provided in Appendix D.

Quantitative survey data was analyzed using descriptive statistics. Frequencies of participants' answers for each question were combined and analyzed using the 5-point Likert-style questions. For analysis purposes the answers to the Likert scale questions were combined into three main categories; agree, disagree, or neutral. Even though the answers to these questions are being combined for analysis, the questions were kept as Likert scales to remain as true to the original instrument as possible. While it might seem like 3-point Likert-style questions would be warranted, a 5-point scale is used to allow participants to choose partially without making a full committed decision thereby easing any discomfort during the study. However, just having the statements in the Likert-style question does not make them equal distance to each other, nor does it imply that the middle statement has any real value. These ordinal data that resulted from the answers on the survey requires non-parametric tests (Cooper & Johnson, 2016). Often a histogram is used to represent these data so as not to miss hidden characteristics with the data. A Chi-Square Test was used to analyze the quantitative data and determine the likelihood of the data resulting from chance. The majority of the quantitative data will be used to determine frequencies to impact and influence the larger qualitative interview instrument and analysis.

Strategies to Ensure Trustworthiness

Informed Consent.

Informed consent for the survey was obtained digitally through a consent form that was electronically signed and dated. This consent form for the survey had the option to be printed, emailed, or mailed based on the preference of the participant and can be found in

Appendix A. In the case of the interviews, some participants felt more comfortable digitally signing, while others felt more comfortable signing a hard copy, which can be found in Appendix E. Effort was made to ensure that participants felt comfortable with whichever method was preferred. The survey through Qualtrics was programmed with skip logic to ensure that only those providing informed consent were able to take the survey (Swanson, et al., 2014). The results of this participation, particularly the identities of the participants, are to be held confidential. To ensure trust and freedom to speak the truth about their workplaces, all teachers were given a pseudonym from a random name generator easily accessible online. Also, identifiable information such as district and school were not provided in the results of this study so that they are not identifiable from information used. Even with those measures in place there is a general apprehensiveness regarding subjective qualitative research. Credibility, transferability, dependability, and confirmability are four aspects of research that help to ensure trustworthiness as identified by Guba (1981).

Credibility

Credibility is the concept that the ideas presented in the data are true (Guba, 1981). One way to lend credibility is through familiarity with the culture being studied. Early familiarity with the culture of the participating organization(s) is relatively easy considering, like the participants, I am also a high school chemistry teacher in Georgia, particularly in a rural area. This and the fact that I have a professional relationship with many of the chemistry teachers across the state through mutual membership in state organizations provided familiarity. That being said, I approached the topic with a sense of newness and clarity, as I understand that each set of circumstances and schools is different. In addition, I understand that I may not fully know

the context of my own school as it relates to others. Teacher participants self-selected based on their content area, specific courses taught, and school location. Science teachers who were currently, at the time of the survey, teaching chemistry in a rural public high school in Georgia were able to participate in this project. In addition, member checking was used, where participants were given an opportunity to view the results before publishing to allow for review of the information presented.

Besides member-checking, which was performed with each of the eight interview participants, data were triangulated using multiple analysts. The main researcher performed all of the analysis, but inter-rater reliability was performed by a colleague who was also bound by the approved IRB. This allowed for multiple perspectives and for an analyst with greater experience to refine the methods of the investigator.

Transferability

Transferability is whether the results can be generalized outside of the observed population. Even though this case is nuanced to public high school chemistry classrooms in Georgia, it can be related to other chemistry and science classrooms around the state and country that may have similar demographics and place-based geography. These schools more than likely have the NGSS standards or standards based on the NGSS. Therefore, readers may find a large portion of the study to be transferrable. It's also worth noting that the study could be replicated in different states and even across larger geographic regions to legitimize the results for larger populations. Detailed description of the phenomenon under study and background data for the context of the study will further allow comparisons to be made.

Consistency

Consistency in how the data are analyzed and interpreted is considered dependability. In order to make sure this is maximized, an in-depth methodological description was used, which involved reporting the process used in detail, similar to a scientific laboratory experiment, to ensure that others may use this same model and methodology to repeat the experiment if desired. Overlapping methods also help ensure that dependability of the larger version of this study has been reached.

Confirmability

Confirmability is similar to credibility, but it relies on the researcher adequately presenting the information and that it is truly the information presented to the researcher by the participants. In addition, admitting my own biases and predispositions in the experiment help to make the study as open and transparent as possible. Reasoning is expressed to allow the reader to know exactly why certain methods were used and others were not. Diagrams are used to show an “audit trail” for the reader to follow, such as the audit trail in Appendix E.

Interview Consent Form

SIGNED CONSENT FORM

Title of Research Study: Rural High School Chemistry Teachers’ Views and Implementation of Inquiry-Based Laboratory Instruction as Set Forth in The Next Generation Science Standards

Researcher's Contact Information: Robert Bice, (404) 939-2423,
rbice2@students.kennesaw.edu

Introduction

You are being invited to take part in a research study conducted by Robert Bice of Kennesaw State University. Before you decide to participate in this study, you should read this form and ask questions about anything that you do not understand.

Description of Project

The purpose of the study is to determine chemistry teachers' views, methods, and funding sources for teaching standards that seem to imply using more resources than previous standards in Georgia public high schools.

Explanation of Procedures

During an audio recorded interview, participants will be asked to describe your views and methods of teaching resource-heavy standards in a Georgia public high school chemistry classroom.

Time Required

The interview should take no longer than 1 hour.

Risks or Discomforts

There are no known risks or anticipated discomforts in this study.

Benefits

An honorarium of \$25 in the form of an Amazon gift certificate will be awarded to those who complete the interview. In addition, the researcher will learn more about how chemistry standards are being implemented in Georgia. Participants may realize that they may or may not be focusing on certain elements and standards in teaching and may decide to include those in the future or seek funding for interesting activities to be done.

Compensation

An honorarium of \$25 in the form of an Amazon gift certificate will be awarded to those who complete the interview.

Confidentiality

The results of this participation will be confidential. All participants will be given a pseudonym and identifiable information such as district and school will not be provided so that they are not identifiable from information used.

Inclusion Criteria for Participation

Participants must be a teacher who has taught chemistry within the last year at a rural high school in Georgia who is at least 18 years of age.

Signed Consent

I agree and give my consent to participate in this research project. I understand that participation is voluntary and that I may withdraw my consent at any time without penalty.

Signature of Participant or Authorized Representative, Date

Signature of Investigator, Date

PLEASE SIGN BOTH COPIES OF THIS FORM, KEEP ONE AND RETURN THE OTHER TO THE INVESTIGATOR

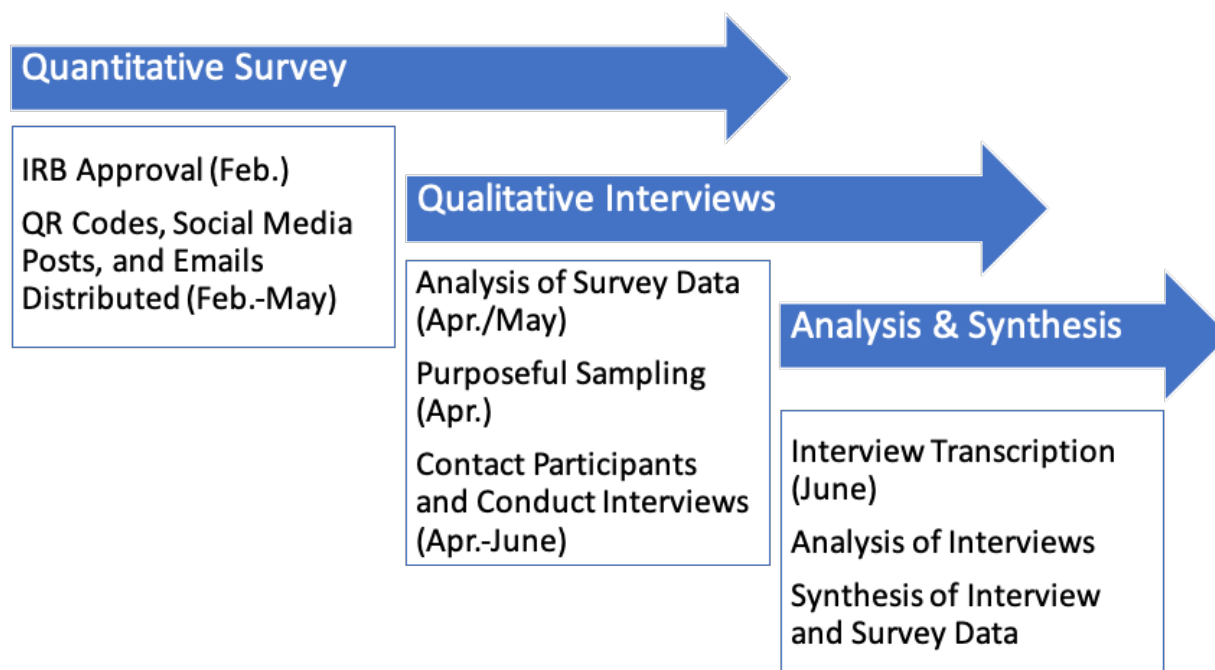
Research at Kennesaw State University that involves human participants is carried out under the oversight of an Institutional Review Board. Questions or problems regarding these activities

should be addressed to the Institutional Review Board, Kennesaw State University, 585 Cobb Avenue, KH3417, Kennesaw, GA 30144-5591, (470) 578-6407.

Appendix F. A theoretical diagram provides a timeline for the reader. Figure 3 includes when surveys were taken, when data were collected and analyzed, and when interviews were conducted in order to provide transparency.

Figure 3

Theoretical Diagram of Research Design Implementation



The inclusion of the interview questions allows for transparency. A data-oriented diagram shows how the data were gathered, processed, and how recommendations at the end of the study were made (Shenton, 2004). Member checking was also utilized to allow for participant confirmability of the results to decrease researcher bias of the information and ensure that the data, analysis, and findings are truly what was intended by the participant(s).

Instrument Reliability

Instrument reliability applies to the survey being used in this study. It is whether the instrument used is reliable in providing the data that the researcher claims. Several factors must be analyzed when determining instrument reliability. One of those factors is that the number of respondents must be greater than the number of items on the instrument (Nunally, 1978). Getting to an $N \geq 50$ allowed for this within the survey. Reliability analysis should not be attempted for sample sizes of less than 30 (Samuels, 2015). For this instrument the minimum threshold of 50 was achieved. Consistency in participant responses from taking the survey and interview questions helped to serve as an additional form of reliability. Inter-rater reliability was used in the coding of the data.

Validity

Any research should be able to justify that what is presented is true, believable, and whether it truly evaluates what it intends to address (Burns, 1990 p. 160). Validity is the term used to describe this and is critical when it comes to presenting findings as the conclusions of the research are based on the instruments for which validity must be established (Fraenkel & Wallen, 2003 p. 158). Content validity is often established by using well-established instruments that have been vetted by experts in the field. For the present study, that was not possible as a survey does not exist that attempts to answer all of the research questions. However, questions were pulled from previously established instruments to create the current survey. Internal validity is, essentially, how in tune the research findings are with reality (Zohrabi, 2013). A Likert question was used as a test of internal validity where participants were asked to select “somewhat disagree” for the answer. Only participants who answered this question correctly were considered for analysis purposes.

Face validity was achieved through consultation with an expert panel of researchers regarding the instrument and survey guide. Triangulation was also used in the study, which is where two or more sources of data were present. In this study there is the quantitative survey with the qualitative interview both presenting data in different ways to bring together a more complete, or realistic, picture of what the participant is experiencing or has experienced. Another way validity was established was through member checking.

Participants were provided transcripts of their interviews along with a one-page analysis of their interviews in light of the research questions. The transcripts and analyses were sent via email, which was the preferred contact method of each participant, and participants were given a specified amount of time to review it. Each participant confirmed with several minor adjustments to spellings of locations or names used in the transcripts. Finally, validity is established through explicitly stated researcher bias. I have already made my particular worldviews, beliefs, and perspectives known in this study and by addressing it have not pretended to be completely impartial in performing the study. By addressing my own inherent bias I hope to let others know that the introspection was done and that the study, research, and analysis contains just as much detailed scrutiny as I apply to myself.

Chapter 4: Results & Findings

The purpose of this chapter is to present the results and findings of the data collected in this study. The evidence and artifacts presented in this chapter will attempt to answer the research questions: RQ1: What are Georgia rural public high school chemistry teachers' views of the feasibility of teaching Georgia Standards of Excellence (GSE) High School Chemistry through inquiry?; RQ2: What are rural chemistry teachers' methods of teaching the concepts with explicit inquiry or plan and carry out investigations (PCOI) in the standard?; RQ3: What access do rural public high school chemistry teachers have to supplies, technology, planning, and professional development required to teach an inquiry-based unit including laboratory activities? The chapter lays out the results and findings gathered from both the mostly quantitative survey and the qualitative interviews in order of research question: analysis from both the survey and interviews will be shown and data displayed. The chapter concludes with a concise summary of key results and findings as they relate to research questions concerning teaching high school chemistry in a rural public setting.

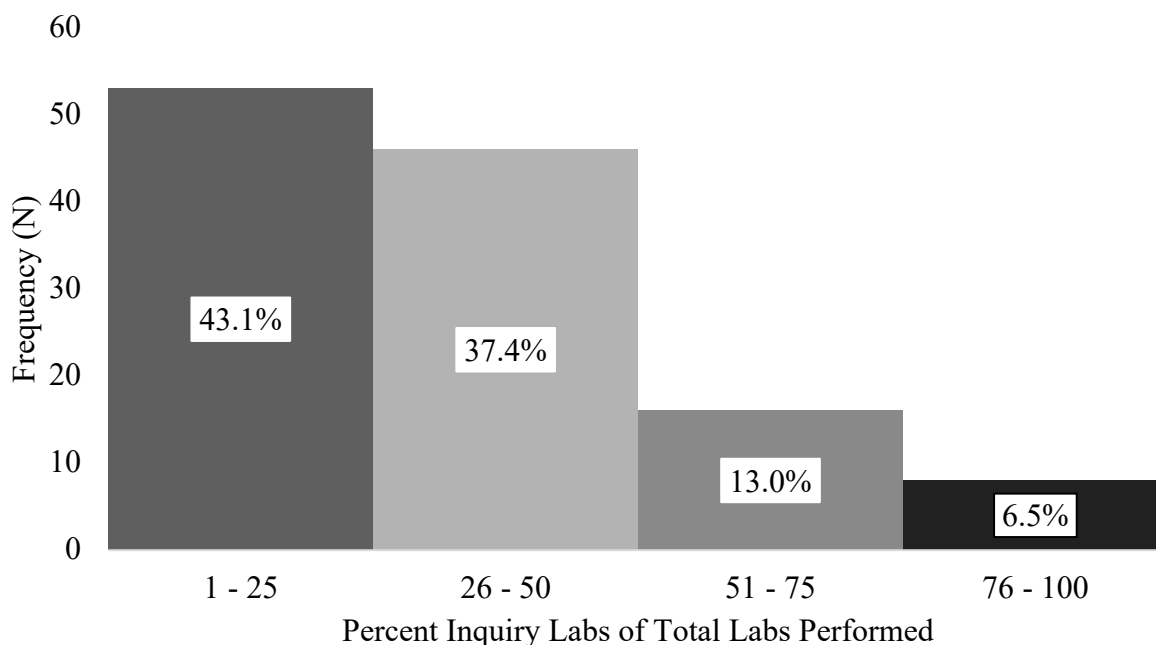
Research Question #1: What are Georgia rural public high school chemistry teachers' views of the feasibility of teaching Georgia Standards of Excellence (GSE) High School Chemistry through inquiry?

RQ1 attempted to determine the views of the participants as to the feasibility of teaching GSE High School Chemistry through inquiry within a rural public high school setting. The survey instrument specifically asked teachers if inquiry was performed in their classrooms. The majority of teachers, 80.4% ($N=123$), indicated using inquiry labs in their general chemistry classroom, as opposed to AP or Honors, which means that the majority of teachers do find

teaching inquiry as something that is feasible to do within the school setting. However, when asked, one participant stated, “I love the idea/concept of inquiry but find it’s neither practical nor safe in my reality... We have limited lab facilities, lab equipment, and lab consumables, and the third person method of requesting supplies really slows down the materials pipeline...[inquiry] requires planning weeks ahead of time and that just doesn’t happen.”

Participants who selected yes to using inquiry were then directed to indicate the percent to which inquiry labs made up the total labs used in their chemistry course, and data revealed that inquiry labs, in some form, are being utilized in the rural public high school chemistry classroom but are perceived to make up less than half of the overall labs in the majority of participants’ classrooms. Answers ranged from a minimum of 3% to a maximum of 90%, and

Figure 4 shows that 43.1% ($N=53$) of participants use inquiry for between 1-25% of their labs while 37.4% ($N=46$) of participants utilize inquiry as part of 26-50% of their overall labs. This indicates that of the participants who admitted to using inquiry in the general chemistry classroom, 80.5% ($N=99$) of those used it in half of their labs or less. Moreover, a very small percentage of teachers, 6.5% ($N=8$), indicated utilizing inquiry labs in some form in over 75% of their labs performed for the chemistry course.

Figure 4*Inquiry Labs as a Percentage of Total Labs Performed*

While these numbers may tell a great deal about inquiry use in the classroom, some participants chose to add some clarifying comments. Some comments from participants regarding inquiry involved using it most often in AP courses or honors courses, and others stated that “student to teacher ratio makes inquiry difficult.” Several participants also cited lack of time as a reason why they did not engage students in as much inquiry in that “52 minutes a class is an extremely short period of time to get full lab experiences in” or that “my biggest barrier is the time constraint of grading in a timely way” and “there just isn’t the kind of time I would want for more fully or even semi-fully inquiry-based labs.” However, these quotes imply that teachers want to use inquiry to teach chemistry, but some feel that they cannot do so within the bounds of

their classroom environments. Further reasons that several teachers felt like they could not undergo inquiry labs with their students will be discussed later in this chapter.

Number of Labs Performed Per Semester

Participants were asked about the number of student labs performed during a semester.

Table 10 lays out the entire data set of participants as well as splits them up into inquiry or no inquiry based on their answer to a previous question on the survey instrument. On average, teachers implemented 13.6 labs with a minimum of 2 and a maximum of 30. The standard deviation was found to be 6.29 with a mode of 20 (

Table 10). The minimum was lower than anticipated for both subgroups which is partially detailed in the interview analysis portion of this chapter.

Table 10

Number of Student Labs Performed Per Semester

Factor	Frequency	Mean	Standard Deviation	Minimum	Maximum	Mode
No Inquiry	30	11.3	6.67	3	27	4 (N=6)
Inquiry	123	13.6	6.29	2	30	20 (N=16)
Total	153	13.6	6.29	2	30	20 (N=17)

There was also a difference in mean number of labs performed per semester in those who performed inquiry (13.6) and those who did not (11.3) indicating that those who stated that they used inquiry in their labs performed, on average, 2.3 more labs per semester than those who indicated that they did not use inquiry in their labs. Even though comments mentioned teachers not having enough time to complete inquiry labs, the teachers utilizing inquiry labs performed more labs on average than those who did not utilize it. This is an interesting revelation in the

data, so the time issue was further examined through comparison of the schedules implemented at each school and the use of inquiry labs.

School Schedules

Data concerning school schedules versus use of inquiry labs, as reported by the participants on the survey instrument, is detailed in Table 11. The majority of teachers ($N=92$) reported being on a semester long block schedule followed by those on a traditional schedule ($N=46$).

Table 11

School Schedule vs. Use of Inquiry Labs

Schedule	Self-Reported Use of Inquiry Labs					
	Frequency			Percent		
	No	Yes	Total	No	Yes	Total
Traditional (Period)	10	36	46	21.74%	78.26	100
Block (Full Year)	1	6	7	14.29%	85.71%	100
Block (Semester)	19	73	92	20.65%	79.35%	100
Hybrid	0	8	8	0%	100%	100
All Block	20	79	99	20.20%	79.80%	100
All Non- Traditional	20	87	107	18.69%	81.31%	100

Even though there is a difference in time to complete labs within one class of either schedule, inquiry labs were still reported in 78.26% of participants on traditional schedules versus 79.35% of participants on a block semester schedule revealing very little difference in inquiry usage between these two subgroups. Those on a hybrid schedule reported a 100% inquiry usage, although the sample size of $N=8$ is not large enough to make an overall conclusion, and 85.71% of participants on a year-long block schedule ($N=8$) reported using inquiry. When looking at traditional versus non-traditional schedules, block and hybrid, 81.31% of participants on non-traditional schedules reported using inquiry as opposed to 78.26% of participants on a traditional schedule. Interestingly, two out of the three interview participants on the traditional schedule reported not completing inquiry labs in their classroom as opposed to only one out of five of those on block schedule reporting that they do not use inquiry labs. This difference in schedule, combined with the number of different or unique course preparations (preps) was cited by participants as a hindrance in completing laboratory experiments. This data reveals that the school schedule may paint a picture of how teachers use inquiry on various time constraints, but this is not the only factor that must be addressed when looking at the teaching of inquiry in rural public high school chemistry classrooms.

School schedules was a topic that also came up during the interviews as possibly impacting the types and number of labs performed by students in a high school chemistry course. Alice had the following to say about inquiry labs and scheduling:

I have them for one semester, which is 18 weeks. And even if I were to teach, you know, give every substandard a week, it's not going to work out. So, a lot of times what we do

with those plan and carry outs [standards] is I find a PhET, because then...they have those limitations already set.

Eleanor, the interview participant with the greatest amount of teaching experience, stated that she did not complete inquiry labs but did complete 14 labs with her students in some form per semester. She also explained that her school recently underwent a change in schedule from traditional to block due to the vision of a new superintendent. When asked whether she noticed a difference between the two schedules in the number of labs she was able to do she stated the following:

[The] only positive is lab time. And again, when the state went through such financial hardships, one of the things our county did was ask for a variance so that we could have larger classes. This past semester, I had 32 students in a gifted class and 34 in a regular chemistry class. And it would, it would give me heart palpitations, to think about lighting Bunsen burners. And, you know, having them do acid-base titrations because it's almost impossible to stand guard over 34 kids in a classroom. So, block was good, only that sometimes I could divide the labs up where half the class was doing the lab. The other half was doing something else. But then it just, you know, it dragged out forever.

Having worked in education for over 20 years, Eleanor recounted working within the confines of different schedules. Changing schedules was not without drawbacks as she recalled how an increased class size combined with a changing schedule resulted in increased teacher anxiety and stress as Eleanor stated about her “heart palpitations” when thinking about that number of students in lab “lighting Bunsen burners” or “stand[ing] guard over 34 kids in a classroom” involved in labs with a significant risk as in acid-base titrations. Her comments in the above

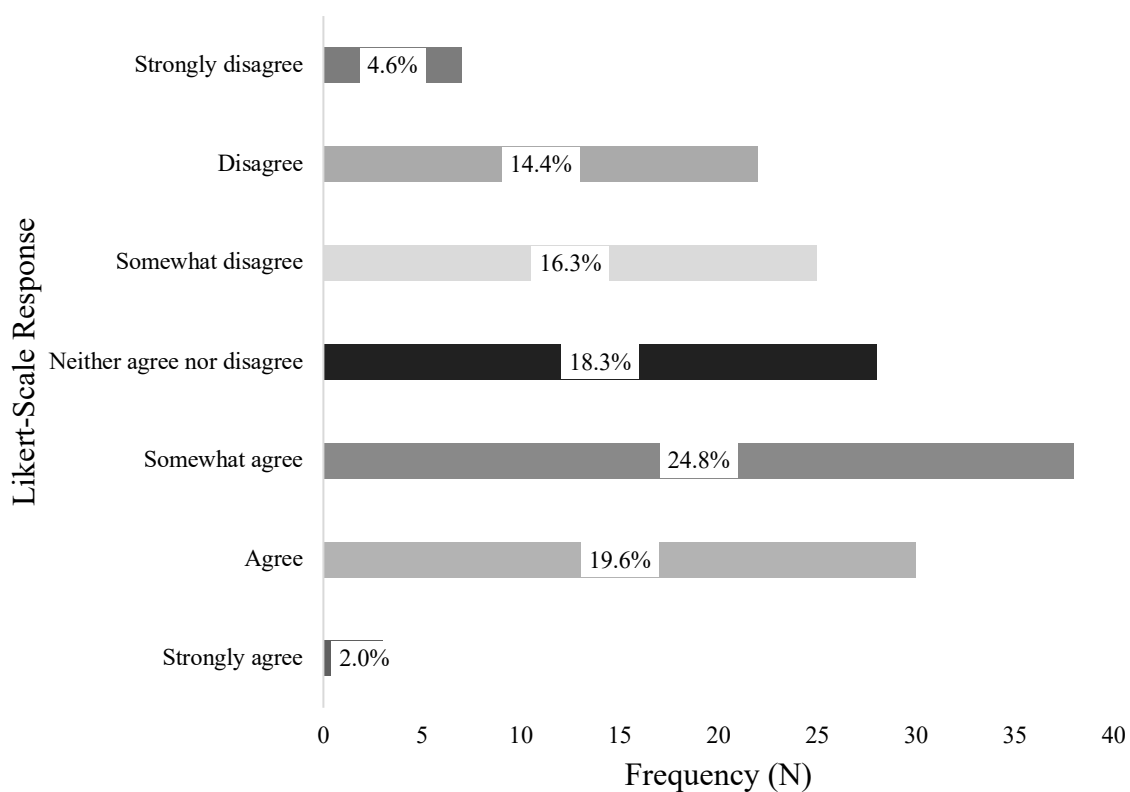
quote combined with her survey responses indicate that inquiry can be stressful, and some teachers feel that they cannot change how they are teaching based on changes at the state level. Modifications were made regarding lab instruction, but these changes were not without extra work on the teacher to overcome challenges faced regarding schedules and numbers of students.

Teacher Views of Inquiry

This section specifically looks at participants' answers to questions regarding their views on inquiry and inquiry-based instruction. Because the GSE explicitly states that students are to plan and carry out investigations (PCOI) without explaining how this could be done or what this might look like in a classroom, the first portion of this section investigates participants' views on whether students designing their own laboratory investigations is a critical component in the high school chemistry course. The views are especially critical when examining schools without a science coordinator in the district or where the chemistry teacher may be the only one in the school. The data for this is presented in Figure 5.

Figure 5

Students Designing Labs as Critical to the Course



Note: The figure presents the data associated with participants' answers to the Likert-style question that began with "Please use the rating which best describes your inquiry teaching and learning beliefs for the following statements..."

To interpret this seven-point Likert question the data was grouped into three subgroups; those who agree to some degree, those who disagree to some degree, and those who neither agree nor disagree. The data shows that 46.4% ($N=71$) of participants agreed that students designing their own investigations is critical to the general chemistry course, while 35.3% ($N=54$) of participants disagreed. Something else to note from this data is that even though the data were grouped into three main subgroups, the extremes of "strongly agree" and "strongly disagree" did not gather many responses with 2.0% ($N=3$) and 4.6% ($N=7$), respectively. Essentially,

participants were relatively split on the importance of students devising their own laboratory investigations with just over 10% more on the affirmative side than the negative side.

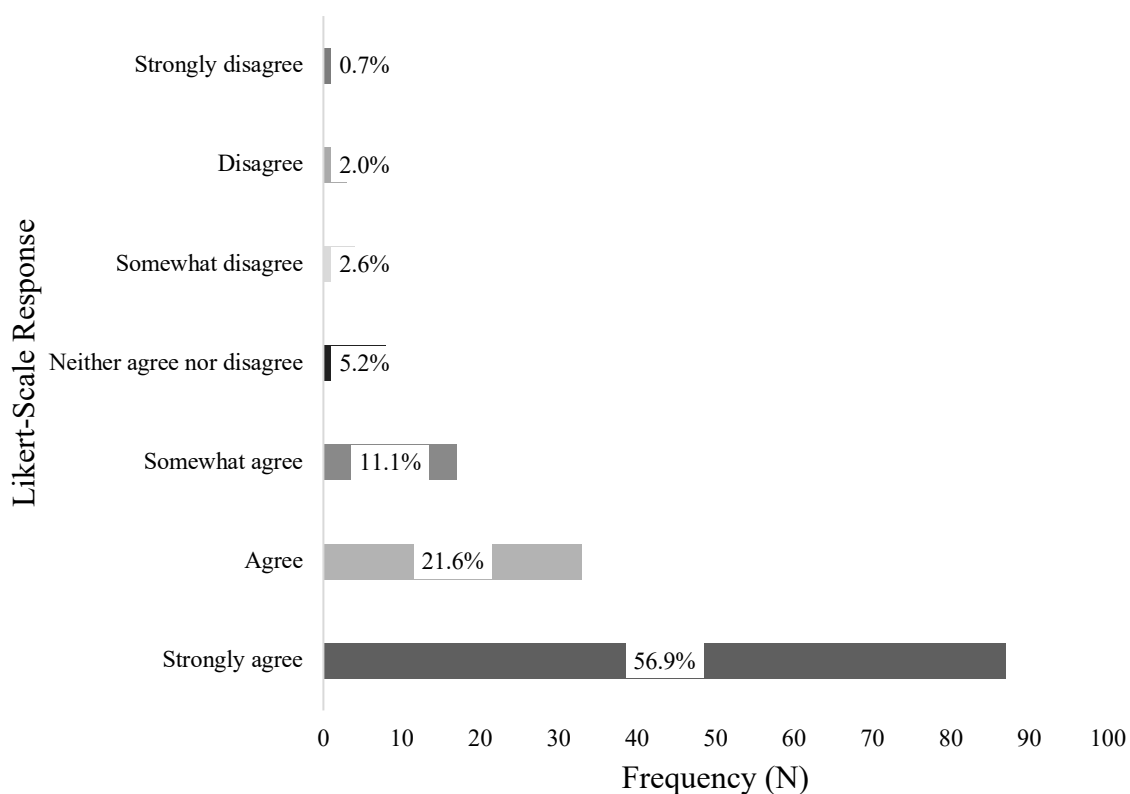
Figure 6 shows the data for participants' responses when asked if they thought that students carrying out investigations, whether through inquiry or teacher directed, is a critical component in the general chemistry course. According to

Figure 6, 89.6% ($N=137$) of the participants agree that student investigations are critical to chemistry. Unlike Figure 5 that shows that students coming up with their own labs had no extremes,

Figure 6 reveals that 56.9% ($N=87$) strongly agreed that students carrying out investigations were critical to chemistry, and this large majority in favor of student investigations is countered by only 5.2% ($N=8$) who neither agreed nor disagreed and 5.2% ($N=8$) who disagreed. The data shows that teachers agree that students should carry out investigations but are mixed on opinions as to how much of the experiment students should plan.

Figure 6

Student Investigations as Critical to the Course



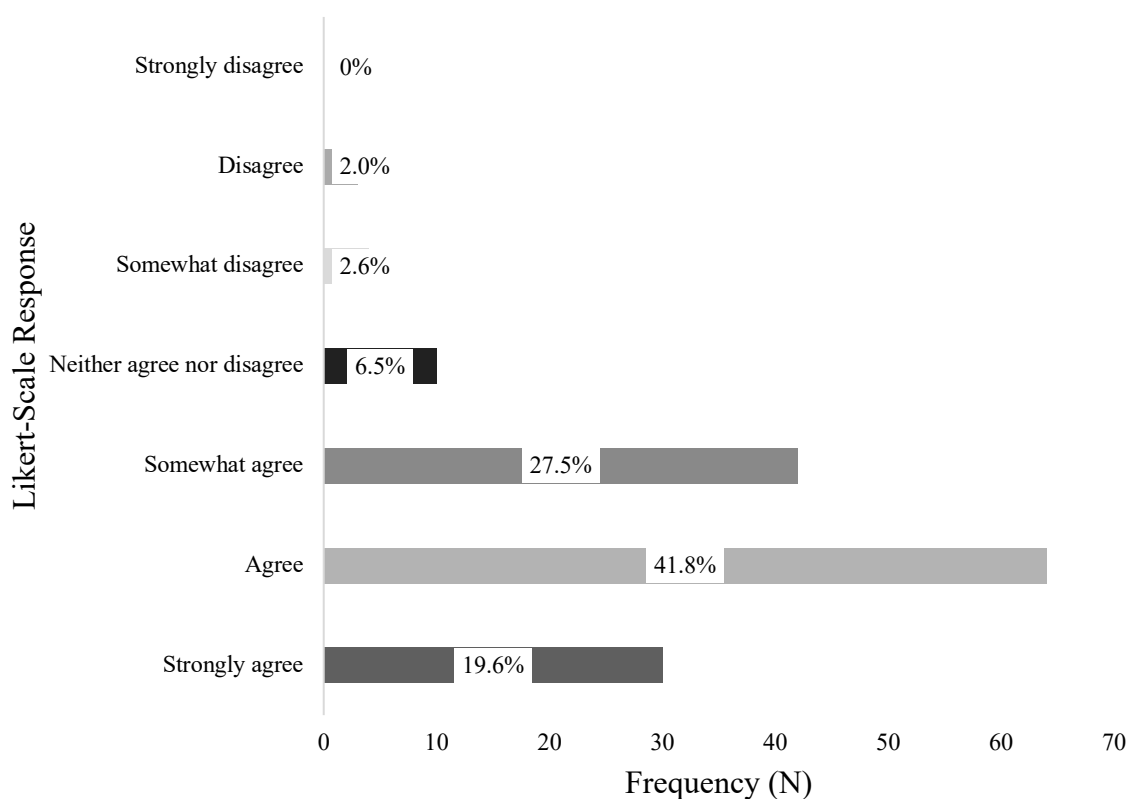
Note: The figure presents the data associated with participants' answers to the Likert-style question that began with "Please use the rating which best describes your inquiry teaching and learning beliefs for the following statements..."

Since participants overwhelmingly agreed that students should carry out investigations, or that investigations were critical to the course, understanding the amount of time that this takes during the course was critical. Participants were asked if they thought that inquiry labs took more time and resources than regular, non-inquiry, labs. One participant stated in the comments after the section that students conducting their own labs took more time but did not necessarily have to take more money if a teacher is creative, but Figure 7 reveals that 88.9% ($N=136$) of

participants believe that students conducting their own labs requires more time and resources than regular labs with only 4.6% ($N=7$) disagreeing with the statement.

Figure 7

Time and Resources for Inquiry vs. Regular Labs



Note: The figure presents the data associated with participants' answers to the Likert-style question that began with "Please use the rating which best describes your inquiry teaching and learning beliefs for the following statements..."

Since the majority of teacher participants believe labs are a critical component in the course, and the majority of them also believe that students conducting their own experiments requires more time and resources than regular labs, the question that must be asked is whether

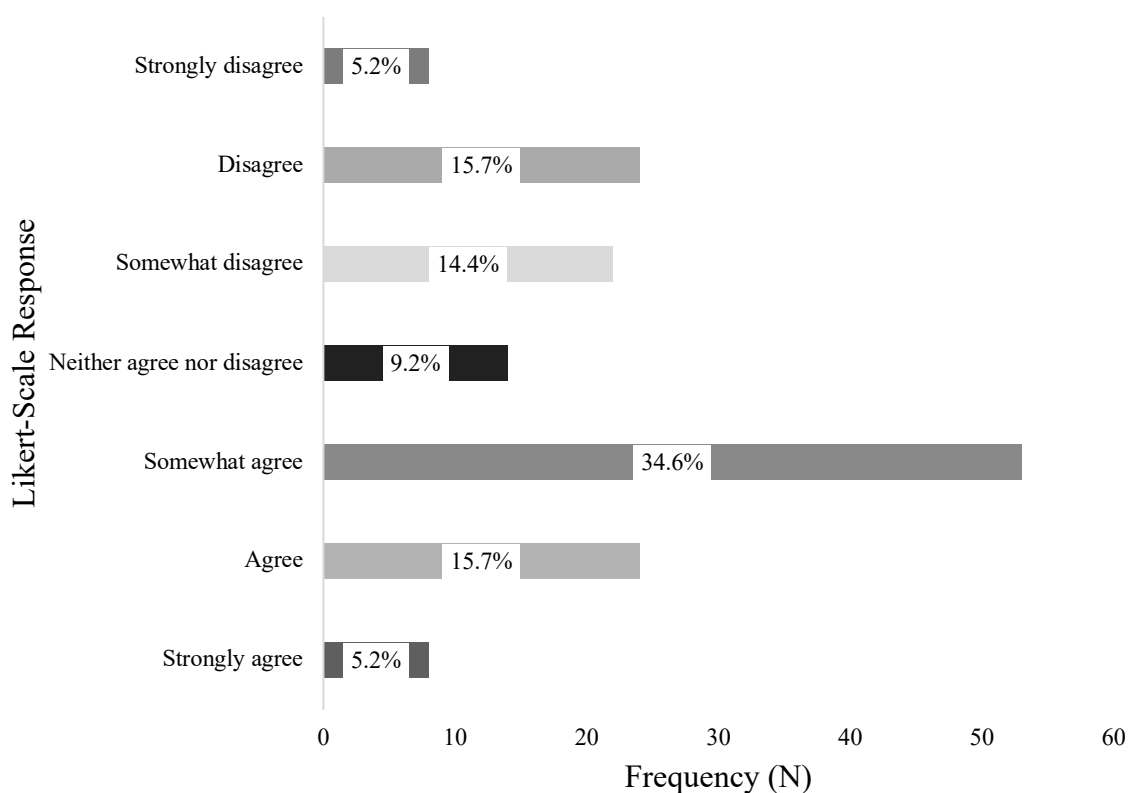
students coming up with their own labs or learning through inquiry-based instruction is too time consuming for the course? So, participants were then asked to select an option based on their view of the following statement: “I believe inquiry labs are too time consuming for the constraints of the course.” The responses were compiled and are displayed in Figure 8. Based on the data, 55.5% ($N=85$) of participants agreed with inquiry labs being too time consuming for the time constraints of the course, but 35.3% ($N=54$) disagreed. Based on the comments after this section, participants interpreted “inquiry” in the question prompt as open inquiry, or that type of inquiry which has the greatest amount of student autonomy and the lowest amount of teacher guidance on the inquiry continuum. One participant stated that time constraints of teaching requires labs to “be more teacher-led” and that the teacher must “stay on task” in order to complete the labs within the time allotted. This was echoed as another participant thought that “inquiry labs take more time and more resources,” but that the “time is better spent with more of a guided inquiry experience.”

RQ1 was answered by showing that the majority of participants viewed teaching GSE High School Chemistry through inquiry as being feasible. Comments on the matter included those participants who voiced concerns over various issues such as lack of time, supplies, equipment, time to grade, planning or preparation time, and student apathy. Even though these hindrances were brought up, comments also included that students are involved in guided-inquiry or teacher-guided inquiry. One participant added that “I do a lab almost every week...for on-level” chemistry courses. Adding these comments to the quantitative data from the survey shows that the majority of participants viewed teaching the GSE High School Chemistry through an inquiry-based approach as at least feasible. More insight than was provided in the

quantitative survey was desired to try and understand in participants' own words the reasons for their views on inquiry in the general chemistry classroom.

Figure 8

Perspectives on Inquiry Labs Being Too Time Consuming for the Constraints of the Course



Note: The figure presents the data associated with participants' answers to the Likert-style question that began with "Please use the rating which best describes your inquiry teaching and learning beliefs for the following statements..."

Even with the time constraints, Alice reported to completing 12 labs per semester of which 10% she classified as inquiry labs, which indicated an assumption that inquiry labs must be wet labs, or labs requiring chemicals within the classroom. The language of the standard does

not indicate that the labs be wet labs. Cathryn was the interview participant who had the highest inquiry percentage of labs at 90% and reported to have completed four inquiry labs per semester, but agreed that inquiry labs were time-consuming and had the following to say when asked how long they took:

Well, one, what if it takes a week? One of them takes and that's five days at one and a half hours apiece. By the time they get in there and they get their head around and it takes some [time] for them to get their head around the question.

However, during the interview she described how strongly she felt about making her students think and struggle with problems and then find solutions to them indicating that though the inquiry process is time-consuming, it does lend to that thinking. The qualitative interviews helped to provide a bit more information than the survey provided on its own, which helped to bridge into RQ2. RQ2 sought to determine the methods of teaching inquiry or PCOI in the standards within the rural public high school classroom.

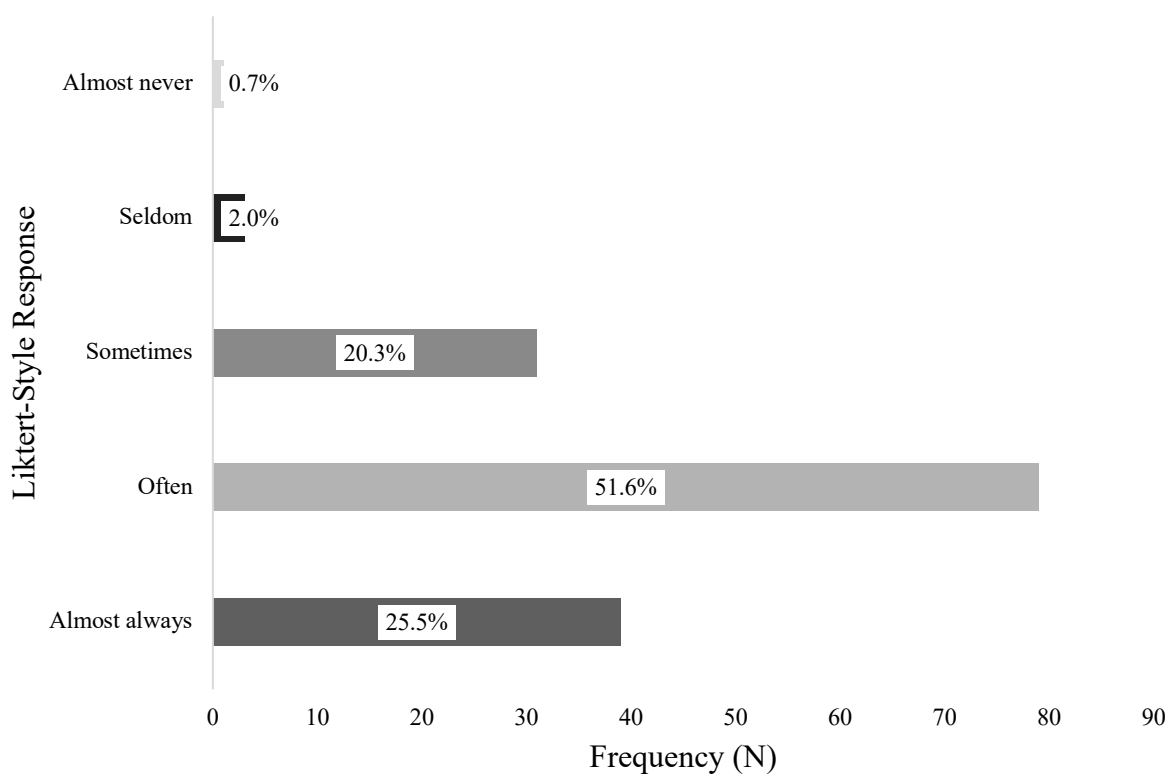
Research Question 2: What are rural chemistry teachers' methods of teaching the concepts with explicit inquiry or plan and carry out investigations (PCOI) in the standard?

Teaching with the worldview that students must construct their own knowledge and ideas about the world is one theory upon which inquiry is founded (NRC, 2000). The present study aimed to determine whether teacher participants saw themselves as facilitators of learning in the classroom, so participants were asked to rate their answers to statements using a five-point Likert-style scale.

Figure 9 presents the data from the following statement: “I see myself as a facilitator in the classroom.”

Figure 9

Perspectives on Teachers as Facilitators in the Classroom



Note: The figure presents the data associated with participants' answers to the Likert-style question that began with "Please use the rating which best describes your inquiry teaching and learning beliefs for the following statements..."

Importantly, as the basis for inquiry-based instruction, the constructivist idea of the teacher as a facilitator in the classroom was something that 97.4% ($N=149$) of participants saw themselves doing at least sometimes in the classroom. 77.1% ($N=118$) of participants saw

themselves as a facilitator in the classroom often or almost always. The data shows that there is an overwhelming majority of rural chemistry teachers who hold the constructivist worldview, at least sometimes, in the public high school classroom. The majority of participants identifying as facilitators in the classroom could indicate that they adhere to the underlying tenants behind inquiry-based instruction, even if some may not understand how to implement inquiry-based strategies. This is in keeping with the responses and comments that some participants did not utilize inquiry in the classroom for a variety of reasons.

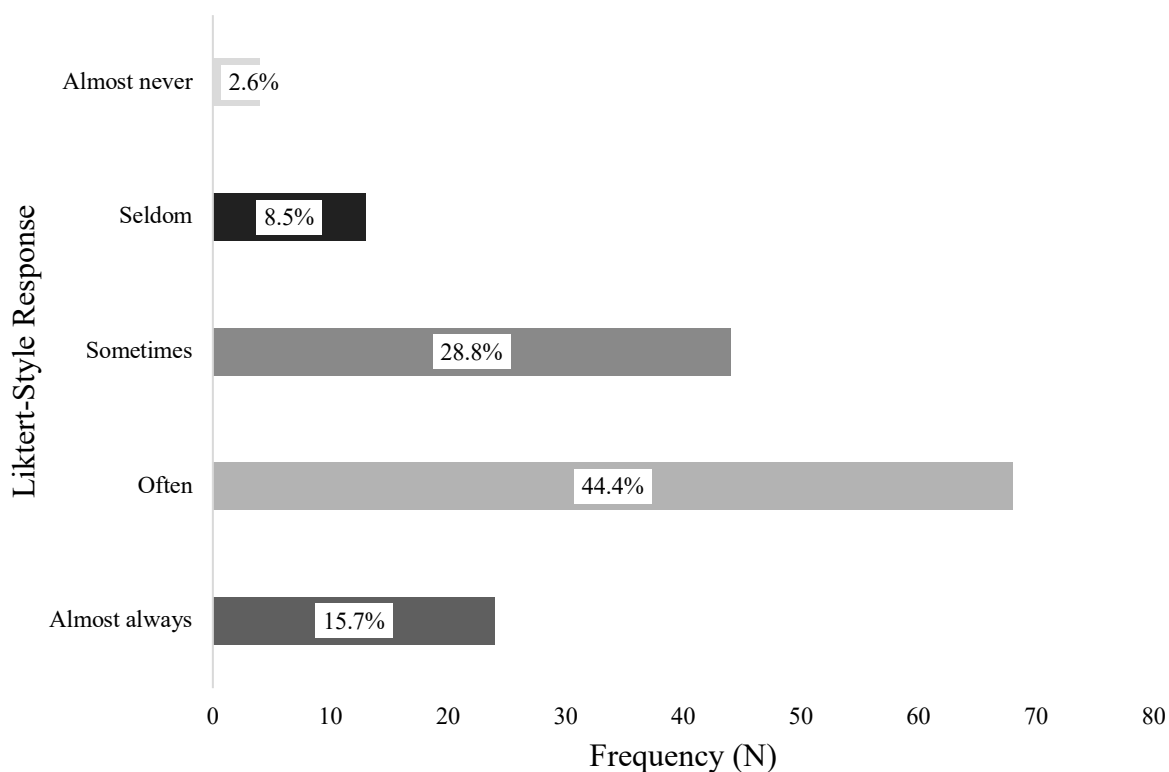
Phenomena are observable events that are used to spark inquiry when presented to students. Presenting these observable events to students within a unit allows for students to construct their own explanations, which is constructivism. Use of phenomena is but one way to teach chemistry using an inquiry-based approach. Participants were asked to rate their beliefs on using phenomena in the classroom; the data representing their responses is shown in

Figure 10. 11.1% ($N=17$) of participants answered that they used phenomena almost never or seldom in their teaching. This is opposed to 88.9% ($N=136$) of participants who use phenomena at least sometimes in their classroom, and 60.1% ($N=92$) who use them often or almost always. Using these methods of teaching inquiry implies that the majority of rural public high school chemistry teachers who participated in this study view teaching the GSE through inquiry as feasible even though they are not necessarily employing all of the methods or strategies for doing so. This does not mean that participants are using inquiry-based instruction in their classrooms.

Objections to using inquiry included lack of PD, resources, time, and student knowledge. Even with these objections, the majority of teachers admitted to using inquiry and phenomena within their classrooms.

Figure 10

Participant Use of Phenomena in Teaching



Note: The figure presents the data associated with participants' answers to the Likert-style question that began with "Please use the rating which best describes your inquiry teaching and learning beliefs for the following statements..."

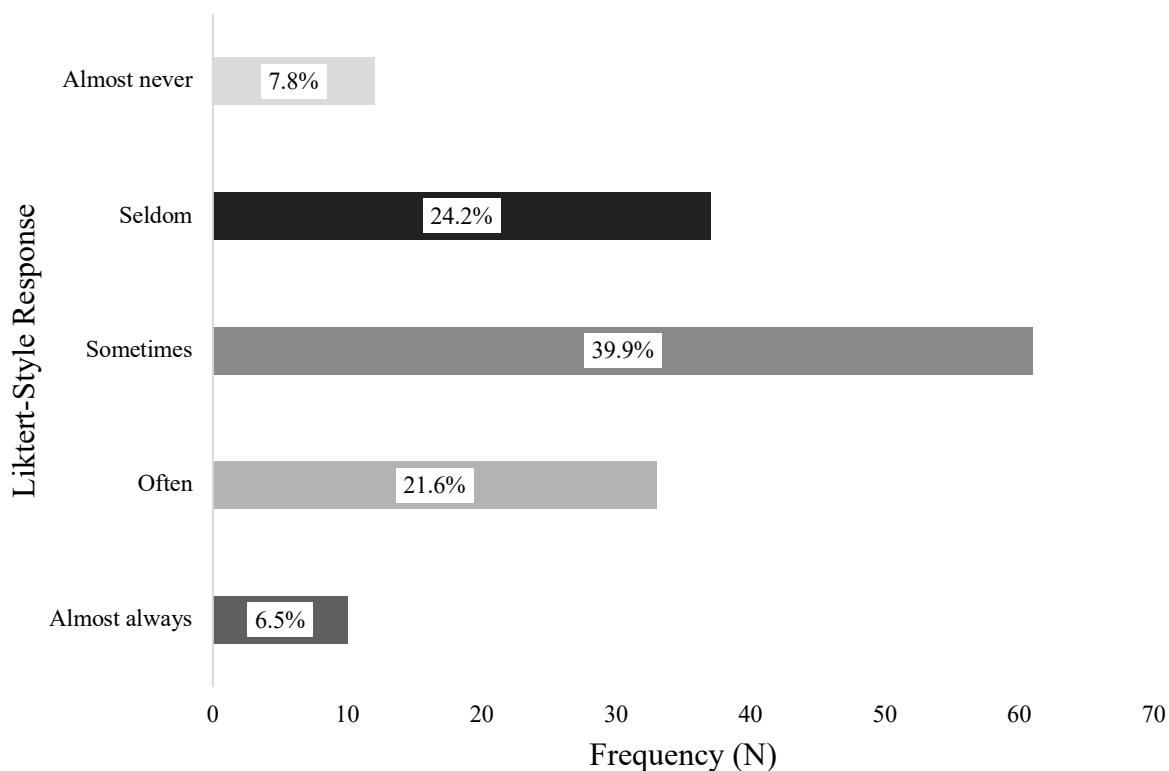
Another aspect of inquiry is allowing student interest to guide lesson plans and curriculum in the course, so participants were questioned about their views of doing just that.

Figure *11* reveals that this is a technique that is done much less frequently than teaching using phenomena. The largest percentage of participants, 39.9% ($N=61$) chose the sometimes option for allowing student interest to guide lesson planning and curriculum in the course. 32% ($N=49$) of participants let student interest guide the lesson plans seldom or almost never, and teacher participants did allow student interest to guide the curriculum at least sometimes for 68% ($N=104$) of participants. This number drops off sharply with only 28.1% ($N=43$) doing this often or almost always within the course. The data spread shows that the majority of teachers do somewhat allow student interest to guide lesson planning and curriculum in the high school chemistry course, but that it is not happening all of the time. This supports the idea of the teacher as a facilitator. Facilitating the ideas and suggestions by students while still keeping boundaries intact may be one way that the data in

Figure *11* is possible.

Figure 11

Student Interest as a Factor in Lesson Planning and Curriculum in the Course



Note: The figure presents the data associated with participants' answers to the Likert-style question that began with "Please use the rating which best describes your inquiry teaching and learning beliefs for the following statements..."

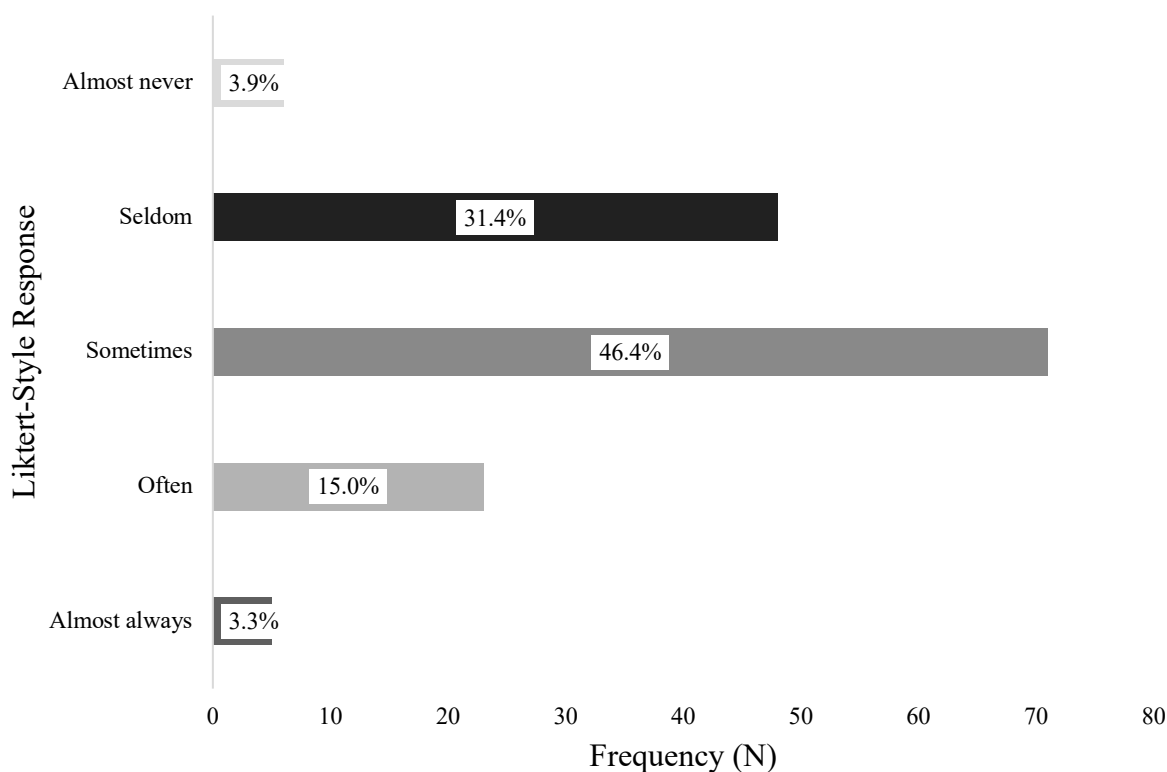
Students Planning and Carrying Out Investigations

Students planning and carrying out investigations (PCOI) is specifically stated in seven places within the GSE Chemistry standards used as the basis of high school chemistry in Georgia. Participants were asked to describe some of these behaviors of students and the frequency that PCOI occurs within their classrooms. Student planning is described in

Figure 12. The addition of the PCOI language was a large change in the GPS to GSE standards for chemistry. Almost never and seldom were selected by 35.3% ($N=54$) participants when asked whether students were involved in planning their investigations. The alternative is that students are given the instructions and must follow them to obtain the expected lab results. 46.4% ($N=71$) of participants said that students are involved in planning their own investigations sometimes in their classrooms. Only 18.8% ($N=28$) of participants describe students planning investigations as something that happens often or almost always. The big takeaway is that PCOI is happening in classrooms across rural Georgia, but that 35.3% of participants are not having students PCOI at all or seldom. This can be countered by the fact that 64.7% of participants are having students PCOI at least sometimes in their classrooms.

Figure 12

Students Involved in Planning Their Own Investigations



Note: The figure presents the data associated with participants' answers to the Likert-style question that began with "Please use the rating which best describes your inquiry teaching and learning beliefs for the following statements..."

Interview participants also weighed in on this issue of students planning. According to Hugh, when asked about what a student would have to do in order to be able to PCOI as written in the standards he stated that "we'd have to have time. I mean, it boils down to time..." He went on to state that "we've got five days a week, and we're pouring the subjects on the kids." The traditional schedule Hugh's students are on limits his class to 48 minutes in which he is

switching back and forth each period between chemistry and biology. He discussed the time, scheduling, and PCOI in the following:

Hugh: So, like I said, I think that one word is, is the dirty word. The plan. I mean you could rewrite that and, you know, given a set of variables, can you carry out an investigation? You know, I just think that when we're plan for this, putting a lot of responsibility on the student who doesn't have the base knowledge, because I don't know what your background is, but if I just threw a concept at you on day one, you know, on Monday, we talked about Planck's constant and whatnot. And then on Wednesday, I asked you to come up with a lab for Thursday. Can you do it?

Researcher: That would be tough even for me.

Hugh: Right. So, you know, I think it's a little unrealistic.

The question he posed was an important one. His description frames the task as unrealistic to expect students, with no real experience in the subject they are learning, presumably for the first time, to both plan and carry out an investigation within the various time constraints imposed by school systems, whether block or traditional. Hugh describes it as “a little unrealistic,” and this parallels to experience he brought to teaching from his previous jobs. Interview participants stressed how inquiry labs were time consuming and that they were often too busy to perform them. One teacher made the time to do inquiry labs, but that teacher had previous experience in a larger school with more teacher mentors, had teachers growing up who mentored her and taught using inquiry, and the participant is not currently coaching any sports. The time factor combined with experience helped at least one participant implement inquiry-based instruction in the chemistry course.

Experience teaching is important but working with people and/or in a laboratory setting can also lend itself well to the teaching profession. For example, Bridgette worked as a wastewater lab analyst before moving and taking a job as a teacher, and Alice experienced tutoring underclassmen college chemistry students while she, herself, was in college. While there, Alice experienced characteristics of both good tutors and bad tutors which helped shape her teaching approach. Cathryn developed her love of science from her high school science teachers, which translated well into her movement into working with fish at a large research university in the region. This work during college required that she use scientific inquiry to determine what may have caused illness, disease, or death among fish. She described it through the following:

I took the fish disease out of the vet school, that the disease the vet was teaching us, we bring in sick fish laying before us, figure it out. We're going to run through all the different tests we'd need to run. So, we had a textbook, but it was always here's a problem. Here's a concern. Here's a question, figure it out and come up with a plan. I mean, it's just that right there. Gives you a very different view. I also worked in a laboratory at [school information removed for confidentiality]. I worked with a toxicologist. That's where my chemistry came in. My chemistry. My love for chemistry came from toxicology, looking at these sick fish. Understanding that it was based on water quality, and then I had to understand the chemistry behind it.

The experience she had of being presented a problem and then having to “question, figure it out, and come up with a plan” helped shape her philosophy of teaching. She even went on to describe how she sat in another teacher’s classroom for observation and “she was just

regurgitating information” which made her decide that “I don’t want to learn this way...I’m not going to teach this way.” Cathryn also stated that she’s a “scientist before teacher” and “had no intent to ever teach” which makes the “application of the science...very, very important.”

Another example of applied chemistry is Gladys who had a background as a lab tech at a chemical plant for more than ten years. When asked why she went into teaching she stated:

I knew I was going to have to change jobs. And when I started looking for jobs, I realized that I was going to really have the same kind of job I had before...the idea of starting doing the same thing again, somewhere else really bored me...so I talked with my husband, and he was like, why don't you? You've always thought about being a teacher, why you give it a try. If nothing else... I have all this great experience in life in chemistry. I can always go back to that, like that's not, you know, we did not end on poor terms. And so, I said, Well, why not? And we were at that point in our lives where I could just up and try something new. It's a nice place to be in life after a lot of hard work, so, I went through the Georgia TAPP program. And I've enjoyed it. I mean, I, I really, I really love it.

The switch from industry to teaching was described by Gladys as her “midlife crisis” in which she found something she loved. In a similar story, Hugh also switched careers from decades in law enforcement to teaching. When asked why he did this, Hugh stated:

So, you know, I've always loved teaching. You know, I was coming up on my [hidden for confidentiality] year mark...in law enforcement and wanted to get into something else...And, you know, did I ever see myself teaching high school students? No, not at all. But it's actually very rewarding. So, I really enjoy it.

Ultimately, each interview participant's response indicates that the mark of experience is that you learn desirable characteristics of a career as well as undesirable ones. Many of the participants who changed careers to teaching described displeasure with aspects of their old jobs, a desire to give back, or a desire to make a change and use their science knowledge to teach. While experience is a sought-after aspect in a teacher it is not the only important factor in trying to determine or predict a teacher's attitude toward inquiry and lab practices.

Supervising other adults in a laboratory setting is one thing, but managing labs in high school with students who may need more direction or have issues with safety that prohibits them from effectively planning the labs is another. However, freedoms, or guided inquiry, can be used to allow students to explore their own questions or curiosities within the confines of the lab. The responses in

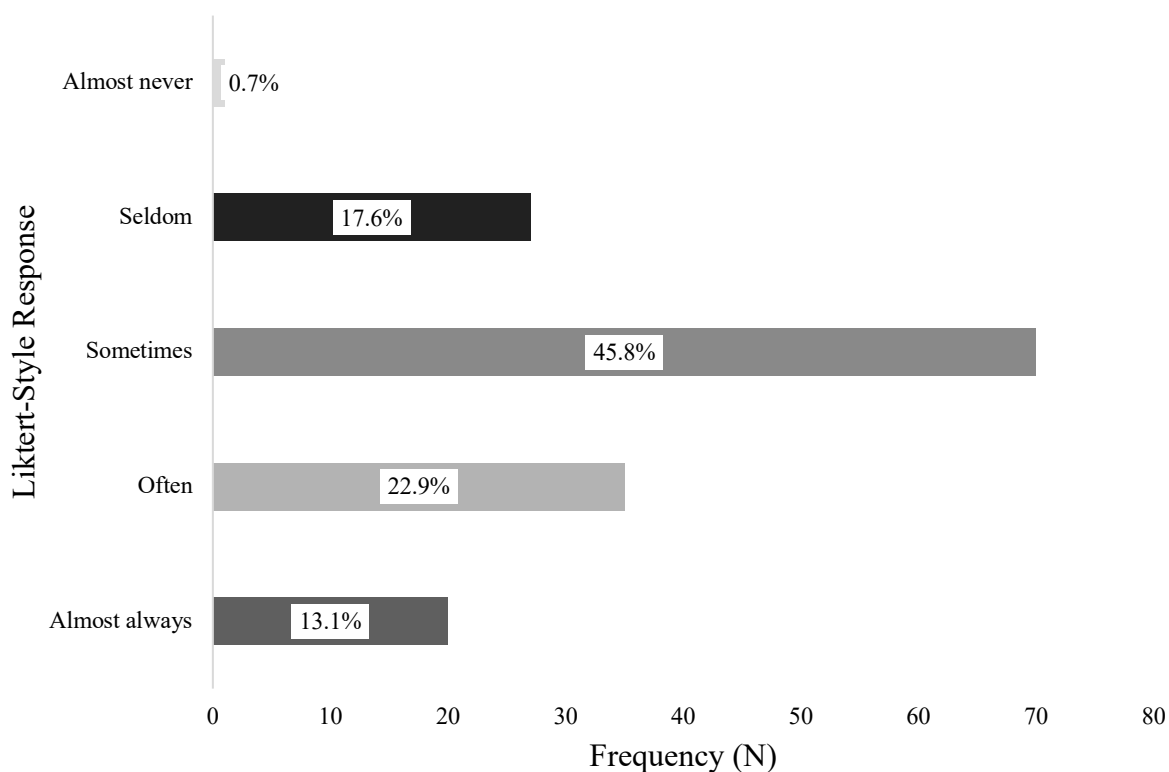
Figure *13* are those that participants gave when posed with the following statement: “I encourage students to use laboratory activities to explore their own questions and curiosities.”

From the data in

Figure *13* it can be inferred that 18.3% ($N=28$) of participants let their students explore their own questions or curiosities seldom or almost never in the classroom. Alternatively, 81.7% ($N=125$) of teacher participants allow students to do this sometimes, often, or almost always. Having students plan investigations, explore their own curiosities, and allowing them to impact the curriculum and lesson planning all lead to students being able to plan and carry out their own investigations.

Figure 13

Participants Encourage Students to Explore Their Own Questions and Curiosities Through Labs



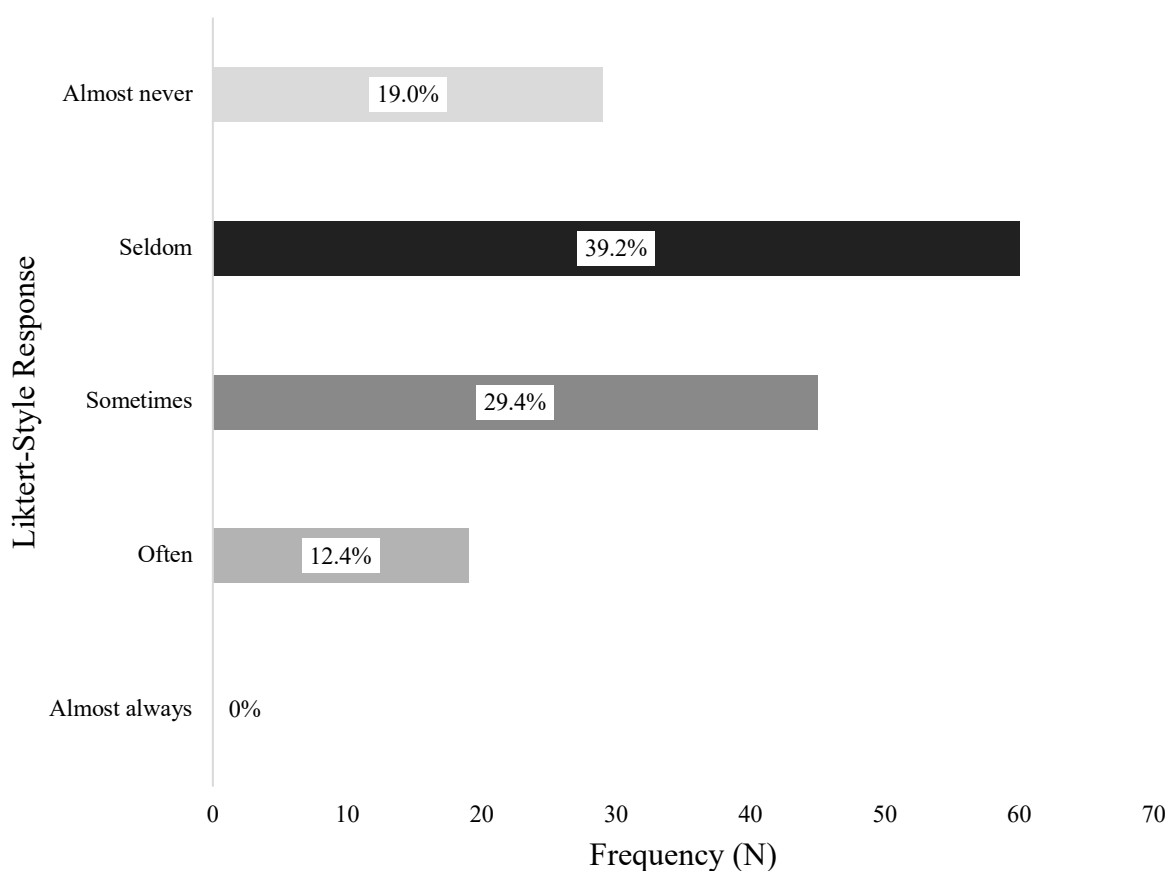
Note: The figure presents the data associated with participants' answers to the Likert-style question that began with "Please use the rating which best describes your inquiry teaching and learning beliefs for the following statements..."

The responses that Figure 14 portrays really gets to the heart of the PCOI matter. It specifically asks participants to weigh in on whether students design their own experiments and then carry them out. The data from earlier questions resembled more of a bell curve, but the responses to this statement are shifted toward the less frequent use of students using PCOI in the classroom. Over half of participants, 58.2% ($N=89$), responded that students planned and carried out their own experiments almost never or seldom in their classrooms. Another difference in this

data compared to the previous statements is that 0% ($N=0$) of participants stated that students used PCOI almost always in their rooms. 41.8% ($N=64$) of participants responded that students planned and carried out their own experiments sometimes or often in their classrooms. This means that the explicit wording of the standards is not being followed in the majority of the participants' classrooms in rural Georgia.

Figure 14

Students Design and Carry Out Own Experiments in the Course



Note: The figure presents the data associated with participants' answers to the Likert-style question that began with "Please use the rating which best describes your inquiry teaching and learning beliefs for the following statements..."

Standards & Teaching Methods

The GSE standards prescribes both the content that is to be taught and also the actions that students should take in demonstrating mastery such as planning and carrying out investigations. The wording of the standards implies an inquiry approach to at least seven standards or elements (parts of standards) within the chemistry GSE. In order to better understand how teachers interpret these standards, participants were asked about these PCOI standards in order to gain insight on what is required to teach them, whether they were taught at all, taught as written, and perhaps gain information on methods used to teach them.

Interview responses indicated that only one out of the eight participants used open inquiry as a form of laboratory instruction and only in four out of the seven PCOI standards/elements which is consistent with the survey data that indicated 41.8% of participants had their students PCOI sometimes or often. However, the participants did admit to using guided inquiry, which applies to most labs that could also be described as teacher guided or teacher centered. Table 12 shows the data for how each of the eight participants responded to questions over the seven standards/elements found in the GSE that all explicitly state that students are to "plan and carry out an investigation" regarding a concept.

Table 12*Participant Data on GSE Standards Involving PCOI*

Standard	Participant							
	A	B	C	D	E	F	G	H
2a	Lab: No plan; Guided-Inquiry	Lab: No plan; Guided-Inquiry	Lab; Open Inquiry	Direct instruction; No PCOI	Lab: No plan; Guided-Inquiry	Lab: No plan; Guided-Inquiry	Lab Stations; No plan; Guided-Inquiry	Lab: No plan; Guided-Inquiry
3b	Lab: No plan; Guided-Inquiry	Lab: No plan; Guided-Inquiry	Lab; Open Inquiry	Stations; Teacher-Guided; Demo; No plan	Lab: No plan; Guided-Inquiry	Lab: No plan; Guided-Inquiry	No lab; Used videos for data	Lab Stations; No plan; Guided-Inquiry
3e	Lab: No plan; Guided-Inquiry	Lab: No plan; Guided-Inquiry	Lab; No plan	Stations; Teacher-Guided; Demo; No plan	No lab	Lab; No plan; Guided-Inquiry	No Lab	Lab: No plan; Guided-Inquiry
4a	Lab: No plan; Guided-Inquiry	Lab: No plan; Guided-Inquiry	No lab; PhET	Demo; No plan	No lab	PhET or other lab; No plan	Demo; No Lab; No PCOI	Lab: No plan; Guided-Inquiry
5a	Lab: No plan; Guided-Inquiry	Lab: No plan; Guided-Inquiry	No lab	Demo; No plan; Lack of supplies	No lab	Lab: No plan; Guided-Inquiry	No lab; Math work; Data given	Lab: No plan; Guided-Inquiry
6b	Lab: No plan; Guided-Inquiry	Lab: No plan; Guided-Inquiry	Lab; Open Inquiry	Lab: No plan; Guided-Inquiry	No lab	Lab: No plan; Guided-Inquiry	No Lab	Lab: No plan; Guided-Inquiry
6h	Lab: No plan; Guided-Inquiry	Lab: No plan; Guided-Inquiry	Lab; Open Inquiry	Lab: No plan; Guided-Inquiry	No lab; Haven't covered since on block	Lab: No plan; Guided-Inquiry	Lab: No plan; Guided-Inquiry	Lab: No plan; Guided-Inquiry

That gives a total of 56 incidents where PCOI should be occurring. Out of the responses given PCOI only occurred in 7.14% ($N=4$) of the incidents. While that number may be slightly misleading in regarding to how many students are performing labs it is not misleading when it comes to how many students are actually enacting the words written in the standards to both plan and carry out investigations.

This open inquiry approach that is implied within the standards, as PCOI, does seem like it is difficult for even veteran teachers to implement, based on data from the interviews. For example, some of the teachers cited time as an obstacle towards implementing inquiry-based labs with one stating that open inquiry labs required roughly 7-1/2 hours of class time. To provide some context, this equates to 5 class periods on block schedule and 7.5 on a traditional schedule which teachers in this study feel is simply too much time to devote to the seven PCOI standards/elements. Open inquiry laboratory investigations allow for student researching, planning, carrying the investigation out, and analysis of the results with the possibility of revising and repeating the experiment. The process takes a considerable amount of time, according to interview and survey data.

Two alternatives when equipment, resources, time, COVID-19 concerns, and other issues arise are the use of demonstrations (demos) or virtual labs such as a PhET. Demos were used in 3.57% ($N=2$) of incidents where virtual labs were used in 7.14% ($N=4$) of incidents. One concerning aspect was that no labs were performed in 16.07% ($N=9$) of incidents.

Hindrances to performing labs such as time, money, resources/supplies/equipment, safety, teacher knowledge, and prior knowledge by the students were mentioned in the survey comments. Time was shown to be a hindrance in that only one out of the eight teachers admitted

to making it through all of the chemistry standards. Not covering standards completely with students does put them at a bit of a disadvantage when it comes to continuing on in their science courses. Participants stated that they did not have enough time and seem to be using the time factor as the one that causes the biggest stumbling block to the implementation of inquiry-based instruction in the classroom. Students who are taught without using inquiry may be at a disadvantage in upper level courses such as AP courses which contain inquiry labs as a requirement for the course. Some ways to alleviate the issue of lack of understanding, knowledge, and lack of time were listed by participants. One mentioned grouping the 37 standards/elements into 25 big ideas. These big ideas were tested early on and then continuously tested so that each time you tested as a student you would take a 25-question test with the questions changing, but each one relating to the big ideas set forth during instruction.

Another method of having students construct an understanding of chemistry that came up was story lining chemistry. This concept has been used in recent years with success in biology and other life sciences (Plummer & Ozcelik, 2015; Reiser, 2013; Roth & Garnier, 2006). The idea is that you present a problem, or phenomena, at the beginning and use it to guide instruction throughout the year. It is a similar approach to how medical schools are teaching their students through problem-based learning (PBL) (Ackerman & Comeau, 1996; Fan et al., 2018; Rutherford, 2019). Neither the participants nor the researcher could remember hearing any of these storylines in chemistry. PBL has been used in chemistry, but an entire course storyline poses an interesting prospect for future endeavors.

Other participants preferred to focus on the basics and get the students ready for college or the work force. This approach may be common in smaller rural schools where teachers are

limited, have multiple preps, and are taking on multiple jobs to help the school run smoothly. One participant emphasized what he/she referred to as “power standards” within the curriculum. When asked what he/she meant by this the answer referred to contact with college professors and former students to determine what standards were taught at the beginning of a college chemistry course and what students there tended to struggle with. The thought being that preparing for a college course, at least the first part, would help ease students into college and lower the dropout rate, thereby increasing a student’s chance of success in college.

Multiple participants cited students’ lack of prior knowledge as a reason for why these students cannot plan a lab. One said that students “can’t plan what [they] don’t know.” Another said that students “don’t know enough to plan,” especially in a single traditional period. “Pie in the sky” is how one participant referred to the standards, particularly those that include PCOI. Another participant stated that the GSE looked more like “college-based standards” and that they were “unrealistic.” When asked what students would need to be able to PCOI both participants who saw the GSE as unobtainable in chemistry said that students would need a chemistry 2 or a second year of the content.

An unrealistic expectation is for teachers to perform labs with students in conditions that are unsafe. One teacher stated that her classroom had no fume hood, no chemical shower, and no negative pressure in place. These are serious safety concerns and limit the labs teachers are able to safely execute with their students. Three out of the eight participants expressed safety concerns regarding lack of safety features or lack of comfort in the lab being performed. Some of the safety concerns can be mitigated by schools purchasing safety equipment while others require professional development and training for the teacher.

Participants who were identified as having taught in Georgia for more than four years and have experience teaching under both the GPS and GSE standards were asked about the differences in the two sets of standards. The latest set of standards, GSE, emphasized “kids doing more,” whereas the old GPS standards told teachers what the concept was. Another participant identified the GSE as “active” or “student centered.” Even those with some safety concerns identified the value of GSE by saying that they were inquiry-based and would lead to a deeper understanding of the content than the GPS. Part of the experience that the participants have that helped them distinguish between GPS and GSE is also rooted in the perception that teaching chemistry in a rural school is different than a suburban or urban school.

Methods as a Function of Place

The methods of teaching the standards is a function of place, which is why this section will begin with place-based education as relating to rural education. However, the conversation of place-based education cannot be had without equity as a large component. One aspect that most of the interview participants brought up first was about the personalities of their students. Bridgette described how her experiences teaching in a rural setting compare to other places she’s taught when she said, “And so my kids represent or remind me of the kids that I went to school with... I can just so much easier relate to their life versus the entitlement that is everywhere else.” Discussing the students themselves she said that the students “are as good as gold.” Eleanor described them in ways that very much sounded like a mom raising her kids and being the one to sort of push them out of the nest, but not without preparing them first. Gladys described how grateful the students were whenever she would make activities for them or engage them in a lab “because a lot of my kids haven’t really got to do a lot labs up [until] now.”

Students themselves who come from rural areas might also possess unique knowledge about livestock or other topics. For instance, Alice brought up how her students know ammonium nitrate due to using fertilizers in fields. She also mentioned about how they know about liquid nitrogen due to artificially inseminating cows. The prior knowledge and experience that many of these rural students have is something that can be used by the teacher to tap into the application of the course material to everyday life. Teachers can also tap into their knowledge of the students' families if they are from that area as well. It helps create a bond or relationship with the students when the teacher knows his or her parents or other family member. Daisy equated this "better sense of community" as a huge advantage that rural schools have. Felicia loved the ease of contacting parents in rural areas as opposed to urban/suburban areas. Also, smaller rural schools have the advantage of teachers getting to know the students better than would be possible in a larger school. Cathryn came from a larger suburban school and moved to teach in a small rural school. She described how she "could actually go to the bathroom during class change" or how she taught students in 9th grade, 10th grade, 11th grade, and then in 12th grade so that when they graduate, she was their "mom" and in tears.

Methods of teaching in a rural school are also different. Bridgette said, "And so a lot of you know, it has to be relevant to who we teach, and I really do believe that there's a huge difference because between what we teach and how we teach it in a rural community" versus the person teaching in a suburban school or private school. Alice said, "That's just what being in a rural school is, is like, and that's not something they teach you about when you when you're in education courses, either." One participant stated that open inquiry worked so well in rural schools because you teach the same kids for multiple years, so they know your routines and

procedures. Eleanor described how the autonomy in teaching the curriculum was an advantage of a rural school. She appreciated not having to follow what someone else wanted to do.

Disadvantages of a rural school include feelings of isolation or loneliness for the chemistry teacher. Alice said that “when we deconstructed standards and things like that...I didn’t have anybody to discuss it with.” She went on to say that teaching chemistry in a rural school is “very lonesome.” These feelings of isolation can be amplified in many smaller districts by not having a science coordinator in the district. A science coordinator has the job, within a district, of working closely with all the science teachers, helping to find funding, guiding PD, and mentoring the science teachers. However, many small, rural districts cannot afford a specific science coordinator and so the feelings of isolation continue with the teachers in the district, especially if the district is a long way away from an urban area. Research funded by the National Science Foundation is currently being conducted to determine how the presence of a science coordinator affects science teaching and practices within a school district. Along with the loneliness, teachers in rural districts can feel a disconnect with leaders at the state level or from large urban or suburban districts that they view as leading the push for curriculum that is not as relevant in rural areas.

Another disadvantage for teachers is having to teach multiple preparations. This increases the planning time, grading time, and spreads the already thin budget across multiple disciplines. This is often because there are not enough students to populate enough sections of a single course to allow a teacher to teach the same subject all day. This is, of course, only true of small rural schools. The larger rural schools would not have this issue. However, more of the

rural schools are smaller ones. There's not a single suburban school in Georgia where there is only a single science teacher.

Rural areas are often associated with poverty, which is quite often accurate, but can, as Alice pointed out, be said of a good number of urban areas as well. She went on to describe how "parents not home" and the like was commonplace at both rural and urban schools. One participant listed how the closer relationship with students was an advantage but went on to describe how it was necessary because "a lot of these kids have horrible home lives...it's appalling to me."

Poverty also can extend and equate to lab budgets. Smaller rural schools with little to no industry present in the community are going to suffer diminished lab budgets. This will be evident to someone who came from a larger rural school or a suburban school. Lab budgets are not the only thing lacking. Sometimes teachers are limited in how many labs they can perform by lacking proper lab equipment, safety equipment, and even gas lines for burners in the small rural setting.

Something else that is lacking in a rural setting is a supply of substitute teachers. PD cannot happen if teachers cannot take time off because there is no one to teach in their place. Concerning finding substitute teachers, Daisy said, "It is a nightmare. I've got one that does pretty well, I've got her number...but if she's already taken, like, finding a sub is ridiculously hard." Part of this may be due to the small size of the school but may also be due to just the low population of the district. In large area counties with small populations the long bus rides, as Bridgette brought up, have an impact on students.

Sometimes being a chemistry teacher in a smaller rural school is what you are thrown into and not what you went to school for. While all science teachers in Georgia with a broad field certification are technically qualified to teach all science courses in grades 6-12 it does not actually mean that the chemistry teacher is someone with chemistry experience. Another disadvantage is that rural teachers often do not get the same pay as teachers in other areas. One participant expressed that the district he/she worked in did not provide a local supplement for the pay. Normally, a teacher's salary is the state minimum combined with a local supplement to bring in teachers and have them stay in an area. The local supplement is how districts like Atlanta Public Schools can offer more pay than a district in rural Georgia.

Increased teacher pay in non-rural areas of the state makes finding science teachers in remote rural areas difficult. One participant stated that there had only been one student teacher at the school in 15 years. Student teachers in an area are good prospects for teaching vacancies, so a lack of student teachers reduces the pool of applicants who are already comfortable with the system. Coaching opportunities can be another reason, according to one participant, that pulls teachers to other schools and leaves smaller rural schools with a high turnover in science teachers. Without consistency in teachers there can be no development of relationships and sense of community that was described as a major strength of small rural schools.

RQ2 asked a broad question about the methods rural public high school chemistry teachers in Georgia used to teach concepts with explicit inquiry or PCOI in the standard. Survey and interview data showed that the methods varied in doing so, but that the rural location impacted the methods utilized by participants in helping students construct an understanding of the concepts within the high school chemistry course. Some participants stated that they utilized

the unique circumstances that rural students experience as a springboard to learn certain standards or ideas. Participants overwhelmingly saw themselves as facilitators in the classroom with the majority utilizing phenomena as part of the chemistry learning experience. 67.4% of participants stated that students are also involved in PCOI within their classrooms, but the data also indicated that knowledge of PCOI may be the problem. However, several interview participants listed hindrances to using PCOI within their classrooms, which leads into RQ3.

Research Question #3: What access do rural public high school chemistry teachers have to supplies, technology, planning, and professional development required to teach an inquiry-based unit including laboratory activities?

To answer RQ3 data must be present to determine the access that rural public high school chemistry teachers have to technology, supplies, planning, and professional development required to teach an inquiry-based unit that includes laboratory activities. Participants were questioned about school technology and given the option to choose more than one answer based on the situation present at each participant's school.

Figure 15 shows the frequency and percent associated with each answer.

Access to Technology

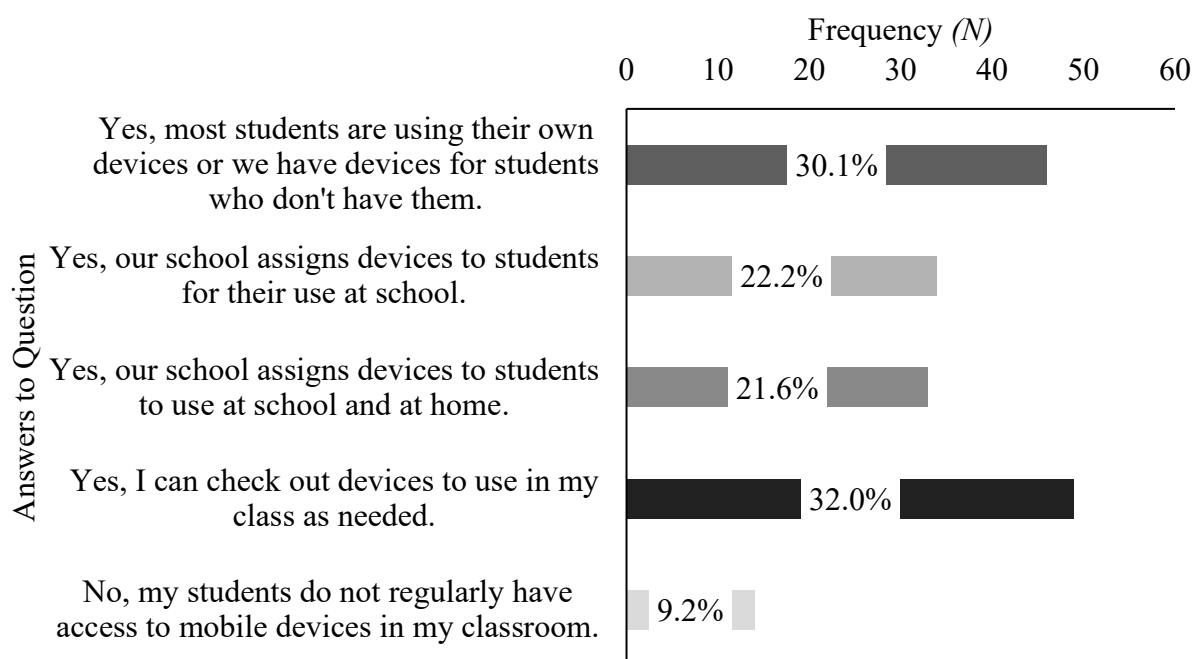
According to the data in

Figure 15, only 9.2% ($N=14$) of participants stated that students did not have regular access to mobile devices in the classroom. The overwhelming affirmative response that participants provided when asked about technology access in schools answers part of RQ3 as to

whether the majority of rural schools, students, and teachers have access to technology devices. Even though participants have access to technology, the question did not ask about reliable internet access in rural areas which is addressed within another survey question as well as the interview analysis later in this chapter. During the interview, Daisy pointed out that some of her students did not have a computer and could not do the online assignments or virtual labs.

Figure 15

Student Access to Technology in the Classroom



Note: Frequency and percentages of participant answers to the main school technology question in the survey instrument. Percentages add up to over 100% because participants could choose more than one answer if it applied to their situation.

This type of inequity is something that is being talked about, especially since COVID-19 forced many schools to switch to virtual learning at the end of the 2019-2020 school year.

Participants were also asked about resources and supplies via Likert-style questions within the survey instrument.

Figure **16** shows the data with the frequencies of answering the questions regarding technology and Internet access. According to

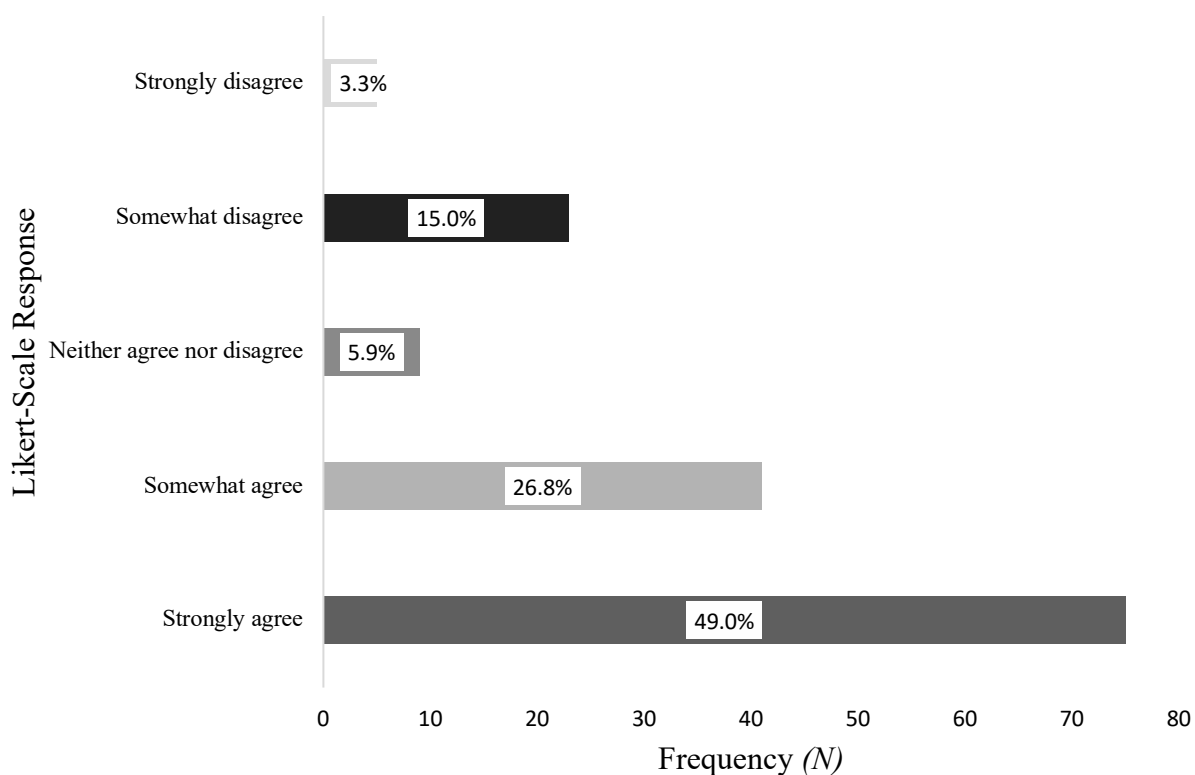
Figure **16**, almost half of participants, 49.0% ($N=75$), strongly agreed that they had sufficient technology, including internet access. Combining participants who agreed in any way shows that 75.8% ($N=116$) felt that they had access to sufficient technology in contrast to the 18.3% ($N=28$) who felt that they did not. One positive takeaway is that the majority of teachers feel that they have sufficient access, but another is that, even though only 9.2% of teachers from

Figure **15** mentioned students not having access to mobile devices,

Figure **16** has nearly double that amount at 18.3% who did not feel that whatever access they did have, if any, was not sufficient.

Figure 16

Teacher Access to Instructional Technology



Note: Frequencies and percent of participant responses to the prompt “Please rate your perception of the following statements as a chemistry teacher in your school...”

One participant stated, “I’ve been here long enough that if I say I need something, they will do their best to provide it,” and another stated, “I always have what I need” or that “my school system is highly ranked and well-funded, despite our location.” These responses indicate that not everyone is lacking supplies or resources and that some are content with what they have for the needs of their classrooms and students.

Internet Reliability and Speed

Reliable internet can be a hindrance in some locations, and this is something that came to light during the interview analysis. Internet in some rural areas is solely provided by satellite,

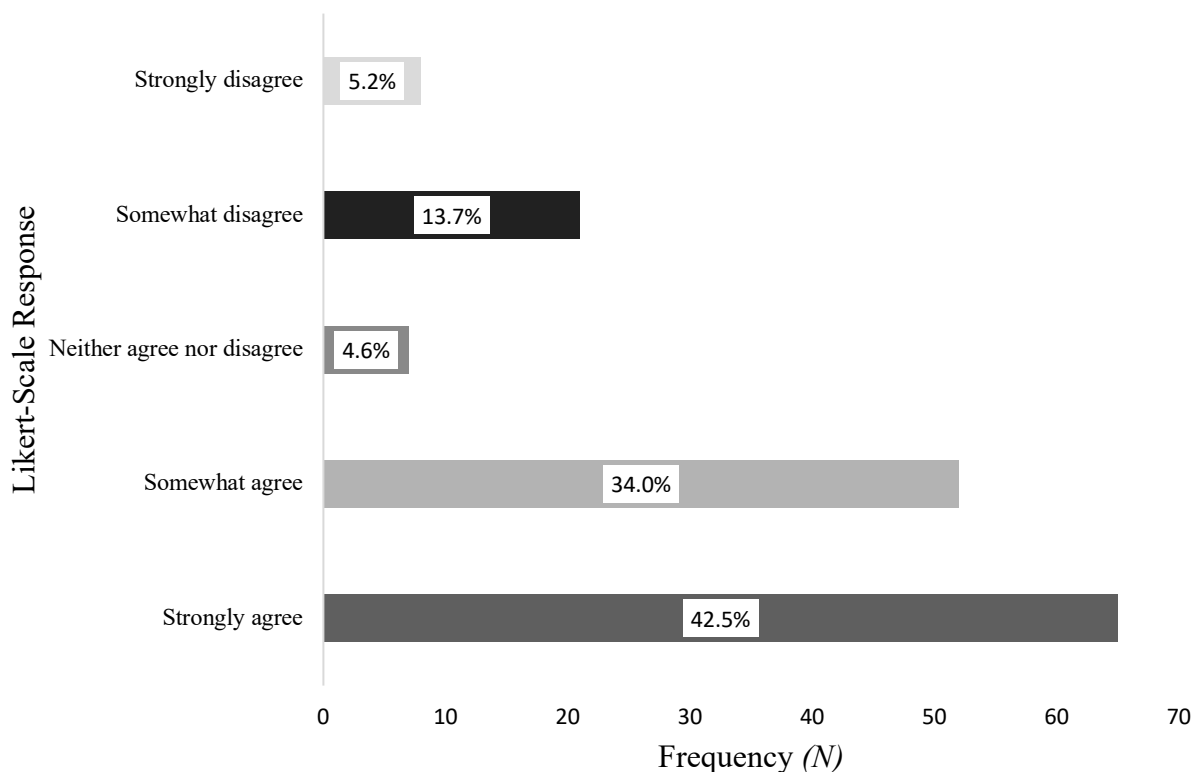
which is subject to great fluctuations due to weather. One interview participant said, “the virtual stuff is out there so that the kids could actually watch something happen...[but] we don’t have the technology.” When students were sent home due to COVID-19, there were suddenly hundreds, if not thousands, of students trying to use Zoom, Google Meet, or some other platform to participate in class virtually. Internet connection in many rural areas was lacking anyway, but this change in everyone being home put a strain on the already fragile infrastructure. Even though it came up in the interview, participants on the survey were also asked about their internet reliability and speed. The data portrayed in

Figure *17* shows that 76.5% ($N=117$) agreed to having sufficient Internet reliability and speed in order to support instructional practices. 18.9% ($N=29$) disagreed, which is in keeping with the 18.3% from the previous question displayed in

Figure *16*. While Internet and technology access are not the only supplies or resources, they are important for providing students access to virtual labs that may be problematic or expensive to perform live in the chemistry classroom.

Figure 17

Reliability and Speed of Internet in Rural Schools Sufficient to Support Instructional Practices



Note: Frequencies and percent of participant responses to the prompt “Please rate your perception of the following statements as a chemistry teacher in your school...”

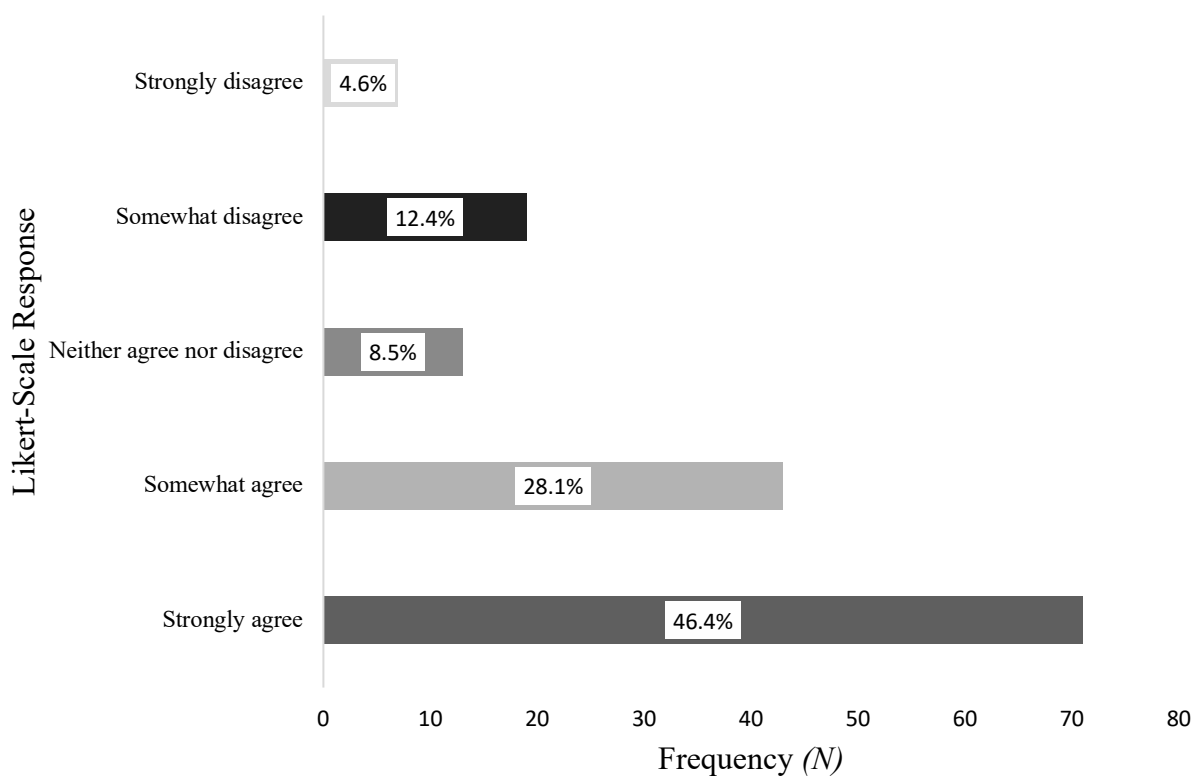
Teacher Involvement in Lab Budgets

Teacher participants were also asked about their involvement in deciding how the lab budget would be spent each year. Based on participant comments, chemistry, as a laboratory science, uses consumables each year for experiments so that students may better understand the chemical concepts and learn laboratory techniques. According to Figure 18, 74.5% ($N=114$) of participants at least somewhat agreed that they had a large role in deciding how the lab budget

would be spent each year compared to 17.0% ($N=26$) who at least somewhat disagreed. This shows that the majority of chemistry teachers in rural public high schools do have a role in making decisions regarding how money allocated for science in their schools is spent. Even with this large percentage of participants involved in decision-making, it does not guarantee that the amount of money received was, in fact, sufficient for instructional purposes.

Figure 18

Teachers Having Large Role in Spending Lab Budget



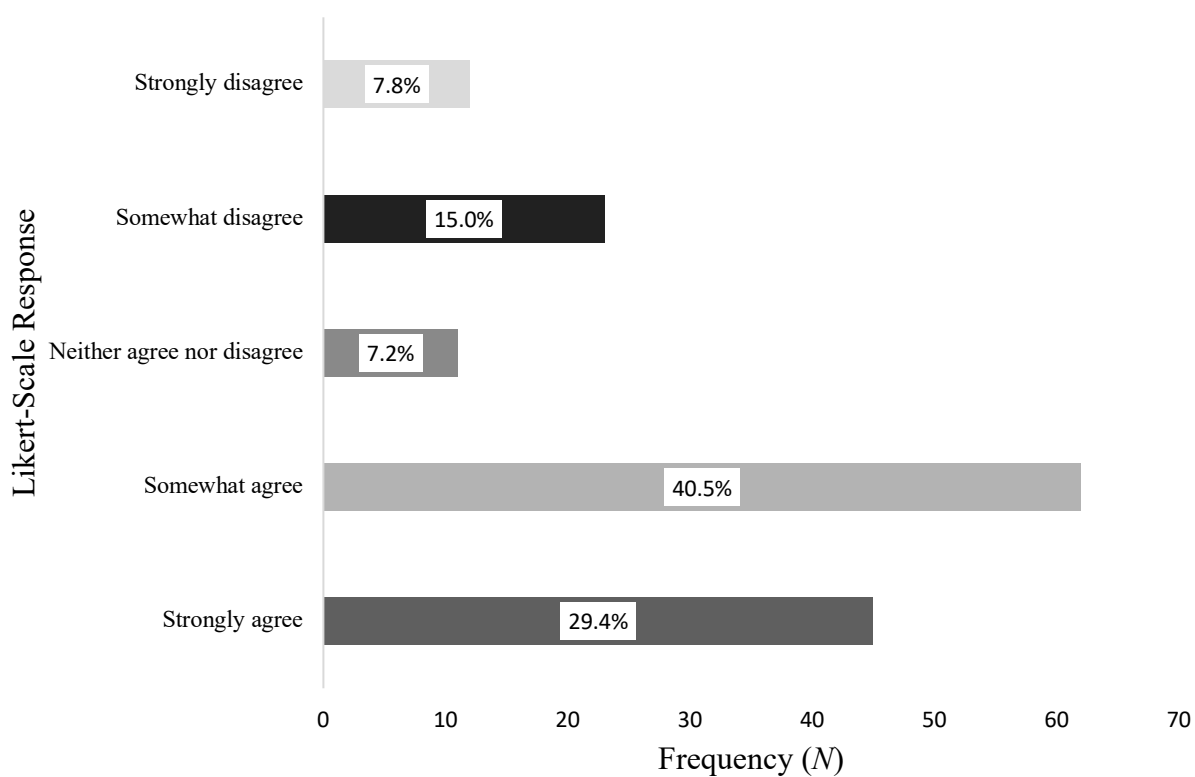
Note: Frequencies and percent of participant responses to the prompt “Please rate your perception of the following statements as a chemistry teacher in your school...”

Sufficient Access to Instructional Materials and Resources

Figure 19 shows that there is a majority of participants, 69.9% ($N=107$), who felt that they had sufficient access to appropriate instructional materials and resources. This is a small decrease from the 74.5% who were involved in decision-making with regard to the lab budgets.

According to

Figure 19, 22.8% ($N=35$) of participants disagreed with having sufficient access to instructional materials.

Figure 19***Sufficient Access to Appropriate Instructional Materials***

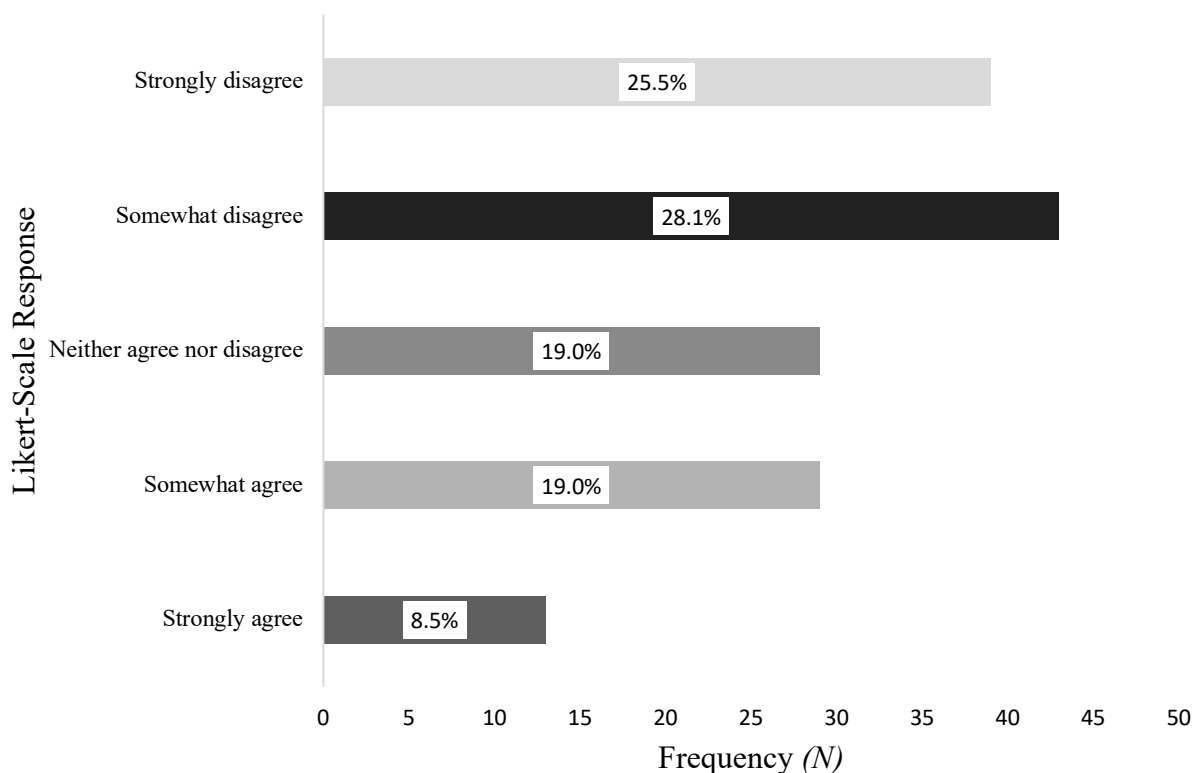
Note: Frequencies and percent of participant responses to the prompt “Please rate your perception of the following statements as a chemistry teacher in your school...”

Even though there were a number of participants who disagreed with having sufficient access to resources, materials, and supplies, the majority of participants felt as if they did receive what they needed, or at least had sufficient access to materials and resources.

Regarding resources and supplies, 27.5% ($N=42$) of participants indicated that they perceived having to beg or advocate for lab supplies (Figure 20).

Figure 20

Teachers Must Beg for Lab Supplies



Note: Frequencies and percent of participant responses to the prompt “Please rate your perception of the following statements as a chemistry teacher in your school...”

Comparison of this with the 53.6% ($N=82$) who at least somewhat disagreed reveals that there seem to be a portion of the chemistry teachers feel who they must beg for supplies, while a slight majority did not feel this way. One participant stated that “we...have to ask for things from a county coordinator...[and] I would much prefer an in-house budget that we manage ourselves.” On the flip side, five teachers indicated that they were “well-funded” or had all the supplies they need during a portion of the survey allocated for comments after each section.

Chemistry, as a laboratory science, requires a continuous influx of money to purchase consumables, specialized chemicals and to maintain equipment, as survey participants and interview participants alike indicated. Hugh described his feelings about this perceived funding disparity during the interview:

So, I felt supported in that they would allow me to use as much money as was allotted. But that allotment was only I think \$1,000. And that covered biology and chemistry. So, and as you know, that can be eaten up very quickly, especially in biology. When I arrived there, being my first year you know, I didn't have a surplus of any kind of chemicals, the stuff that was there was, you know, like potency was degraded. I couldn't get the reactions that I wanted. You know, a lot of the experiments I wanted to do wouldn't work just because the chemicals had degraded and whatnot so basically starting from scratch. You know, things like, let's say like hydrogen peroxide, you know, degrades very quickly. So, a lot of the experiments are not doable just because I didn't have the

chemicals. I spent a lot of my own money just so I could give the kids something, you know.

Some important takeaways from Hugh's statement is that he feels supported, but also admits that his \$1,000 lab budget was not enough to spread over two courses when the existing chemical stock was not up to date. Moreover, his sentiments further support that many teachers must spend their own money in order to provide a quality lab experience for students. When asked about how much he spent, Hugh felt like he needed to spend an additional \$1,000 of his own personal money to supplement the purchasing of lab supplies for his students.

Lab Budgets

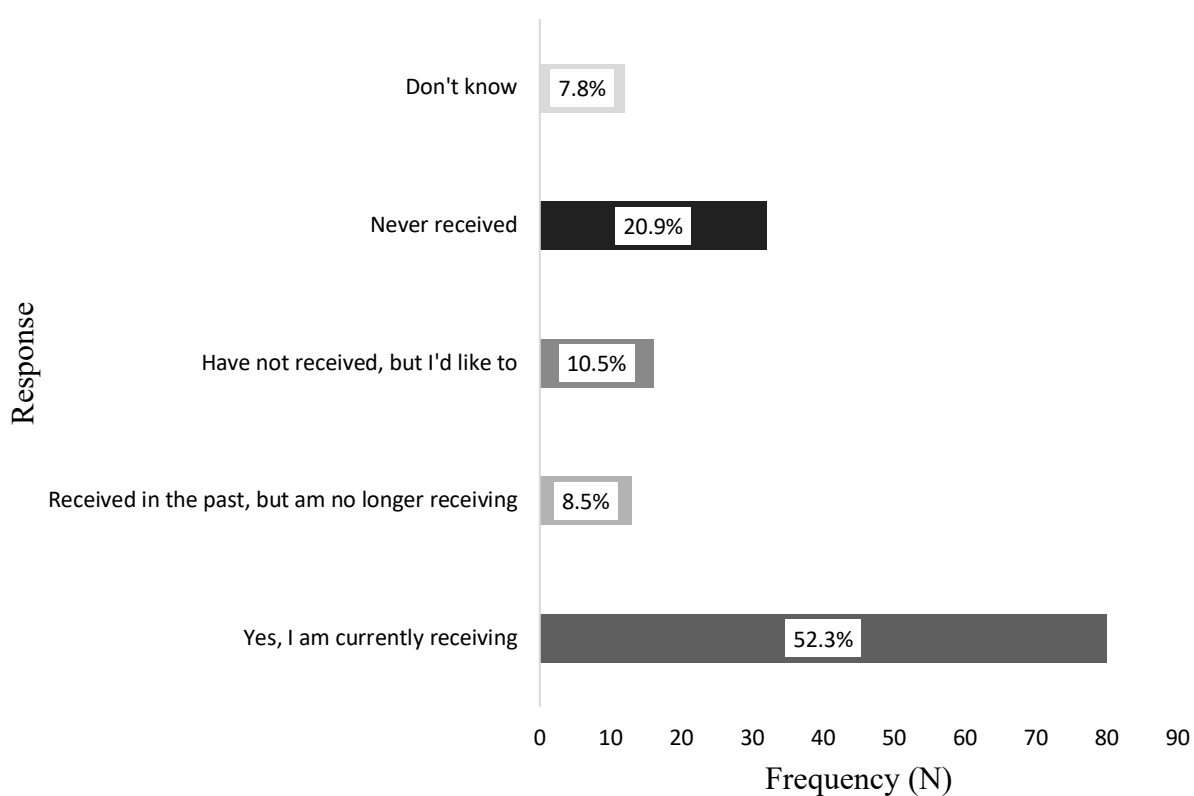
Having a well-funded lab or being involved in the decisions coincides with having knowledge of the lab budget available. Answers to whether participants had explicit knowledge of their lab budget helped to understand if there was a disconnect between chemistry teachers' desire for resources and department heads or administrators relaying financial information about lab budgets. The responses participants gave for this question can be found in

Figure 21. Just over half of the participants, 52.3% ($N=80$), stated that they were currently receiving information about their explicitly stated lab budget. 8.5% ($N=13$) more participants had received information like this in the past but were not currently given the information about their lab budgets. Combining the two subgroups who have both never received information about their lab budgets, with one subgroup stating that they'd like to know, results in 31.4% ($N=48$) of all participants not having current knowledge of their lab budget. This means that while just over half of the teachers receive the information, almost one-third of rural public high school chemistry teachers do not receive information about their explicit lab

budget. Additionally, responses also indicated that despite having some knowledge of current budgets, some participants still felt that they needed more money than their schools allocated for their chemistry lab budgets.

Figure 21

Teacher Awareness of Explicitly Stated Lab Budget



Note: Frequencies and percent of participant responses to the prompt “Considering your career thus far, please answer based on whether you’ve received the following supports or experiences...”

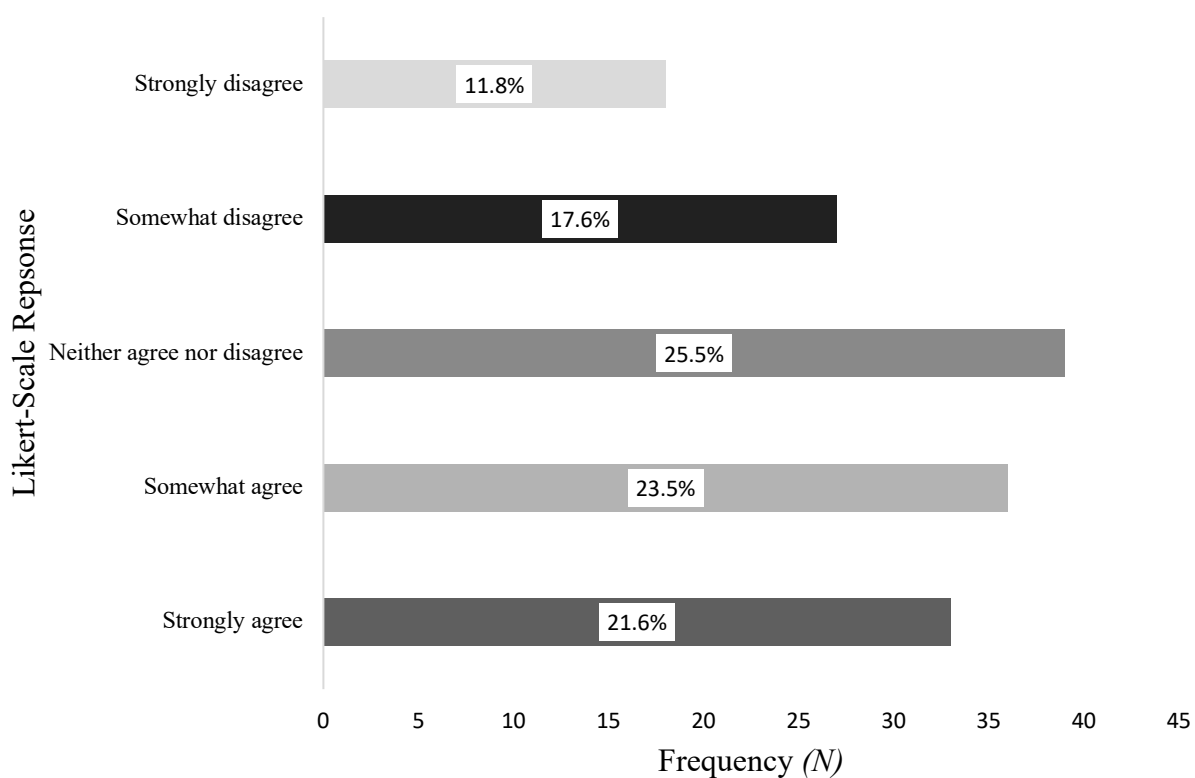
Outside Sources of Funding

Participants were also asked whether they felt like outside sources of funding, such as grants and community sponsorships, were required for laboratory activities in the chemistry classroom at the school each was located.

Figure 22 details the responses participants gave regarding outside funding. 29.4% ($N=45$) of participants at least somewhat felt that outside sources of funding were required while 45.1% ($N=69$) felt that outside funding was not required.

Figure 22

Views of Outside Sources of Funding for Labs as a Requirement



Note: Frequencies and percent of participant responses to the prompt "Please rate your perception of the following statements as a chemistry teacher in your school..."

Of those who felt that outside funding was necessary, at least two participants specifically indicated that they send home a lab donation sheet or offer an optional lab fee at the beginning of the year in order to reduce the strain on their lab budgets while six participants indicated that they spent their own money on perishable supplies due to lack of funding or “out of convenience...to [avoid] the wait on the purchase order process.” Some teachers also raise money using a little ingenuity and marketing. Specifically, one of the interview participants, Eleanor, described how she felt that she had a lack of funding from her school. As a result, she constructed a lucrative fundraising platform that helped to stock multiple science labs in the school with whatever supplies the teachers desired.

Eleanor described how she raised money for lab equipment and supplies for the department through candy sales at school, like a concession stand during the day. Her idea was sparked when “on the first day of school, they gave us \$100 and said, ‘Here’s your lab budget.’” She knew that she couldn’t get anything done with that amount of money, so she “got \$300 out of [her] piggy bank, went to Sam’s, bought \$300 worth of candy and turned it into \$600.” She kept doing this until the whole department had electronic balances and triple beam balances, glassware, and anything else they needed. She said she joked around with the kids that she “[knew] how much every piece of lab equipment cost based on candy bars.” When someone would break something she’d chime in with, “So, that graduated cylinder you broke is 26 candy bars.” So, while Eleanor must be acknowledged for her ingenuity, this type of creativity further highlights issues with funding.

Further, some of the stories the participants told really shed light into how much teachers spent on their classrooms from their own personal funds. Even though Cathryn spends a lot of

her own money on lab supplies, she still tries to stretch it as far as possible. Cathryn describes the situation in the following:

I spent a lot of personal money when I had to do my taxes every year, and I collect all the receipts up. Oh, my goodness. I think the difference in me having an undergraduate at T4 (certificate with a bachelor's) versus a T6 (certificate with a specialist) doesn't make a lot of difference because that money, that difference in the money I made here, was all for purchasing my kids' equipment. So, inquiry is expensive, and it costs me my personal money. I'm not talking just about pennies. I'm talking it adds up. And does that help you to understand it? And then I do a lot of other things. I have come up with ways to use things that I can get at Walmart.

When the subject of having a T4 versus a T6 certificate came up, she is referring to the state salary schedule. The state salary schedule has a difference of roughly \$5,000 between T levels meaning that a teacher with a T6 certificate would earn at least \$10,000 more per year than a T4 certified teacher of the same experience level. She described getting supplies from Walmart and cutting and welding them to make lab equipment. She talked about “going to my Ag teacher and [saying], ‘I need you to weld these tubes to this, these rods to this device for my physics class.’” Cathryn also mentioned how she used coffee filters for filter paper, created her own funnels, and had no gas in her classroom. When asked about how she completed some of the labs she responded by saying, “...I have a blowtorch to where I can show the flame test in a fume hood...but I’m the only one doing it...[so], there are some cases where that’s the best I got.” This lack of supplies means that students are hindered in what labs they can plan and carry out.

The interview data shows that students can still PCOI in classrooms without a fully stocked lab with state-of-the-art equipment, as evidence by Cathryn's ingenuity.

During their separate interviews, both Felicia and Bridgette mentioned their schools instituted a lab fee for students in the classes as a way to add additional funds for consumables. In both cases, it is an optional lab fee and there was a definite equity disparity between the honors classes and on-level classes. According to Bridgette, "90% of any of the lab supplies that are used are purchased by the teachers." Her efforts to bring in more funds also included sending out a donation letter the first week of school that stated the supplies were not mandatory, but that they did have a list of supplies students could bring in that would help offset the costs. An alternative offered was that a monetary donation could be made of \$5 or \$10 for lab funds. Still there was inequity between the honors and on-level classes.

Having multiple chemistry teachers is a type of resource, but this does not mean that equity exists between the different classes or levels of the course. In general, participants felt that money and resources were very important in being able to teach chemistry, but this may be because they are only interpreting PCOI as implementation of wet labs. However, Bridgette reiterated that "if you took the money piece completely out of it, and if you had all the money to order all the stuff you needed to have some whiz-bang awesome labs; it still goes back to the time factor."

Teacher Feelings of Equity

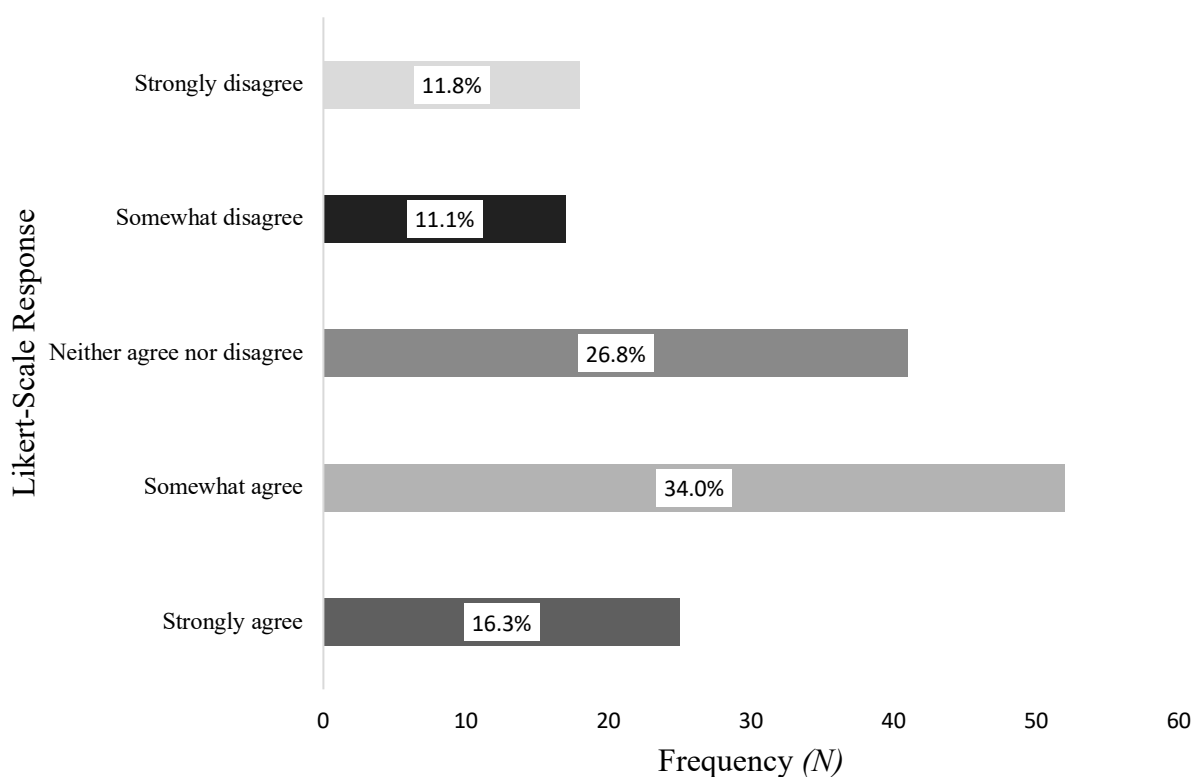
One of the main premises of the research study is to understand the views of the rural public high school chemistry teachers on a variety of topics related to teaching inquiry as stated in the standards. An interesting point of view that was explored was whether teachers at these

rural public high schools felt that other schools, whether suburban, urban, or other rural schools, seemed to have more resources for activities or labs than the school where the participant was currently teaching. 50.3% ($N=77$) of participants agreed that they felt that other schools seemed to have more resources for activities or labs than they did (

Figure 23) while only 22.9% ($N=35$) disagreed with these feelings of inequity. One participant indicated that “I do not regularly visit other schools, so I am unsure how our program matches up” compared to another who stated that “other schools have newer versions that are tech friendly models of lab equipment.”

Figure 23

Teacher Perception of Greater Resources at Other Schools



Note: Frequencies and percent of participant responses to the prompt “Please rate your perception of the following statements as a chemistry teacher in your school...”

Another participant echoed this sentiment by saying that “while my school has lots of lab supplies many of them do not incorporate newer technology.” Furthermore, teachers mentioned the course textbook as a simple piece of “technology” found in the classroom with one participant stating that “my chemistry book is 12 years old” and that “I think a textbook is useful and I believe students need to learn to read and use books as a resource.” While participants may have interpreted resources to be monetary or technological, they can also be as simple as time available to plan lessons and prepare for courses each day.

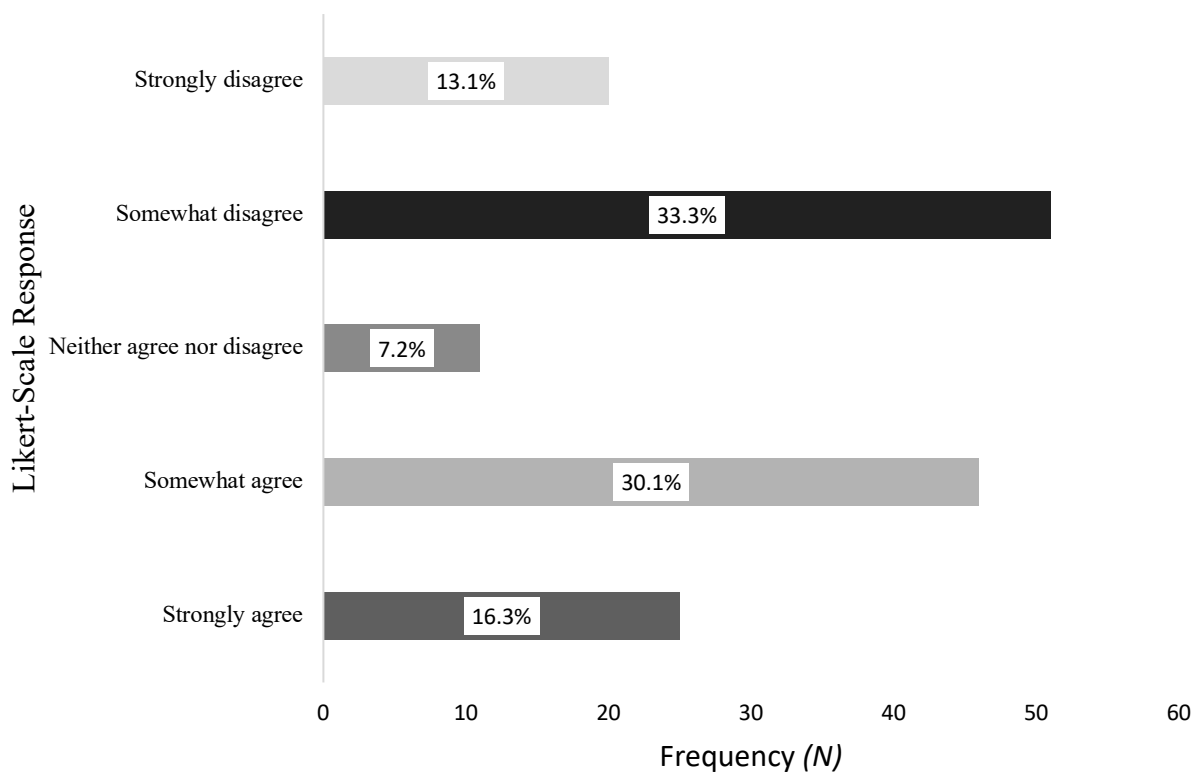
Teacher Planning Time

One aspect of time that is coveted by many teachers throughout the day is their planning period. Generally, public high school teachers have very few breaks in their day, but a planning period provides teachers with time to prepare for upcoming classes, reflect on past classes, grade papers, set up technology and/or laboratory experiments, complete mandated professional development, take work to in-school-suspension (ISS), contact parents, and, perhaps, if there’s time, go to the bathroom or sit and clear their minds. However, if a teacher is responsible for instructing multiple courses including chemistry, physical science, and biology, then s/he must use one planning period split three ways to accomplish the tasks for all of the preps taught. Data regarding participant perception of adequate planning time for the number of course preparations on the teacher’s workload are shown in

Figure 24.

Figure 24

Adequate Planning Time for Preps Taught



Note: Frequencies and percent of participant responses to the prompt “Please rate your perception of the following statements as a chemistry teacher in your school...”

The results are identical on both sides of the issue with 46.4% ($N=71$) of participants agreeing that they felt they had adequate planning time while those who disagreed made up 46.1% ($N=71$). Based on the data, planning time is a topic upon which teachers were divided (

Figure 24). When asked to elaborate, one participant stated, “I would have enough planning time if our school did not take it up with collaborative planning, data analysis meetings, professional learning meetings, etc.,” and another participant added that when teaching three different preps, “I felt as if I was drowning...[even] though I would get there early and stay late.” This same participant also added that “in low income schools the lack of planning and multiple preps is often a problem...we tend to lack supplies that we need.” While a number of participants indicated a lack of lab supplies and money as a problem in their classrooms the lack of time was voiced by both survey participants and interview participants. Participants voiced having too many course preps and not enough planning time to adequately prepare for those courses. Moreover, not everyone gets a planning period. Alice, a teacher of 8 years, described the following:

I haven't had a planning period since [my] first year teaching, maybe second year teaching [six years ago]. Just the fact that we have, you know, a [small] school [with less than 200] people in a grade and, up until last year, only three teachers to spread that out over. So, there's been several years where I've taught three different subjects, you know, so physics, Earth Science, chemistry or physical science, biology, environmental science, you know? That's just what being in a rural school is, is like, and that's not something they teach you about when you go when you're in education courses, either.

While Bridgette did not have her planning period completely removed, she did have to use it for mandated trainings or state-mandated PLC meetings. Regarding those trainings, she said, “one

day a month...we receive computer training during our planning period where we learn about all the new software that the [system's] purchasing and how to use it in our classroom." This might seem like a great idea, but she went on to describe her feelings toward it by saying, "The sad thing is nobody has time to play with it and figure out how great it is because we're too busy." Her sentiment further gives credence to what other participants have said, teachers need more time to effectively plan and implement their curriculum.

Planning time and PLCs can be ways in which teachers receive training and share best practices. However, some schools do not have common planning for science teachers. When asked if lack of common planning among science teachers made PLCs problematic, Felicia said, "That makes it torturous." She said that the other science teachers have three different lunches which made it "awful. It's awful." Even when there is not common planning it is possible to remain similar in both pace and expectations as Felicia eluded to when she said, "...we don't have common planning, but we do stay pretty similar as far as what we do and how we do it." But not everyone's experience is the same which shows that it differs from school to school. Daisy was asked to describe her PLC meetings to which she replied that it was "lacking." She stated that the teachers were either heads of clubs, coaches, or had other responsibilities within the school system, which is not an uncommon story among teachers at rural schools, particularly smaller ones, as five of the participants indicated. Cathryn expressed a similar experience when she stated that "in rural schools it is very much about who you hire in the science department ...in small rural Georgia, you have lots of preps because there's not a lot of sections in one course that's being taught." Hugh also revealed his busy schedule when he described how he taught "three biology [sections] and two chemistry [sections], a planning, and then had to cover

middle school lunch, but next year it's [going to be] a little bit different." Participants above expressed their busy schedules and that they do not feel that they have adequate time to prepare their lessons or implement something that may be new to them, such as inquiry-based instruction.

Inquiry-Based Instruction and Time/Resources

Chemistry is a laboratory science, and GSE standards require that there be a laboratory component, meaning time must be dedicated to incorporating and completing these labs. So, participants were asked about their views of inquiry-based instruction and their thoughts on the time and money requirements of using it while teaching.

Figure 25 reveals that 39.2% ($N=60$) of participants agree that inquiry-based instruction requires too much time and money (resources). Specifically, one participant stated that "often time inquiry-based labs take double the amount of time because students will not produce relevant investigations." Alternatively, 32.7% ($N=50$) disagreed with the statement, but at least one participant commented that inquiry labs required a lot of time but not much money, so the answers conflict based upon the wording of the question. Three more participants added that inquiry-based labs take too much time and/or resources, and another participant stated "lack of money is not [an issue] for us. The cloud that hangs over me is the driving of the curriculum forward at such a brisk pace in order to complete the entire curriculum." This same participant went on to say:

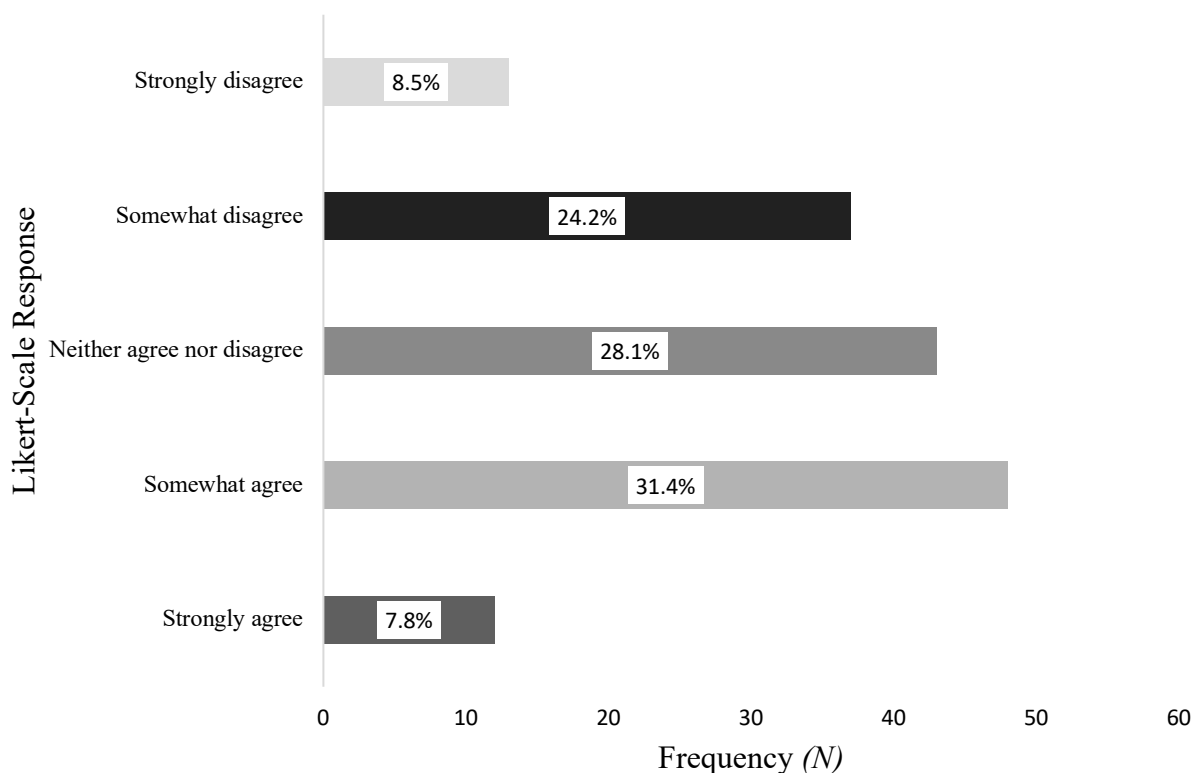
I have all the resources I want, but I am allowed less time to let kids explore and do great labs due to bureaucrats hovering over the work we do. In my department, my opinions are valued least of all. Thus, I feel somewhat hamstrung by the demands of having

identical tests and exams. I want my kids to know what I teach really well and not worry with checking a bunch of boxes off on the curriculum.

This is opposed to the participant who added that “the chemistry instructor’s wherewithal is critical in planning and executing labs. If he or she has the ambition and creativity to work within the means present, then it can happen.” This participant feels that teachers can plan and execute labs, even within time constraints, if they just have the ambition and creativity to work within their means, but, again, this requires time as other participants clearly stated.

Figure 25

Participant Views of Inquiry-Based Instruction as Requiring Too Much Time and Money



Note: Frequencies and percent of participant responses to the prompt “Please rate your perception of the following statements as a chemistry teacher in your school...”

Gladys and Hugh both expressed concern regarding labs and the time required to complete them. Gladys experienced more issues with time-constraints:

[We’re] 50-something minutes now. We used to be 62, but not anymore. And so, we’re right under an hour. And so, for labs, that was also an issue there where, there were labs like that wanted to do with them, and then when I would do them ahead of time, you know, a couple of days before the night before whatever, it would take me over an hour, and I knew what I was doing. And there was no way to stop it, you know, you can’t really stop a lab on specific heat if the purpose of the lab is to heat a metal and then cool it. You know, so you can’t stop that and come back the next day.

Professional Development

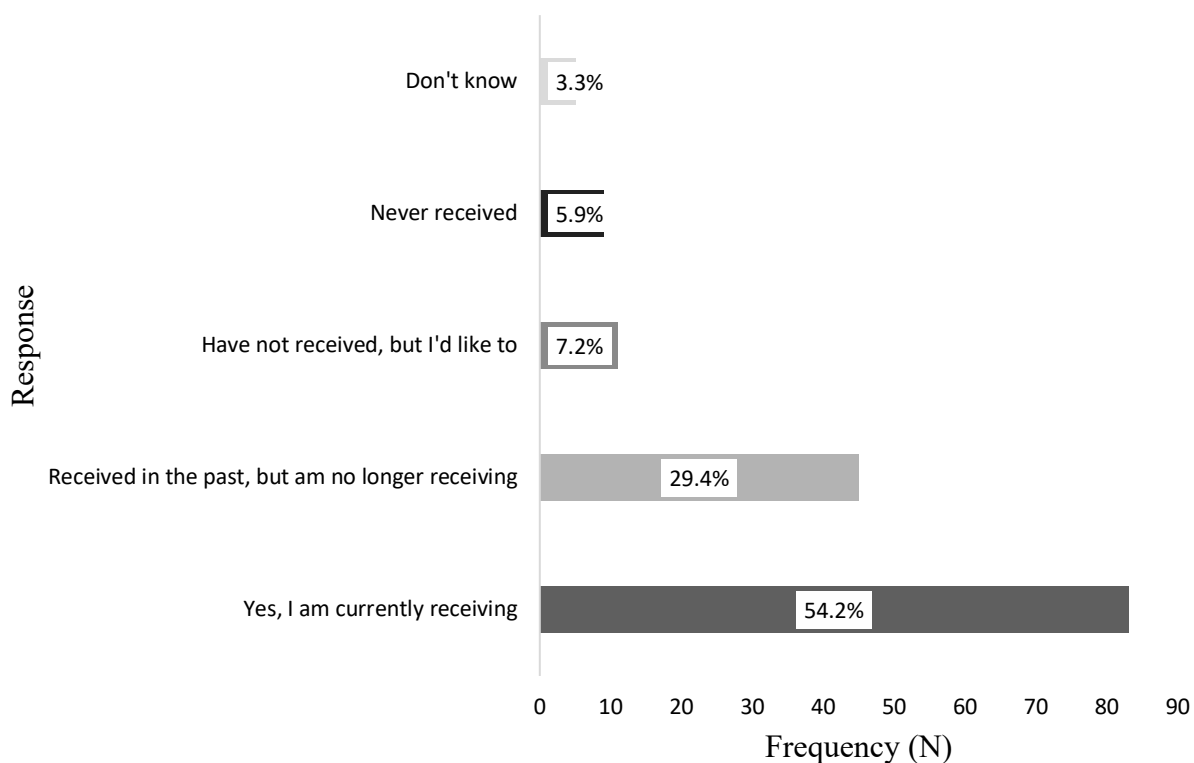
Professional development (PD) is another critical component of any educator’s current and on-going experience in the field. PD is needed for teachers to keep current with their craft, and this may involve self-paced learning, online webinars, or in-person conferences or PD sessions. Many new teachers are required to have PD by their school or district before starting the school year as well as during the year, so participants were asked seven questions regarding PD to determine who was receiving it, how it was funded, and whether it was still happening.

School or District-Mandated PD. Typically, school or district-mandated PD will be very general in nature, applying to the greatest number of employees. Bridgette indicated was the case with her school during her interview. However, while this may be efficient, it may not always meet the needs of teachers in a specialized field like chemistry.

Figure 26 shows the response data when participants were asked about school or district-mandated PD. The majority of teachers, 83.6% ($N=128$), reported currently receiving or having received school or district-mandated PD, and an additional 7.2% ($N=11$) of participants indicated that they had never received any of the type of PD but were interested in receiving it. Further, school or district-mandated PD may not be what some teachers would have picked had they had a choice as evidenced by participants description of mandated PD as being “stupid” or “a waste of time.”

Figure 26

Participant Received School or District-Mandated Professional Development



Note: Frequencies and percent of participant responses to the prompt “Considering your career thus far, please answer based on whether you’ve received the following supports or experiences...”

School or District-Funded Autonomous PD. In the survey and interviews, participants voiced that they would like to be able to choose the type of PD that they participate in throughout the school year. As chemistry teachers, sometimes the only one who has ever taught it in their school, chemistry-specific PD is something that may benefit their knowledge of how to teach chemistry concepts, as at least two interview participants indicated. Seven participants voiced that their “professional development is not focused on chemistry” or that they “have never received, never been offered, but would love!” autonomous chemistry-specific professional development. Another participant added that the “professional learning that I receive is not on the subjects I teach but are general like teaching methods, classroom management, etc.” These teacher participants express the desire to receive chemistry-specific PD. However, some teachers, as evidenced by their lack of a local supplement and inequity in salaries across the state, rely on their schools or districts to pay for their PD.

Figure 27 shows the data collected when asking participants about whether they received external PD that they themselves chose and that was funded by the district or school.

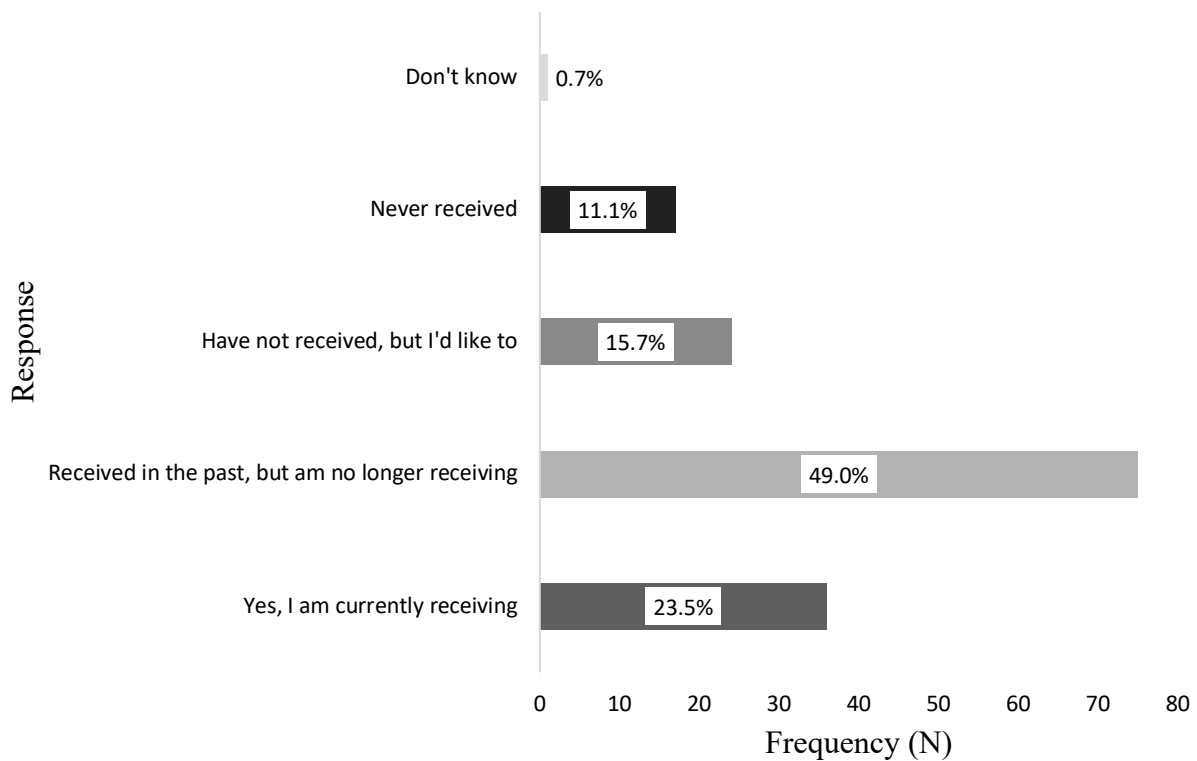
At the administration of this survey, 23.5% (N=36) participants reported currently receiving district or school-funded PD that was chosen by the participants. In fact, 15.7% (N=24) of participants indicated that they would like to receive autonomous PD funded by their school or district (

Figure 27), but they have never received any. The most common response (N=75) to this question was that participants had received PD they chose, and the school or district funded in the past, but they were no longer receiving it (

Figure 27). After the survey was administered, Georgia's Governor Kemp announced an 11% budget cut to the entire state due to loss of revenue from COVID-19 which is likely to affect the PD numbers in the future. This may mean that more teachers will have to turn to funding their own PD endeavors in the future.

Figure 27

Teacher Received PD involving Autonomy - School or District Funded



Note: Frequencies and percent of participant responses to the prompt "Considering your career thus far, please answer based on whether you've received the following supports or experiences..."

As indicated by survey responses, the autonomy to choose PD that one believes will be relevant is something that is not always a luxury that teachers in this study enjoyed (

Figure 27). This may be due to issues such as finding substitute teachers to cover the teachers who are out for PD or finding money to pay the fee and mileage to send teachers to a conference or outside training. To better understand this, interviewed participants were asked about their personal experiences with PD in order to shed light on PD in rural schools. Alice shared the following:

I get to go. I can go to free stuff at RESA. But a lot of times the science stuff that...gets cancelled the night before, because like two people signed up. [Because] a lot of the systems around here are not willing to pay for substitutes. And so, they deny their teachers going to professional learning. We're expected to get our professional learning through our professional learning communities, which is basically like at my school, the four of us sitting around talking about a topic. Well, you're very limited.

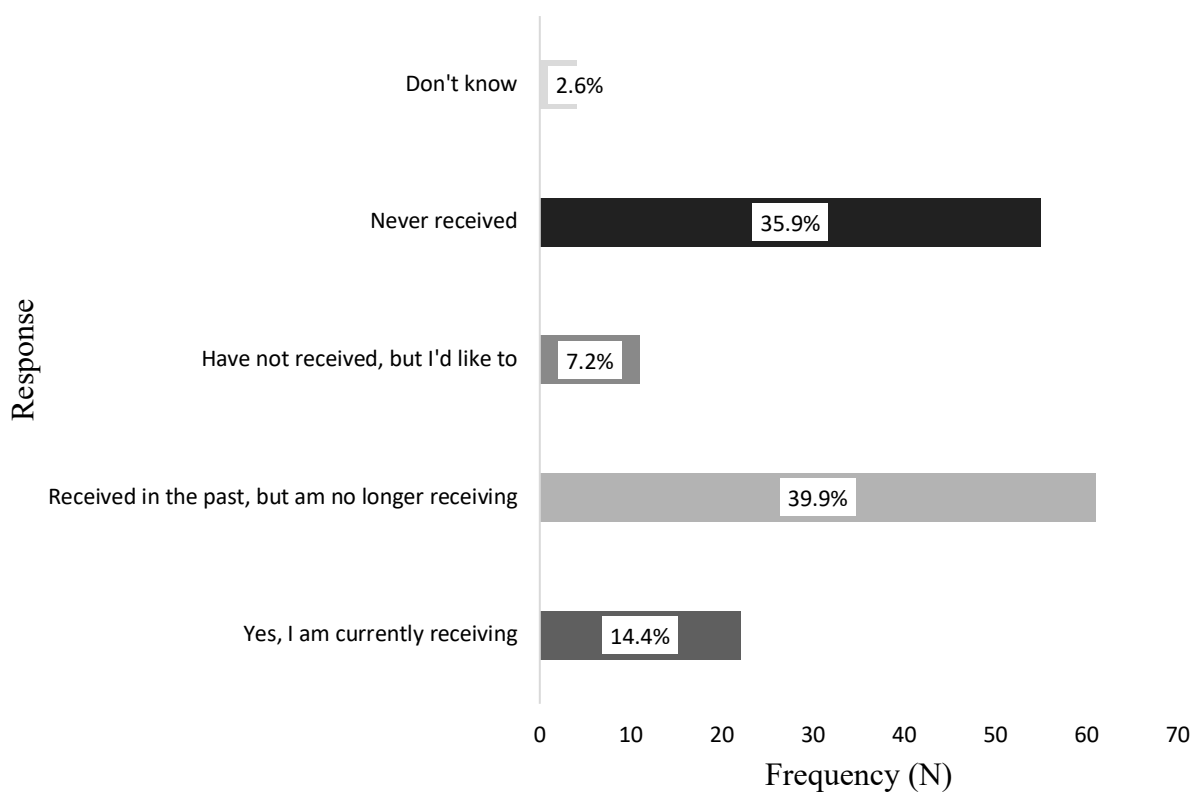
Daisy expressed that “[We] just don't have substitutes,” and Felicia added a note about resources in saying, “If we can find the funding to pay for, like the professional development, then [the school and administrators] don't have a problem with us going.”

Teacher Self-Funded Autonomous PD. Teachers reported spending their own money on supplies and PD, in general, which is evident with the data shown in Figure 28. 14.4% ($N=22$) of participants reported currently paying for their own PD; another 39.9% ($N=61$) stated that they had paid for their own PD in the past but were not currently, and yet there remains 35.9% ($N=55$) of participants who never self-funded their own PD. This indicates that participants want chemistry-specific PD, but that over one-third of them had not self-funded their PD endeavors and only 23.5% (

Figure 27) were currently receiving PD they chose that was also funded by their schools or districts. While the state minimum salary is the same throughout all public schools in Georgia, each district has a local supplement that is used to attract and keep teachers in positions within the county as well as offset the cost of living in a particular city, county, or district. One of the interview participants, Alice, brought up that her district did not offer a local supplement. This could be a difference of thousands of dollars in salary between a rural district offering no local supplement and one offering a generous one. The relevance to self-funded PD is that the PD is rarely in rural areas, which means that the cost to get to PD for teachers is much greater from rural areas than urban or suburban areas. Attending PD is cost-prohibitive for teachers from rural areas and even more so when their salaries are lower than their urban or suburban counterparts.

Figure 28

Teachers Participation in Self-Funded and Self-Directed Professional Development



Note: Frequencies and percent of participant responses to the prompt “Considering your career thus far, please answer based on whether you’ve received the following supports or experiences...”

Lack of autonomous PD or lack of districts or systems paying for PD requires teachers to seek out grants or use their personal money which can be difficult. For example, Hugh explained, “I have been presented with some grants. I have not looked into them and all and I basically [am] just paddling to keep my head above water.” The hours he keeps working on all of this until “you know, one or two in the morning every night try to get these things done” also seems stressful and leaves a teacher without time to seek their own funding to get to PD if their school, system, or state is not providing ways to make this happen without removing the stress or

burden upon teachers to do it on their own. Inquiry-based instruction will not become prevalent if teachers do not feel that they have time to implement it.

Another positive aspect of being able to choose autonomous PD options is that attending regional, state, and national conferences centered around a discipline or common pedagogical interest can help teachers to network with one another, even if they are the only science teachers at their schools as was expressed through feelings of loneliness by at least two of the interviewed participants. Felicia said, “I kind of feel like that lone salmon swimming upstream as a chemistry teacher.” Cathryn issued similar remarks in the following:

The second I came down here rural, I stopped all the professional development. I stopped going anywhere. I don't really, can't tell you what I think all of a sudden. Here's my philosophy: When I moved down here, I was all alone. And I wasn't working with anybody. It was me and my classroom and that, you know, I don't know if I stopped my involvement because I just didn't have time. I don't know if I didn't stop my involvement because it was too far away to travel, even though to [location 20 miles away] is not that far. Or if I stopped participating because there's a lot of work involved in 3 preps. Or maybe I stopped going because things weren't as good, things didn't apply to me in rural Georgia. You know, great, I'm glad you can do all this. This is really cool. But that didn't help me in rural Georgia. Or maybe I felt like I had a lot of things in my toolbox already. That could be a reason too; maybe it's a combination. It's probably a combination of all those things on why I started not being as involved. But I mean, I had these leadership roles in these organizations. And then it's like I disappeared, like off the off grid when I moved to [rural] Georgia.

Currently, there are several conferences that relate to chemistry such as the American Chemical Society (ACS), American Association of Chemistry Teachers (AACT), Georgia Science Teachers Association (GSTA), and the National Science Teaching Association (NSTA). All of these offer an in-person component, or did before COVID-19 restrictions, as well as an online component. Offering rural high school sciences the option to attend these conferences could provide effective PD at a reduced cost to both presenter and school districts willing to send their teachers to receive the PD.

On the other hand, some schools occasionally allow a limited number of teachers to go to PD as described by Daisy when asked whether or not she had ever requested funding to attend a conference or specific PD; she said, "...I haven't tried, but I know that other teachers have gone to different things like that. Not very often though. Usually it's like one person in that department, and, like, that's it for the semester..." Eleanor also did not attend "since we've gone to block, it's either too far to go...[or] if you go, they want you to share a room with four other people...[or] you're paying for it yourself." The MSP program, described earlier in this chapter, was a federal grant that paid for some teachers like Alice to attend professional conferences, but this is something that has since been phased out at the federal level (CDE, 2017).

However, some schools have sent teachers to conferences, and they realized the value of these PD experiences. For example, when Gladys was asked what could be done to improve the PD in Georgia for chemistry teachers, she said the following:

When I went to that first NSTA conference, GSTA, the standards had just come out. And I went to things and I thought I was really learning something. But it's like, I didn't know what I didn't know. And so, after having a year of experience with them, I went to that

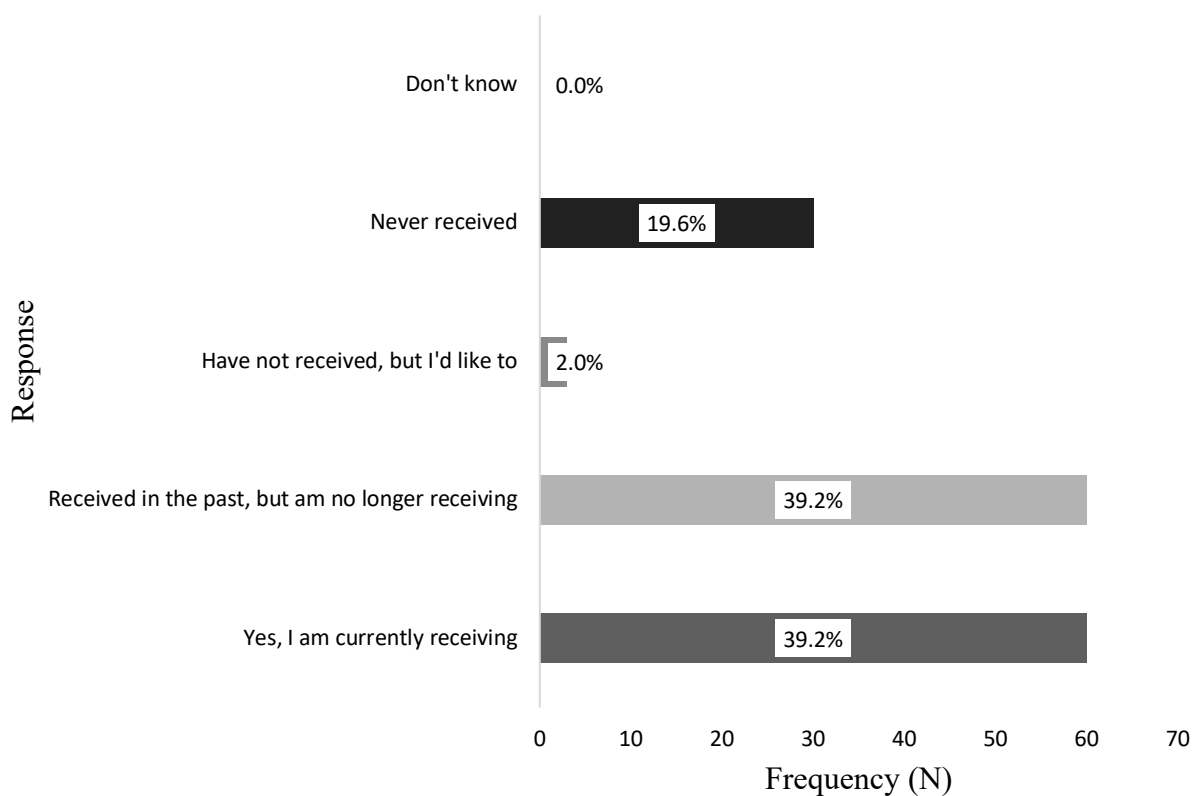
first GSTA in Columbus. And it was like, I got so much more out of that. But it was because I was more familiar with the standards...

Alice also explained that because specific PD intended for chemistry teachers is more expensive for schools to offer, and because it affects a much smaller portion of their faculty and budgets are stretched thin as it is, attending outside PD is incredibly important. Specifically, she said:

When I was doing my, my education courses and everything I focused on chemistry, even there even that I didn't have what I needed. What I have now what I had to learn on my own in order to be a successful chemistry teacher and I still don't think that ...I'm there because I'm not, you know, there are some topics that I don't get to often enough to really have you know, hone it and get the things that I know work and that kind of stuff. When you're talking about managing chemicals and lab safety and disposal and things like that, and...do you have any electronics? Do you have balances? What can you do with those or you know, the other thing is if they give you money, what do you need to order?

PD Delivered by Teachers at Participant's High School. PD in a different location typically requires payment of a conference or workshop fee, money to pay the substitute teacher, gas or mileage to the event, food while the teachers is gone, and lodging if the event is far away or overnight. Due to the potentially high cost, one method that districts can opt for when trying to save money is to have teachers within the district deliver or redeliver PD. This saves the district the money that would be spent on bringing in a speaker or sending teachers to a location. As expected, the majority of participants have experienced this option with 78.4% ($N=120$) of participants indicating that they either had received or were currently receiving PD delivered by a teacher at their school (

Figure 29). On the other hand, 19.6% ($N=30$) of participants responded that they had never received PD from a teacher in their own school.

Figure 29*Received Teacher-Delivered Professional Development at Own School*

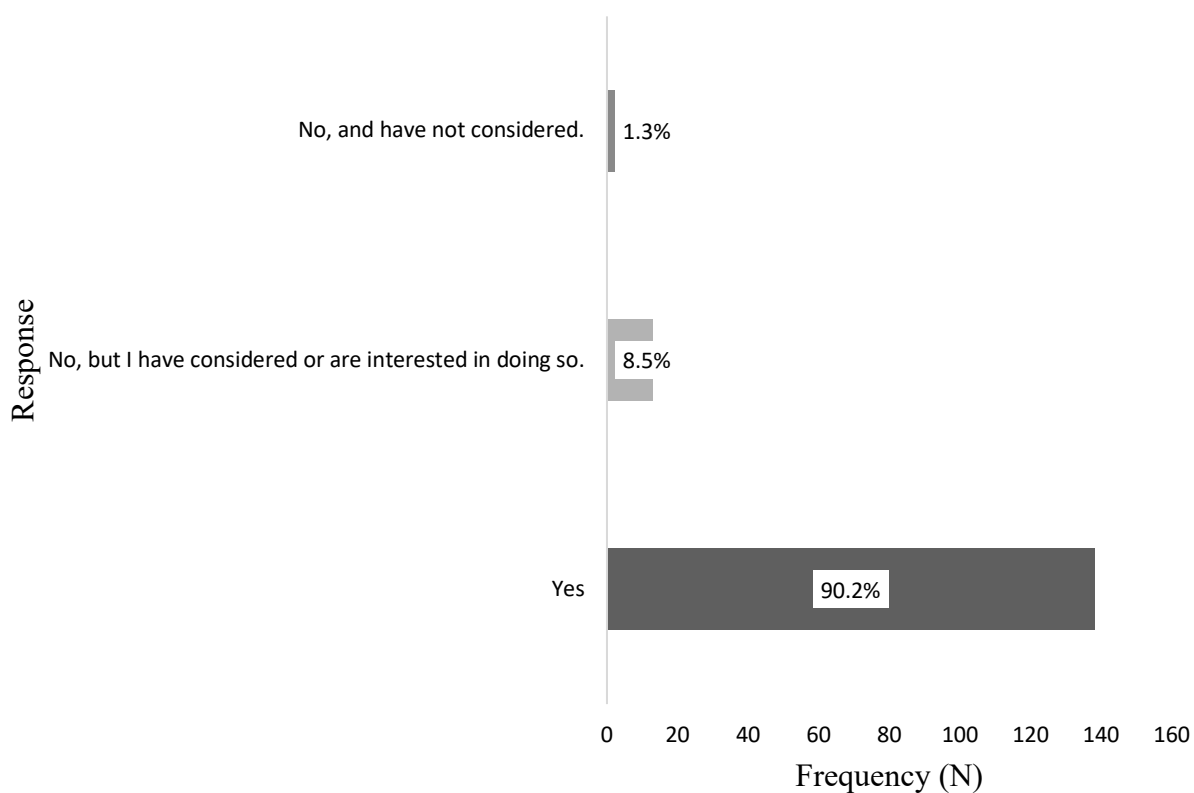
Note: Frequencies and percent of participant responses to the prompt “Considering your career thus far, please answer based on whether you’ve received the following supports or experiences...”

Participation in Activities to Improve Teaching. To better understand the PD options chosen by chemistry teachers in rural areas, participants were also asked whether they participated in activities that were aimed at improving awareness of teaching as a profession such as being a member of a professional association or teachers’ association, and an overwhelming majority, 90.2% ($N=138$), of chemistry teachers in rural public high schools in Georgia

participated in activities to help improve their teaching, with an additional 8.5% ($N=13$) of participants interested in these activities or joining a professional association (Figure 30).

Figure 30

Participation in Activities Aimed at Improving Teaching as Profession



Note: Frequencies and percent of participant responses to the prompt “Considering your career thus far, please answer based on whether you’ve received the following supports or experiences...”

As expected, only 1.3% ($N=2$) of participants stated that they had not participated in any activities aimed at improving awareness of the teaching profession. One benefit that some of the

professional organizations in Georgia offer is legal counsel and liability insurance. For this reason, administrators and veteran teachers will advise younger teachers to be active and to make sure to join a professional organization if only for the legal aid as form of legal insurance.

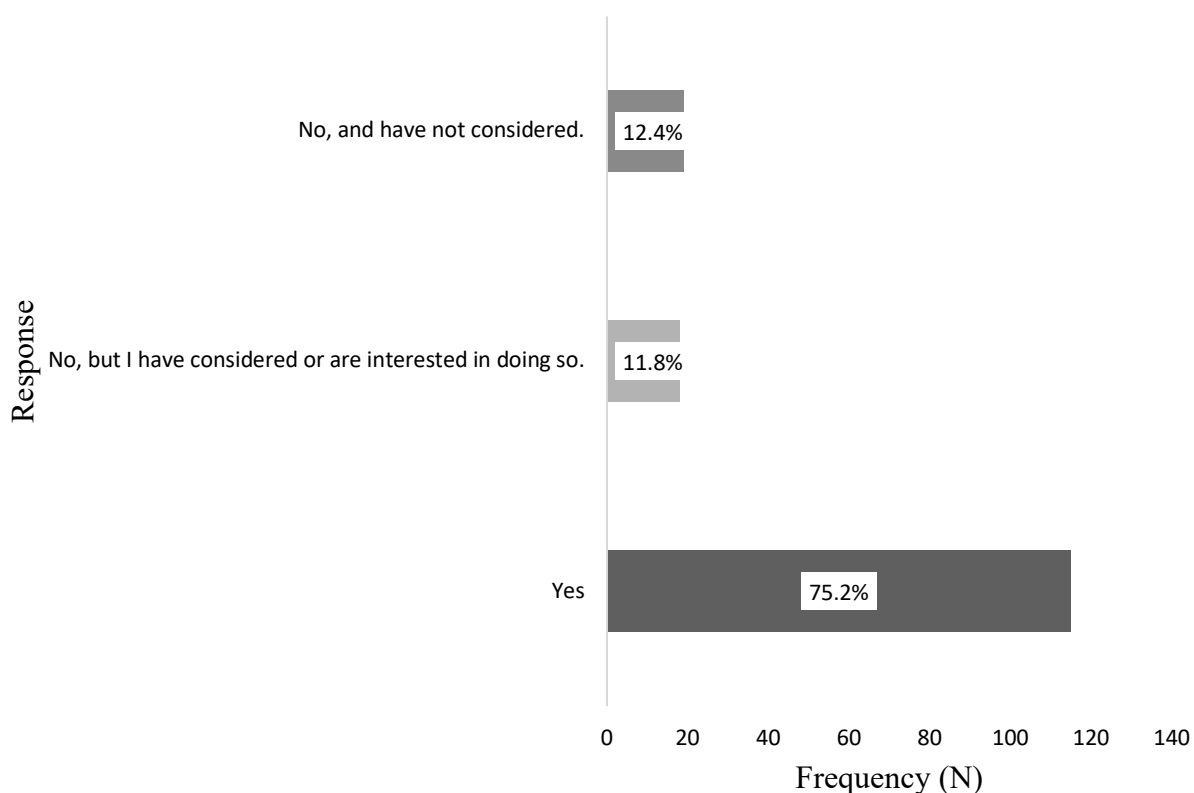
Professional Learning Communities and Collaboration. Professional learning communities (PLCs) were made requirements by the State of Georgia Department of Education (GaDOE) within the past five years as part of each teacher's yearly evaluation. However, there are many versions of PLCs that have been accessible to teachers even before PLCs were mandated within schools. Since the GaDOE requires PLC participation of all teachers, there was no need to ask teachers whether they participated in them or not. However, participation in optional PLCs in the form of teaching organizations or social media groups dedicated to a common purpose or content area have become the norm as more and more teachers become comfortable with sharing information between schools and time zones as barriers.

Figure 31 reveals that over three-quarters of teacher participants, 75.2% ($N=115$), stated that they have participated in these non-required PLCs, and an additional 11.8% ($N=18$) stated that they had not participated, but that they were interested in doing so. Surprisingly, one participant stated that this is the only way to receive chemistry-specific PD because "when it comes to PLC I have to go outside my own school district to collaborate about my content if I wish to collaborate in chemistry," and another participant stated, "we always have stupid professional learning topics such as: differentiation, data mining, and any ridiculous topic that does not matter...PLCs are a total waste of time and a way for the State to cheapen its way out of continuing education opportunities." These responses indicate that PD specifically for chemistry teachers can be problematic and expensive since there are typically very few chemistry teachers

in small rural high schools and districts. So, this indicates that one important step for these schools and districts in the future is to allow for the autonomy to attend a state or national organization conference that has the resources to offer chemistry-specific PD.

Figure 31

Participation in Optional PLCs



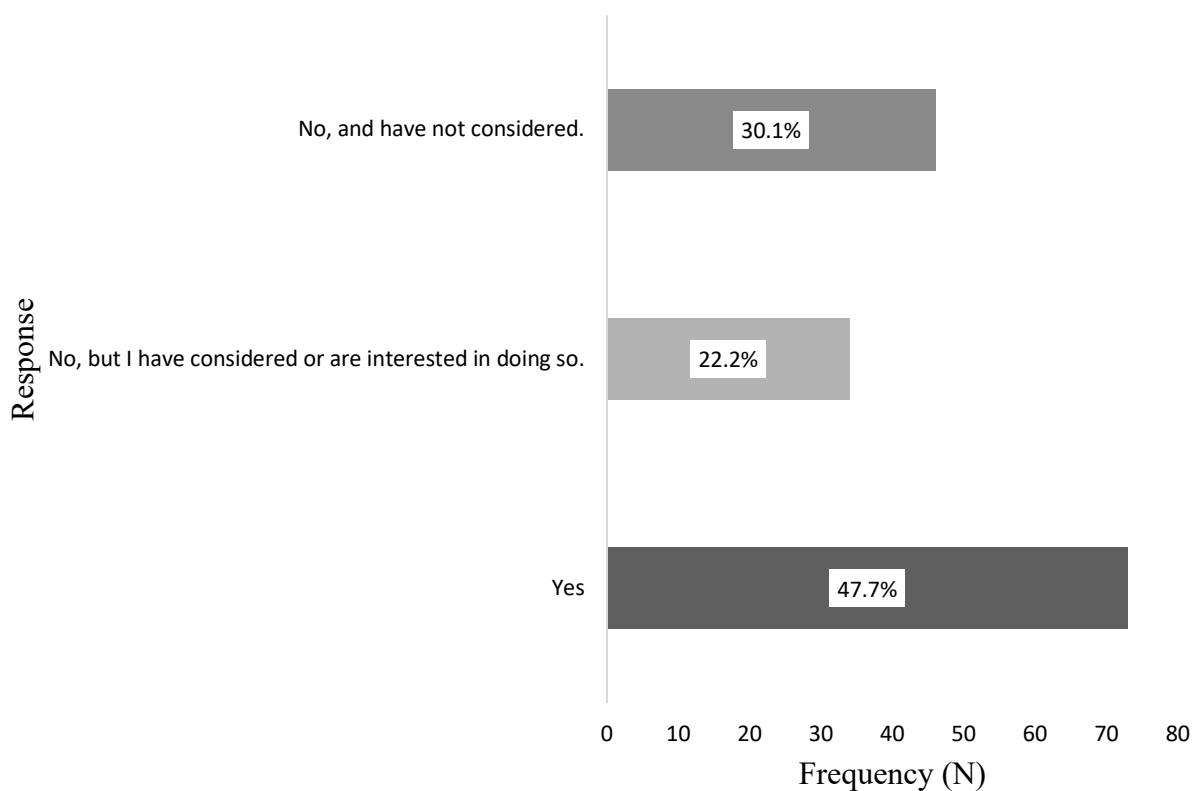
Note: Frequencies and percent of participant responses to the prompt “Considering your career thus far, please answer based on whether you’ve received the following supports or experiences...”

Presentation to Peer Groups or at Conferences. Teachers across the state have the option to attend a conference or to spend time with a peer group. For example, when the

standards changed from GPS to GSE in 2016, the GSTA Annual Conference had over 1,000 science educators in attendance, which was higher than 500-800 in years when standards have not changed. Importantly, educators at these conferences are given autonomy to choose specific sessions to attend which allows for great content-specific PD to occur. Because the sharing of best practices and ideas both online and in person can help to strengthen other educators, participants were asked whether they presented at a conference or to peer groups to help determine how many teachers were actively involved in making PD happen in their state and around them; the data is displayed in Figure 32.

Figure 32

Presentation at Conference or to Peer Groups



Note: Frequencies and percent of participant responses to the prompt “Considering your career thus far, please answer based on whether you’ve received the following supports or experiences...”

Figure 32 shows that a little less than half of the teacher participants, 47.7% ($N=73$), have ever presented at a conference or to a peer group. The idea of presenting in front of people can be daunting and the fear of speaking in public is a real one, which may lend some insight into why 30.1% ($N=46$) of participants had not presented or ever considered presenting at a conference or to their peers. The other 22.2% ($N=34$) participants had not presented but were interested in doing so. At least one participant added an affirming note for conferences or conventions by saying “almost everything that I have done has been self-taught or learned by attending science conventions...It seems that I am the only [teacher] that doesn’t mind undertaking the endeavor.” Undertaking the process of getting approval and setting up the logistics for going to a conference or convention is more work than not going to one. However, the data shows that the majority of rural public high school chemistry teachers either are involved with professional organizations, attend conferences or conventions, or even present at them. These numbers show the value the participants placed on those activities.

The survey and interview data both indicate that for chemistry teachers, pedagogical training alone is not enough. Participants shared examples where they walked into labs after the previous teacher who had been there for many years or there had been so much turnover in the position that no one had organized and kept up with the chemicals in the lab. This is problematic because these are aspects that teacher training programs and even science majors typically do not cover in their classes. Alice was the only one of the participants who had experience with

Material and Safety Data Sheets (MSDS) and using them as part of her teacher training. The remainder either learned on their own or had a career that required the use of them beforehand. Therefore, chemistry teachers should also be provided with laboratory-specific training as lab safety is a strong consideration when it comes to a teacher's decision on whether to implement laboratory experiments as required by the GSE standards. Eleanor said the following when asked what helped her be a better chemistry teacher and what could be done to improve that for new teachers:

Now, actually tutoring. Tutoring college kids, and finding out what, like, for example, even when I was in college...I never had a course, on storing chemicals, on maintaining your chemical storage area, on disposing of chemicals. And here after [more than 20 years] I still haven't had a course. And so I think, you know, that's one of the biggest [injustices] we're doing to anybody, that we're letting out it with this, with this chemical storage room, no idea where to put it, how to put it, where to store it, how to store it, what to do, what not to do, what to mix and, and so I really think that's lacking in science education.

Knowledge of setting up labs, lab safety, and other concerns within the classroom is something that comes with experience, but not even that experience in industry can substitute for lab experience with teenagers, as Gladys indicated. Cathryn continued the sentiment by describing difficulties new teachers have for lab in that “[new teachers] didn't have the materials and the equipment and they just didn't know how to make substitutions.” Substitutions are often required when teaching lab because you may not have all of the equipment or have to make your own equipment due to funding, but sometimes it is not the substitutions that teachers find

difficult. It may be actually teaching the students or teaching them the chemistry content specifically, such as PCOI, as Felicia stated, “I think...if I had, like professional development that taught me how to teach them, that would be great...because I don't know how to teach them.” A teacher may know the content knowledge, but getting students in a high school chemistry classroom to actually plan and carry out an investigation may require additional PD. Gladys, as a former lab manager and chemist, had the following to say:

I would like some training on how they see the student planning. You know, like, as a student who's never planned, like, how do you see that working? You know, like take one lab and show me how you expect all different levels of students to plan it. You know...everybody doesn't do the exact same lab, right? [Everybody] does just a little bit above what they're comfortable with to kind of move them. But, you know, not everybody's going to do, in my class anyway, the exact same lab, I'm going to change it a little bit based upon what their needs are....You know, what do you see someone who's never planned a lab before, who doesn't know what a beaker is? You know, like, if I say go get a beaker, they would come back with a graduated cylinder. I see it every year, you know that they don't know how to tear a scale? Or what that even means. How do you see them planning a lab?

Interview participants gave indications that they genuinely want to follow the guidelines and teach their students the GSE standards and techniques to be successful. However, they need to be given the tools to do so and this happens through knowledge using PD. Hugh even suggested that GaDOE provide information about labs that are aligned with the GSE standards, cost-

effective, and that could be implemented in a 40-50-minute class. When asked what he needed or wanted to in PD he added the following:

...like, guidelines on labs and maybe put out a couple of PowerPoints of, you know, hey, this is how we want, you know, whatever taught, you know, or at least guidelines. Not how we want it, but the way to do it. I'm sure there's a bunch of people up there in the state, you know, working on this, you know, they can, they could bust out a PowerPoint of this is what we want taught, the concepts we want covered, which aligns with the standards. And a suggested lab, which is cost effective.

As a new chemistry teacher and person who switched careers to teaching, Hugh is just asking for the tools and guidelines to go along with the content knowledge that the teacher presumably has by passing the teacher exams, such as GACE in Georgia. He is asking for help from the State in helping to teach the chemistry GSE standards the way they are written. Participants strongly voiced the desire for PD, more time to plan, and for clarification from the state as to how to implement the standards.

Support

Mentors. Mentors are meaningful both when you are a teacher and when you are a student in providing the foundation of a support network. Memorable science mentors can infect their students with a love for science by encouraging them to construct their own knowledge and learn through curiosity, which is inquiry-based learning. Bridgette emphasized her mentor relationship when she described how she “had two of the greatest science teachers on the planet” when she was a student in high school. She went on to describe how she “could have graduated after her junior year [of high school], and I stayed my senior year and took all of the science

classes they would let me sit in just to prepare myself for college...I just loved them.” While describing how much she loved her high school teachers when she was a student, Bridgette recalled that her teachers did not have the students “do that many labs.” However, the number of labs performed as a student did not tarnish the memory of how amazing her teachers were; “They were great.” Cathryn also related how her high school biology teacher influenced as many as 15 individuals to become science teachers out of just her graduating high school class. She related this meaningful science experience as being due to “discovery and inquiry.” The discovery and inquiry she referred to involved the teacher “[picking] up roadkill and [bringing] it in and [dropping] it on the table.” Her teacher would then ask, “Well, how did it die?” This same teacher would also take them on field trips and “made science so real” to her students. Cathryn attributed these experiences as shaping her teaching philosophy.

Just as teachers can influence their students, they can also influence other teachers and motivate them. The support of a mentor who encourages with words or provides materials is a form of professional development in and of itself. Science teacher mentors also helped Cathryn to become the teacher she is today, because, in her first years teaching, she “was around awesome people...who moved on to [work at the state and federal level].” These people were “great role models” and she “saw the excitement” that resulted from these people using inquiry before it became popular on the national level. Alice would agree with this and stated that she learned “just how much teachers need each other” through her involvement with the Math and Science Partnership (MSP), a federal grant-funded program whose purpose was to increase the academic achievement of students in mathematics and science by enhancing the content

knowledge and teaching skills of classroom teachers (OAI, 2015). Felicia stated that a past colleague had served as her mentor and said the following:

I learned a lot from him when I first came in, he was, he had been a chemistry major and stuff and so it was kind of like when I was trying to remember everything I would run over to him all the time, but I feel like right now I don't really have anybody to go to.

Felicia went on to talk about how the lack of mentors was “kind of a con [at] rural schools” because they are “small and there’s not much collaboration, but I feel isolated. Like I don’t feel connected to other teachers.” These feelings of isolation and place-based education will be further explored later in this chapter.

Teachers, Administration, District/System & State. Participants were asked about the support they received from other teachers, administration, districts, school systems, and their state. They expressed appreciation when they were made to feel valued and supported by their schools and administrations. Even though Hugh experienced stress from being a first-year teacher and dealing with a small lab budget, he also expressed that “as far as my school, anything I needed, I put in for, you know, they would pretty much approve...as long as they had the money.” When describing his principal, he said the following:

She’s a wonderful person. She supports me 100%, supports the department...100%, so I know if I came to her with something legitimate, and was prudent to the success of the children, which is her primary concern, then, absolutely, she would be for it all.

In a separate interview, Gladys added that her school was supportive of purchasing resources, and she expressed “I’m sure money is an issue...[but] I don’t feel like if I plan far enough in advance if I ask for it that I wouldn’t get it.” While Hugh and Gladys each conveyed that they

felt supported by their schools, not everyone revealed the same feelings about their district or state.

Having an administrator evaluate you who has worked as a science teacher can be another feeling of support for a science teacher. Eleanor expressed how in over 15 years in her district that she “[has] never had an administrator evaluate [her] who was a science person.” She also stated that there were years when she was the only person in her county teaching chemistry and she “[has] never felt at all, any support from the State. I mean, zero, like none.”

Cathryn described how she’s had administrators who have been supportive and then some that have not been. Her apt description of a rural school is as follows:

These smaller schools, I've watched the leadership of small schools and leadership matters on how you do. You've got to have an administrator that likes the way you teach science. You are that science department. There's not a group, you are that science department. You've got to have an administrator that supports what you do. And what I have found is that when the administrator comes from within, in these rural schools, they are powerful, because they know the way it works.

Administrators alone don’t make the school pleasant. Kathryn also said, “If you have a teacher that wants to improve their practice, we've got to have mentorships.” This type of support is especially important in smaller districts where the chemistry teacher may be the only chemistry teacher at the school or district or may even be the only science teacher at the school. If a school hires someone with little to no experience, then a support structure is needed to make sure the teacher is using best practices and understands how to run a chemistry lab.

Synopsis of Research Questions

The purpose of this chapter is to present the findings of the data collected in this study from both the survey and the interviews to help answer the research questions. RQ1 asked about Georgia rural public high school chemistry teachers' views of the feasibility of teaching GSE High School Chemistry through inquiry. The survey data shows that 79.49% of participants used inquiry in their labs. However, this did not measure the frequency of the inquiry alone and it also did not measure this against the seven PCOI standards/elements. Those who answered yes on the survey to using inquiry in their courses reported an average of 35.94% of their labs as involving inquiry. Interviews further explored the use of inquiry labs, and participant responses revealed that while each of the eight participants admitted to commonly implementing guided inquiry during their lab instruction of the seven PCOI standards/elements, only one participant utilized PCOI during chemistry labs. Even that one participant only used PCOI during four out of the seven incidents of PCOI in the GSE.

RQ2 asked about rural chemistry teachers' methods of teaching concepts with explicit inquiry or PCOI in the standard. This was not a question that could have been solely answered using the survey data. Interview data yielded answers as participants admitted to using open inquiry, guided inquiry, demonstrations, and virtual labs to teach the concepts. Surprisingly, only one participant actually had students carry out *and* plan the investigation, which further shows that PCOI is not occurring in the majority of participants' chemistry classrooms in Georgia as written in the GSE. However, participants did express that though they see the value of implementing various forms of inquiry, time is the most difficult barrier to performing more open inquiry experiments.

The third research question asked about rural public high school chemistry teachers and their access to supplies, technology, planning, and professional development required to teach an inquiry-based unit including laboratory activities. 92.31% of survey participants stated that students had access to some form of technology in their school or class. However, interview participants further explained that poor internet access, lack of devices, and poverty are hindrances to students using technology and therefore having easier access to activities that may be inquiry-based. Teachers on both the survey and in interviews also mentioned lack of money, resources, and supplies as a limiting factor to completing labs. Thankfully, though, several teachers also indicated that their district provided most everything they need as long as requests are submitted in a timely manner which comes with experience and time within a school. This is not the case with all the participants because teachers who were isolated were not necessarily provided with relevant PD that was specific to their chemistry course or to the laboratory knowledge needed. Much of the PD listed by participants involved generic teacher PD provided by the district. When asked about autonomy to pick other more relevant PD several participants stated that their district wouldn't have an issue so long as the teacher found funding to go. This is on top of the majority of participants stating that they spent a considerable amount of their own personal funds on lab supplies already.

When asked about the PCOI standards participants indicated that they would like PD on the topic to see the best way to get students to plan and carry out investigations in a cost-effective and time-effective manner. This is something that some would like to see the state provide while others wanted nothing to do with training from the state. Even if this PD can be secured it does not mean that these teachers in small rural areas can find substitute teachers to

watch their classes while they're gone. This lack of PD, subs, and funding to provide chemistry specific and lab relevant PD contributes to the low numbers of teachers complying with the wording of the PCOI standards/elements within the GSE.

Chapter 5: Conclusions, Implications, and Future Work

This chapter presents the overall conclusions for the findings presented in Chapter 4 in the context of the theoretical frameworks discussed in Chapter 2, and implications of this research are presented as a means of informing future policy regarding professional development and funding for rural public high school chemistry teachers. The chapter concludes with future work based on the results from this dissertation.

Conclusions

The body of work and research on inquiry-based instruction within the high school classroom is quite extensive (Bybee et al., 2006; Capps, et al., 2012; Chang & Mao, 1999; Cullen, 2015; Fang, et al., 2010, p. 3; Geier, et al., 2008; Hayes, et al., 2016; Marshall & Alston, 2014; NRC, 2012, p. 30; Schraw, et al., 2006; Schraw, et al., 2013; Windschitl, 2008), and there is also a growing field of place-based education, which looks primarily at how location impacts education (Brenner, 2016; Deck, 2001; Eppley, 2010; Howley, 2009; Howley, et al., 2009; Jimerson, 2005; Lawrence, 2009; Martin, 2010; Sherburne, 2016). However, few studies have given a voice to those public high school chemistry teachers located in rural areas; specifically, a need exists for these teachers to explain their views on teaching standards within the state of Georgia, use and requirements of inquiry-based instruction in class as well as for laboratory experiments, methods of teaching inquiry and planning and carrying out investigations (PCOI), and access to technology and other resources needed to teach the high school chemistry course using inquiry. So, the present study was devised in order to meet that need.

The goal of this research study was to answer the following research questions regarding rural high school chemistry teachers and the Georgia Standards of Excellence (GSE):

RQ1: What are Georgia rural public high school chemistry teachers' views of the feasibility of teaching GSE High School Chemistry through inquiry?

RQ2: What are rural chemistry teachers' methods of teaching the concepts that have explicit inquiry or PCOI in the standard?

RQ3: What access do rural public high school chemistry teachers have to supplies, technology, planning, and professional development required to teach an inquiry-based unit including laboratory activities?

This study examined the inquiry-specific standards in the Georgia Standards of Excellence (GSE) for high school chemistry through a sequential explanatory mixed-methods design utilizing both a quantitative survey followed by qualitative interviews (Figure 2). These standards include active verbiage requiring students to both plan and carry out investigations (PCOI) in seven specific elements. Survey participants were asked about the use of inquiry, number of labs, and percent of labs used that include inquiry, but they were not asked specifically about which standards they used PCOI. Each of the eight interview participants was asked about PCOI and the methods of teaching the specific standards or elements within the GSE. The combination of the survey data with the interview data helped to add to the richness of the narrative of the rural public high school chemistry teacher as portrayed in this study.

Data from the survey and interviews revealed that teachers are somewhat divided on whether inquiry-based instruction of the GSE is feasible. 80.4% of survey participants stated that they used inquiry in their classrooms indicating that inquiry-based instruction in high school chemistry using the GSE is feasible. Interestingly, when the answers were cross-referenced to

participants' scheduling, there was very little difference in inquiry percentages between traditional schedules and block schedules.

RQ2 sought to understand the methods rural chemistry teachers use to teach concepts that have explicit inquiry or PCOI in the standard. The interview data provided insight into eight participants and their varied implementation of the inquiry language used in the seven standards or elements in the GSE stating students are to PCOI. Table 12 provides the data showing that interview participants indicated PCOI only occurred in 7.14% of the incidents it should have occurred in according to the GSE. This is not to imply that students are not involved with inquiry in those incidents; rather they are not fulfilling the intent of the GSE that students are to “plan *and* carry out” investigations. Responses indicated that typical teacher-guided labs are given to students, but these usually have instructions that students carry out. Though some of these labs may have inquiry involved, planning and carrying out investigations seems to be thought of as open inquiry based, and participant commentary expressed they do not feel they have the time required to do true open inquiry in the classroom. For example, one participant said, “I’m barely keeping my head above water” (Hugh). Essentially, the inquiry continuum exists, and the lack of using open inquiry can be thought of as a misunderstanding of the PCOI standard requiring a wet lab as opposed to inquiry.

An important tenant of constructivism in practice in education is the educator as a facilitator. 97.4% of participants saw themselves as a facilitator at least sometimes and 77.1% saw themselves as a facilitator often or always. Another element of the Next Generation Science Standards and inquiry has been the use of phenomena in teaching concepts and allowing students to construct their own ideas and understandings within a course. Participants overwhelmingly,

88.9%, admitted to using inquiry at least sometimes in the classroom. Student interest guiding lessons and students involved in planning or having an active role in determining what is learned and how it is learned was reported as happening at least sometimes in 68% and 64.7% of participants' classrooms, respectively. However, what is concerning is 46.4% of participants did not think students' devising their own investigations was important in a chemistry course, which shows a fundamental difference in ideology between almost half of the teachers in the classroom and the wording of the state standards. If the state desires this to change, then it must be changed through professional development and active intervention with chemistry teachers around the state.

Several participants stated that they use Physics Education Technology (PhET) simulations to complete the standards, but the teachers also stated that students are not planning investigations even though these online simulations can be setup in a way that students must plan and carry out the investigation. However, creating the assignment and rubric for grading takes planning time before and after the activity, and adequate planning time is a resource that 46.4% of participants do not have (

Figure 24). This indicates that though teachers may be willing to implement PCOI more, they do not feel they have the time to do so.

Further, responses indicated that while teachers do not have adequate planning, they also do not feel they have adequate training for implementing true inquiry in their chemistry classrooms. When asked about planning time, one participant stated that the planning time was taken up by general school-mandated professional development that was not content specific. This response indicates that the participant was obviously frustrated with losing time for PD that was seen as not being relevant which highlights an additional need for teacher autonomy in PD choice. Only 23.5% of participants actually received PD that they chose and for which the district paid (

Figure 27). However, this is not because teachers do not want to be involved as 90.2% of participants reported being involved or a member of a professional or teacher organization.

Ultimately, PD, planning time, and autonomy in PD may all be seen as an equity issue or lack of access, which is what RQ3 attempted to answer.

RQ3 looked specifically at teachers' access to supplies, technology, planning, and professional development required to teach an inquiry-based unit including laboratory activities. Good news for the state of Georgia is that 90.8% of participants stated their teachers had access to devices in the classroom (

Figure 15). Also, the majority of the participants stated having sufficient access to technology, internet access, reliable internet access and speed as well as access to instructional materials and resources. However, almost half of the participants stated that they did not have adequate planning time, and over half of the participants felt that other schools had more supplies and resources than they had. Surprisingly, 27.5% of participants stated that they felt they must beg for lab supplies with only 52.3% receiving explicit lab budget information. The feelings of a lack of equity, planning time, and autonomy in PD show that while access to some of the tools for teaching are present in the majority of classrooms, the time and training required to use these in an effective manner to teach inquiry as stated in the GSE simply is not a resource that the majority of teachers feel they possess.

Definition of Inquiry as a Finding

Inquiry can be defined in different ways, which can lead to confusion as to its true meaning. As described in Chapter 2, the *Frameworks* state that inquiry includes the following skills and practices: planning investigations, reviewing what is already known in light of experimental evidence, using tools to gather, analyze and interpret data, and proposing answers, explanations and predictions (NRC, 2012). This list of skills and practices from the *Frameworks* helps to identify that which is scientific inquiry. Fang et al. (2010, p. 3) describe scientific inquiry as important for learning science because “it recognizes science as a process of discovery and invention that involves engagement, exploration, explanation, application, and evaluation.” The issue arises when teachers, such as those who expressed how much time and resources inquiry-based instruction requires as put forth in the GSE, view inquiry as singular in definition. Table 5 shows the continuum of inquiry and highlights that inquiry can have multiple outcomes and methods (NRC, 2000, p. 29). The reason the continuum exists is to show teachers that inquiry is not just reserved for open inquiry.

The overwhelming majority of participants indicated that they used inquiry, as defined on the survey instrument and in the *Frameworks*, within their classrooms. Teacher participants also believed that students need to plan and carry out investigations to get the most out of the course and to address the standards. A need to address all standards was expressed, but the majority of teachers cited lack of time as a reason why the inquiry was not completed in all of the standards or elements within the GSE stating for students to plan *and* carry out investigations. There are many mitigating factors that might allow for this to occur, with the rural setting being just one of those factors.

Limitations

While both the survey and interviews yielded valuable data that can be used to inform future work, they are not without limitations. This section explores the limitations that exist in the instruments and methods used.

Instrument Limitations

The survey instrument itself was created using several existing instruments. In an effort to be mindful of participants' time and increase the quantity of participants, the decision was made to not include the entire survey instruments upon which the one created for the present study were based. This allowed the survey instrument to be completed in 15 minutes or less by participants and resulted in $N=153$ participants. In total, 128 unique rural public high schools were represented, which is 63.37% of the 202 rural public high schools that fit the research parameters in Georgia. However, this does not take away from the fact that using only a portion of the instrument is a limitation in the study as it draws into question the integrity of the modified instrument. This limitation could be remedied in the future by either establishing a more reliable instrument upon which multiple quantitative analysis techniques could be performed or by using an already established instrument. However, the use of in-depth narratives from participants does add reliability and validity to the current study's findings.

Definition of Inquiry as a Limitation

While the survey instrument included definition of inquiry from *A Framework for K-12 Science Education* (NRC, 2012), there were no further questions that determined participants' own definitions of inquiry. In addition, the interview guide did not include questions regarding participant or researcher definitions of inquiry. The lack of presenting or asking for a common definition of inquiry as a point of symmetry in both instruments is a point of limitation within the

current study. Without the common definition of inquiry being stated or asked for the questions involving inquiry could have been interpreted in various ways regarding the survey.

Implications

Findings from this study indicate that the majority of public high school chemistry teachers in rural Georgia report using inquiry-based instruction, especially when it comes to laboratory investigations. One method of inquiry-based teaching in science classrooms is students participating in investigations through planning and carrying them out. However, interview responses indicate that many of these teachers interpret PCOI as something to only be implemented during wet labs. Though wet labs are one method of implementing inquiry via PCOI, they are not the only type of laboratory investigations or inquiry activities available to teachers. Online simulations are available and allow students an element of PCOI. However, even these can be as teacher-directed as a cook-book lab. The instructor is responsible for determining the desired level of inquiry using the inquiry continuum (Table 5) and can turn any cook-book lab into an inquiry lab to some degree with the appropriate amount of editing.

Scheduling and education were shown to not have significant impact on the use of inquiry in the classroom. The majority of participants, 60.1%, reported being on a semester-long block schedule, but the schedules did not significantly impact teacher use of inquiry in labs. Additionally, 83% of participants earned a degree greater than a four-year degree which shows that education regarding degrees conferred upon instructors is not a limitation in the incorporation of inquiry-based instruction by chemistry teachers in rural areas. However, education level does not necessarily equate to dedicated PD in chemistry pedagogy. One major finding of the study is that the majority of teachers, 80.4%, report using inquiry labs in the

general chemistry classroom. The issue is that there are still approximately 20% of chemistry classrooms that are not using inquiry labs. However, the inquiry portion is written into the standards. The present study cannot say for sure in each case whether it is a lack of understanding into what inquiry is or a deficit in how to prepare labs using inquiry; either of these can be solved utilizing PD, but the PD plan must diagnose whether the issue is one or both of the deficiencies causing the lack of teachers' utilization of PCOI within the chemistry classroom.

Professional Development

Professional development was the focus of several survey questions in order to understand its impact towards implementations of inquiry in rural high school chemistry classrooms; participants in the interviews also expressed a desire to have chemistry-specific PD. Specifically, teachers want PD to be centered around laboratory experiments that are cost-effective as well as efficient to allow students to construct their knowledge of the concepts. These responses indicate that teachers understand the need for PD that is content-specific in order to zero in on the issue of inquiry in the chemistry classroom; PD for the sake of just offering it is not enough. Small systems that have difficulty finding substitute teachers or paying for their teachers to get to locations for PD will still be limited in what they offer their teachers. Interview participants further indicated that though there is funding available for supplies, if requested well in advance, not all teachers know what amount is available. One potential option is for the state to provide content-specific training free of charge made available through a virtual format; this would also allow teachers in rural areas to participate which is something that 15.7% of survey participants and 100% of interview participants indicated they wish for. The lack of

general PD, chemistry-specific PD, as well as lack of funding all contribute to the low number of teachers who are in self-reported compliance with the PCOI wording within the standards/elements of the GSE. Changing standards without proper implementation through professional development of the teachers who will be using those standards has led to the problems highlighted within the current study.

Funding

This study also revealed that schools and districts are not doing enough to provide teachers with resources for implementing chemistry specific lab activities, as almost one-third of participants felt that outside sources of funding were required to have enough lab supplies to adequately teach the class (

Figure 22). One participant remarked that a resourceful teacher can make it work with less, but the participant only knew this from years of experience working in a school where teachers worked together to formulate a plan for implementing more labs with fewer resources. At least two participants described fund-raising efforts through optional lab fees while another detailed an elaborate science department candy fundraiser that stocked the labs with updated equipment and chemicals which removes that as a barrier to inquiry.

Future Work

The current study investigated the perceptions of public high school chemistry teachers from rural areas in the state of Georgia. Participants expressed a desire to have more chemistry-specific PD on the topic of facilitating laboratory investigations, particularly for students' PCOI. These teachers would also benefit from chemistry-specific pedagogy in the areas of inquiry and facilitating student' PCOI. PD needs to be enacted in Georgia to provide these rural public high

school chemistry teachers the training the data showed is needed for effective implementation of the GSE.

This study could be replicated for any demographics, but rural-specific research could be done throughout the United States to determine the perceptions of rural teachers from around the country in order to ascertain possible commonalities and differences from all states. This could help to inform chemistry education in each of those states as well as the country. Future research could also include private schools as well as urban and suburban schools or similar schools in different states. Additional studies into teachers' definitions of inquiry and what is required for students to plan and carry out an investigation would be beneficial to those looking to provide reliable and effective PD. NGSS and states incorporating NGSS-like standards (such as Georgia's GSE) would also benefit from determining teacher perceptions of inquiry regarding chemistry curriculum. The researcher did not look at degree level or education when considering whether to interview survey participants, but it would be interesting to see how background or degrees impact teaching of chemistry and other laboratory sciences.

COVID-19 caused much of the nation to shift to a virtual environment, or at the very least brought up that systems should have virtual plans in place. Some districts opted for no labs at all to prevent the spread of COVID-19 while others went face-to-face with very few restrictions. Both districts that opted for normal face-to-face school and those that chose to meet virtually have a need for innovation in how courses are being taught. Now is the time to try something new in the classroom and show students that teachers are not afraid to fail, which means they should not be afraid of it either. Shifting to virtual meetings would increase access to the remote areas where many of the participants of this study work.

Data from the current study showing over 80% of participants using inquiry in the classroom is encouraging, but that excitement must be tempered when thinking how that leaves almost 20% of participants who are not using inquiry in their classrooms. In addition, the 80% who indicated that they used inquiry may have different definitions of inquiry, even though a definition was provided in the survey. Discovering how teachers define inquiry would be a pivotal finding for future research. Teachers, schools, districts, and each state's department of education should not rest until over 90% of teachers are using inquiry and doing so in all of the areas written in the standards if each state intends for its teachers to teach the standards as written. Without a standardized test in chemistry in Georgia, studies, like the present one, are needed to check in on the teachers and to give them a voice. Understanding what is actually being done in the classroom through the words of the teachers themselves is important and identifying the needs of teachers in rural areas is part of the overall mission of providing free and adequate education to all students in the United States.

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Appendices

Appendix A.

Survey in Qualtrics

ONLINE SURVEY CONSENT FORM

Title of Research Study: Rural High School Chemistry Teachers' Views and Implementation of Inquiry-Based Laboratory Instruction as Set Forth in The Next Generation Science Standards

Researcher's Contact Information: Robert Bice, (404) 939-2423, rbice2@students.kennesaw.edu

Introduction

You are being invited to take part in a research study conducted by Robert Bice of Kennesaw State University. Before you decide to participate in this study, you should read this form and ask questions about anything that you do not understand.

Description of Project

The purpose of the study is to determine chemistry teachers' views, methods, and funding sources for teaching standards that require the scientific practice of planning and carrying out investigations within the GSE in Georgia public high schools. These new standards, the Georgia Standards of Excellence (GSE), invoke language that implies more inquiry-based instruction than previous standards have done. The aim is to discover what teacher views are of the standards, determine if they are in fact all taught during the year, resources used to teach them, methods used to teach them, and determine some consensus as to what standards may require more resources than others, if applicable. Teachers in rural areas have traditionally been overlooked. Determining the degree to which these feelings are true based on PLCs, peers, and professional development opportunities will allow the researcher a glimpse into what it means to be a chemistry teacher in a rural public high school in Georgia.

Explanation of Procedures

Participants will complete an online survey with questions based on their feelings, views, and experiences.

Time Required

10 - 15 minutes

Risks or Discomforts

There are no known risks or anticipated discomforts in this study.

Benefits

The findings from this research could benefit science education in Georgia, especially those in rural areas.

Compensation

Participants will be given the option of opting in to a drawing for one of ten \$25 Amazon gift cards. Opting in or out will not affect the results of the survey and are purely optional. Drawing to take place before results are published. Random number generator will be used to determine winners based on timestamp of completion of survey.

Confidentiality

The results of this participation will be confidential. All participants will be given a pseudonym and identifiable information such as district and school will not be provided in the results of the study so that participants are not readily identifiable from information used. Once research commences the data will be collected regularly and stored securely. All records will be kept securely for at least one year past the completion of the study. Digital audio, video, or other electronic data will be kept on site at Kennesaw State University for a period of one year past the completion of the study, when all transcriptions have been made. At that point all identifiable data (audio, video recordings) will be destroyed at that point. All non-identifiable information will be kept indefinitely in order to ask additional questions of it.

Inclusion Criteria for Participation

You must be 18 years of age or older to participate in this study.

Use of Online Survey

Data collected online will be handled in a confidential manner (identifiers will be used), but Internet Protocol addresses **WILL NOT** be collected by the survey program.

Research at Kennesaw State University that involves human participants is carried out under the oversight of an Institutional Review Board. Questions or problems regarding these activities should be addressed to the Institutional Review Board, Kennesaw State University, 585 Cobb Avenue, KH3417, Kennesaw, GA 30144-5591, (470) 578-6407.

PLEASE PRINT A COPY OF THIS CONSENT DOCUMENT FOR YOUR RECORDS, OR IF YOU DO NOT HAVE PRINT CAPABILITIES, YOU MAY CONTACT THE RESEARCHER TO OBTAIN A COPY

- I agree and give my consent to participate in this research project. I understand that participation is voluntary and that I may withdraw my consent at any time without penalty.
- I do not agree to participate and will be excluded from the remainder of the questions.

Condition: I do not agree to participa... Is Selected. Skip To: End of Survey.

22 Jan 2020 2:16pm Robert Bice Skip logic added for those who do not consent.

Part I: Demographic Information

Please enter the following information, keeping in mind your information will be kept confidential and not released as part of the results of this survey.

First name

Last name

Email address

22 Jan 2020 2:15pm Robert Bice To verify demographic information.

Hide Discussion

Add a Comment

Are you currently a teacher of high school chemistry (or have taught it in the last three years)?

Yes

No

Condition: No Is Selected. Skip To: End of Survey.

Options

22 Jan 2020 2:17pm Robert Bice Part of the requirements for participation in the study is for teachers to be currently teaching chemistry or have taught in the past three years. This also includes skip logic to remove those who do not qualify from participation in the study.

How many years have you taught chemistry throughout your career?

22 Jan 2020 2:17pm Robert Bice Establishes experience level of the teacher.

Hide Discussion

Add a Comment

What is your highest level of education?

- Bachelor's degree
- Master's degree
- Specialist degree
- Doctorate degree

22 Jan 2020 2:19pm Robert Bice Education may have an impact on a teacher's content knowledge or pedagogy.

Hide Discussion

Add a Comment

What school do you currently teach at? (please select the last school where you taught chemistry if no longer employed as a teacher)

22 Jan 2020 2:19pm Robert Bice In identifying the school the researcher can verify the demographic information of the school to ensure that it may be used in the study.

Please state whether your school is private or public.

- Public
 Private

22 Jan 2020 2:21pm Robert Bice Public education is the main focus of this study, so private school data is not preferred and will not be used in the study. However, any private school teachers who wish to participate may do so so that the data may be used in the future to inform other studies.

[Hide Discussion](#) [Add a Comment](#)

What type of schedule is utilized at your school?

- Traditional (45-60 minute periods)
 Block (w/classes lasting a full year)
 Block [w/classes lasting only a semester (4X4)]
 A mix of traditional and block

22 Jan 2020 2:22pm Robert Bice Scheduling may have an impact on activities and courses offered. This question seeks to determine how many rural schools which teach chemistry have it set up.

[Hide Discussion](#) [Add a Comment](#)

What chemistry courses do you teach or have you taught (Check all that apply):

- General (1st year) chemistry
 ChemCom/Applied chemistry
 Honors (1st year) chemistry
 AP/College Chemistry/2nd year chemistry

22 Jan 2020 2:24pm Robert Bice The realization that each course carries with it a different level of inquiry instruction and teacher involvement this question seeks to determine the mindset of the participant.

Are you teaching in a class/school where your students have access to at least one mobile device (e.g. tablet, laptop, Chromebook, etc.) to use regularly within instructions? (Check all that apply)

- Yes, most students are using their own devices or we have devices for students who don't have them.
 Yes, our school assigns devices to students for their use at school.
 Yes, our school assigns devices to students to use at school and at home.
 Yes, I can check out devices to use in my class as needed.
 No, my students do not regularly have access to mobile devices in my classroom.

22 Jan 2020 2:23pm Robert Bice Access to resources is one of the aspects being studied. If schools have access to resources for technology, but teachers are not utilizing the virtual representations, then that gives the researcher something to discuss during an interview.

[Hide Discussion](#) [Add a Comment](#)

----- Page Break -----

Part II: Inquiry

For this survey "inquiry" is defined as instruction and activities that include students planning investigations, reviewing what is already known in light of experimental evidence, using tools to gather, analyze and interpret data, and proposing answers, explanations and predictions.

22 Jan 2020 2:49pm Robert Bice This is the same definition that is used in chapters one and two. Reference found therein.

Do you use inquiry labs (activities) in your general chemistry classroom?

- Yes
 No

Condition: Yes Is Selected. Skip To: If yes, approximately what percentage...

Options

Condition: No Is Selected. Skip To: Approximately how many labs (total-1...

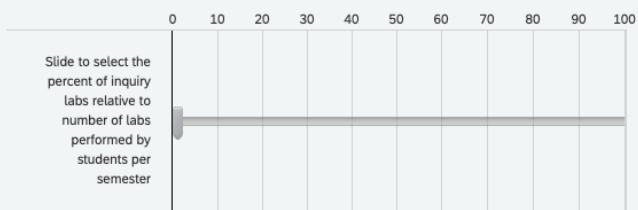
Options

22 Jan 2020 2:51pm Robert Bice If inquiry occurs, I'd like to know whether or not teachers of chemistry identify their activities as inquiry. If so, skip logic is used to proceed to ask how many are completed each semester. The number completed per semester may also correlate to the type of schedule the course is taught on.

Hide Discussion

Add a Comment

If yes, approximately what percentage of your overall labs students perform per semester would you describe as inquiry labs (activities)?



22 Jan 2020 2:51pm Robert Bice Same reasoning as previous question. Participants who chose "no" on the previous question will not see this particular question.

Approximately how many labs (total--inquiry, cookbook and everything in-between) do your general chemistry students do per semester?



22 Jan 2020 3:12pm Robert Bice Want to compare the number of labs completed in general with the number of inquiry labs to see if there is a difference.

Hide Discussion Add a Comment

Page Break

Please use the rating which best describes your inquiry teaching and learning beliefs for the following statements:

	Almost always	Often	Sometimes	Seldom	Almost never
I see myself as a facilitator in the classroom.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
My students are involved in planning their investigations (labs).	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I encourage students to use laboratory activities to explore their own questions and curiosities.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I let student interest guide my lesson planning and curriculum in the course.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I use phenomena (discrepant events) in my teaching.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

I have students design their own experiments and then carry them out.

Almost always	Often	Sometimes	Seldom	Almost never
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

22 Jan 2020 3:33pm Robert Bice The questions on this were taken and modified or condensed from the survey Inquiry Beliefs and Practices used by Jeanpierre (2006). This survey was developed and modeled after Burry-Stock's (1995) ESTEEM survey. This particular version asks more specific inquiry type questions of the participants. More data can be found during the interview stage.

Hide Discussion Add a Comment

Please use this space to voice any comments or confusion about the above questions/statements above.

Please use the rating which best describes your inquiry teaching and learning beliefs for the following statements:

	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree
Students coming up with their own labs is a critical component in the course.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I believe inquiry labs are too time consuming for the constraints of the course	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Students conducting their own experiments requires more time and resources than regular labs.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Students carrying out investigations, whether through inquiry or teacher directed, is a critical component in the course.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Please use this space to voice any comments or confusion about the above questions/statements above.

Part III: Resources and Access

Considering your career thus far, please answer based on whether you've received the following supports or experiences:

	Yes, I am currently receiving	Received in the past, but am no longer receiving	Have not received, but I'd like to	Never received	Don't know
I have received school- or district-mandated professional development.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I have received external professional development that I chose, funded by the district or school.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I have received self-directed, self-funded external professional development.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I have received professional development delivered by teachers at my own high school.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I have a lab budget explicitly stated by my department head/administration.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Show Discussion (1) Last Comment 22 Jan 2020 3:38pm by Robert Bice: Questions in this section were adapted, with some additions, from the survey instrument Teacher Perspective

Considering your career thus far, please answer based on whether you've received the following supports or experiences:

	Yes	No, but I have considered or are interested in doing so.	No, and have not considered.
I have participated in activities aimed at improving my awareness of teaching as a profession, such as membership in a professional association or teachers' association (GAE, PAGE, etc.).	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I have presented at conferences or to peer groups.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I have participated in professional learning communities/collaboration activities (NOT the PLCs required by the GaDOE) with other teachers.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Please use this space to voice any comments or confusion about the above questions/statements above.

Part IV: Perceptions

Please rate your perception of the following statements as a chemistry teacher in your school:

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
I have sufficient access to appropriate instructional materials and resources	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I have sufficient access to instructional technology, including computers, printers, software, and internet access.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The reliability and speed of Internet connections in this school are sufficient to support instructional practices.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Please select "SOMEWHAT DISAGREE"	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Teachers have a large role in deciding how lab budget will be spent.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel that I must beg for lab supplies.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Outside sources of funding are not required for laboratory activities in the general chemistry course at my school.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Inquiry-based instruction requires too much time and money (resources)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

<p>I have adequate planning time for the number preps that I teach.</p>	<input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/>
<p>Other schools seem to have more resources for activities or labs than mine.</p>	<input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/>

22 Jan 2020 3:51pm Robert Bice Ladd (2009) developed the survey where most of these questions derive. Ladd studied North Carolina teachers and their perceptions of their workplace environments. This is akin to how the participants will view their individual classrooms, resources, and inquiry-based instruction.

22 Jan 2020 3:53pm Robert Bice In addition, a measure of validity and reliability was added to have participants choose a particular answer to ensure that they are still paying attention after answer so many of the Likert-type scale questions.

[Hide Discussion](#) [Add a Comment](#)

Please use this space to voice any comments or confusion about the above questions/statements above.

Part of the research design for this project involves qualitative data from interviews. Would you be willing to help further chemistry education by participating in a confidential interview conducted virtually at your convenience? To help compensate for your time each individual selected for an interview would receive a \$25 Amazon Gift Card.

- Yes
- No

Condition: Yes Is Selected. Skip To: Please select the best method to cont....

Option

Invalid Skip Logic

Option

22 Jan 2020 3:54pm Robert Bice Skip-logic added to this question so that those not willing to participate in an interview would not be contacted again. Those that are willing will give preferred contact information on the next question.

[Hide Discussion](#) [Add a Comment](#)

Please select the best method to contact you and fill in the information.

Email

Phone

[Click here to edit form fields](#)

22 Jan 2020 3:55pm Robert Bice Preferred contact method of participant for interview purposes. Used for trustworthiness in case participants did not want to use their own school email addresses in fear of retribution regarding results of the research identifying them.

[Hide Discussion](#) [Add a Comment](#)

If you have any questions or comments about any aspect of the survey you've just completed, then please comment below:

22 Jan 2020 3:56pm Robert Bice Participants allowed to input any questions or concerns here to make sure that there is a space for it. This will allow them to voice these to the researcher.

[Hide Discussion](#) [Add a Comment](#)

Continue to the next page to opt in to the Amazon gift card giveaway.

----- Page Break -----

OPTIONAL: Would like your name entered into a drawing for one of ten Amazon gift cards (\$25 value each)? Select the appropriate response below

- Yes
 No

Condition: No Is Selected. Skip To: End of Survey.

Options

Condition: Yes Is Selected. Skip To: Please enter your email below to be e...

Options

22 Jan 2020 3:58pm Robert Bice Completely optional, the drawing is only for those who have reached this stage, with forced responses on the main survey questions prior. Those desiring it will be placed into a drawing for these once the survey has closed. The contacting of the participants may also help when contacting them for possible interviews.

Please enter your email below to be entered into the drawing.

22 Jan 2020 3:59pm Robert Bice Some districts may have policies about receiving funds. This allows participants to use a personal email to enter such drawings without fear of district or school punishment.

Appendix B.

IRB Approval

Study 19-596: Teacher Views of and Methods Used to Teach Resource-Heavy Standards in High School Chemistry in Georgia irb@kennesaw.edu

<irb@kennesaw.edu>

Thu 2/13/2020 9 42 AM

To: Robert Bice <rbice2@students.kennesaw.edu>

Cc: irb <irb@kennesaw.edu>

2/12/2020

Robert Bice

RE: Your application dated 6/26/2019, Study number 19-596: Teacher Views of and Methods Used to Teach Resource-Heavy Standards in High School Chemistry in Georgia

Hello Bice,

I have reviewed your application for revision of the study listed above. The requested revision involves changes to the protocol. Your request is eligible for exempt review under FDA and DHHS (OHRP) regulations.

This is to confirm that I have approved your request for revision as follows:

Recorded interviews with teachers that will be coded and used to determine survey questions to ask in the future to determine chemistry teachers' views, methods, and funding sources for teaching standards.

2/07/2020: adding a survey element to increase participation.

You are granted permission to conduct your study as revised effective immediately. The date for continuing review remains unchanged.

Please note that any further changes to the study must be promptly reported and approved. Contact the IRB at irb@kennesaw.edu or at (470) 578-6407 if you have any questions or require further information.

Sincerely,

Christine Ziegler, Ph.D.

- KSU Institutional Review Board, Director of Human Subjects

Research cc: klinenbe@kennesaw.edu

Appendix C.

Interview Guide

Date: _____ Interview #: _____ Time: _____

1. **Script: Welcome and thank you for your willingness to participate in research regarding chemistry education in the state of Georgia. I wanted to start off by stating that this interview will be recorded for the purposes of information and development of a future instrument for educational research. Your name and information will not be used in any way for the development of the instrument. Everything you say will remain confidential. My name is Robert Bice, and I am conducting this research on behalf of Kennesaw State University for the purpose of discovering more about the views of high school chemistry teachers on the inquiry-based standards that exist as part of the GSE, which is the topic of my doctoral dissertation. First, would you please state your name, school currently employed at, and years of experience teaching chemistry?**

(NEED INITIAL INFORMATION TO MAKE SURE I AM TALKING TO THE CORRECT PERSON AND ESTABLISH A RELATIONSHIP WITH THE INTERVIEWEE)

2. Name: _____

3. School: _____

4. Years of Chemistry Teaching Experience: _____

(WANT TO DIFFERENTIATE BETWEEN A FEW YEARS AND MANY YEARS OF EXPERIENCE IN CASE THERE IS A DIFFERENCE IN OPINIONS AND IDEAS)

5. **Script: First, I'd like I'd like to talk about you as a teacher now. How would you describe your teaching style?**

(RQ2: Building rapport and listening for points discussed to jump into other topics related to RQs)

6. Notes: _____

7. Script: **Can you describe your background and how you got into teaching? I want to know your story and how you came to be who you are today with respect to teaching chemistry.**

(RQ1: DEVELOP RAPPORT AND DETERMINE MOTIVATIONS FOR TEACHING. MIGHT INFLUENCE ABILITY TO ADAPT OR REAL-WORLD APPLICATION)

8. *Script:* **For the purposes of this study, a rural school is defined as a school in a town or rural area. What this means is that it is an area that ranges from being smaller than a suburb (100,000 people) to a place that is more than 25 miles from a city. Have you always taught in rural schools? Can you describe the socio-economic status of the majority of your students without revealing personal information about them?**

(RQ1 and RQ3: DETERMINE DIFFERENCES AND SIMILARITIES IN RURAL SCHOOLS)

9. Notes: _____

10. Script: If you've been teaching for three or more years, what are your views on the new GSE for chemistry versus the GPS?

(RQ1: WANT OPINION ON DIFFERENCE BETWEEN MORE INQUIRY IN THE GSE VS THE CONTENT AND HABITS OF MIND IN THE GPS. ONLY ASK IF TEACHING LONG ENOUGH TO HAVE ACTUALLY TAUGHT UNDER THE GPS)

11. Notes: _____

12. Script: (If taught both the GPS and GSE then ask) Inquiry-based instruction is defined as “a student-centered approach where the instructor guides the students through questions posed, methods designed, and data interpreted by the students. Through inquiry, students actively discover information to support their investigations.” Have you noticed a change in the standards with regard to inquiry and inquiry-based instruction? Do the old or new standards emphasize inquiry more, the same or do neither emphasize it?

(RQ2: DEFINING INQUIRY AND DETERMINING IF A DIFFERENCE EXISTS IN THE MINDS OF TEACHERS WITH MORE EXPERIENCE TEACHING IN A PUBLIC-SCHOOL SETTING IN GEORGIA)

- 13. Script: There are many standards or elements that, as a chemistry teacher, I've observed as requiring lots of chemicals, lab supplies, and/or technology to teach. Are there any topics or standards that you find require a significant portion of your lab budget? What are your methods for teaching these topics? Where do the funds for these lab supplies come from?**

(RQ2 and RQ3: DETERMINE WHICH STANDARDS THE TEACHER FINDS TO REQUIRE RESOURCES OR SUPPLIES. WANT TO ENSURE I WAS NOT BIASED IN JUST WANT I THOUGHT WERE IMPORTANT OR REQUIRING INQUIRY-BASED INSTRUCTION)

- 14. Script: Do you teach these inquiry-based standards or elements as written to your students?**
- a. If so, with what frequency do you do so? Every year, only when you have time, etc.?**
 - b. If not, why do you skip these?**

(RQ1 and RQ2: ENSURING THAT THE TEACHER DOES IN FACT TEACH THESE STANDARDS)

- 15. How do you teach or get across information regarding these inquiry-based standards or elements?**

(RQ2: REALLY NEED THE TEACHER'S INPUT ON WHAT HE OR SHE DOES TO GET ACROSS THE INFORMATION TO THE STUDENTS. NEED TO KNOW ITEMS THAT MAY BE REQUIRED TO IMPART UNDERSTANDING)

16. Script: **How do you teach or get across information regarding standards that instruct students to “plan and carry out an investigation...”?**

(RQ2: GETTING TO THE HEART OF WHAT I'M LOOKING FOR. METHODS OF TEACHING THE STANDARDS/ELEMENTS IN QUESTION. SPECIFIC METHODS IN DETAIL. HOW THE ACTIVITIES ARE CARRIED OUT. LEADS INTO A RESOURCE QUESTION NEXT)

- a. **What I mean is, are students involved in inquiry? Is there a specific lab you give them?**
- b. **Do students have complete or limited autonomy about how to plan and carry out investigations?**

Up to this point we have discussed your views of the GSE and how you enact them in your classroom. Now I would like to discuss the resources you are provided as a chemistry teacher to be able to teach these standards.

17. Script: **What sort of budget do you have for supplies for your classroom? Is this just for chemistry or do you have to share this among your other courses taught? Does everyone in your department get this amount to spend on supplies?**

(RQ3: RESOURCE QUESTION. IF NO RESOURCES WHERE DO THEY COME FROM? WANT TO KNOW HOW TEACHERS GET WHAT THEY NEED TO TEACH THE STANDARDS)

18. Notes: _____

19. *Script:* **Has lack of resources available ever hindered activities you wanted to do in class or planned to do? Can you describe how that made you feel, if so? What did you do about it?**

(RQ2 and RQ3: WANT TO KNOW IF ACTIVITIES SKIPPED OR STUDENT EDUCATION SUFFERED AS A RESULT OF A LACK OF RESOURCES)

20. Notes: _____

21. *Script:* **If obtaining resources have been an issue, have you ever sought out additional funding sources as a rural teacher to teach the lab-based standards? What sorts of additional funding sources have you attempted to get? Can you describe your experience with them? Please mention both successes and failures.**

a. **How about resources for professional development? Conferences?**

(RQ3: HOW OFTEN DO RURAL TEACHERS SEEK OUTSIDE FUNDING OR FEEL FORCED TO DO SO)

22. Notes: _____

23. *Script:* **Do you have business or industry near your school that has partnered with your school to provide speakers, internships, or equipment that would aide in teaching chemistry?**

(RQ3: SOME RURAL SCHOOLS MIGHT HAVE AN EASIER PATH TO PROVIDING RESOURCES BY PARTNERING WITH AN INDUSTRY. COULD BE A POSSIBLE SOLUTION TO MONEY ISSUES WITHIN A ROOM, SCHOOL, OR DISTRICT)

24. Notes: _____

- 25. Script: What are some areas of strength a rural high school may have over an urban or suburban school with regards to chemistry? What are some struggles that you have with teaching chemistry in a rural high school?**

(RQ1, RQ2, & RQ3: CURIOUS ABOUT TEACHER VIEWS ON RURAL EDUCATION VS OTHER TYPES IF A COMPARISON CAN BE MADE BY THE EDUCATOR)

26. Notes: _____

We've discussed the standards, your views and methods of teaching them, and resources that you use to teach them. Now, I'd like to switch gears and think about your professional development you receive or seek out as a chemistry educator.

- 27. Script: Can you describe the number of teachers in your department who also teach chemistry? Have any of them ever taught it?**

(RQ3: ISOLATION? MOST RURAL SCHOOLS HAVE LOW NUMBERS OF TEACHERS AS THEY ARE SMALLER. ONLY ONE CHEMISTRY TEACHER IN A SCHOOL HAS AN EFFECT ON THE IDEAS AND LABS USED IN THE CLASSROOM, SO I'VE HEARD.)

28. Notes: _____

- 29. Are you part of a chemistry professional learning committee (PLC)?**

- a. If so, can you identify which ones you are part of?**
- b. Can you describe whether you feel that it has helped you as a teacher?**

(RQ3: WANT TO SEE HOW EFFECTIVE PLCS ARE AT BRIDGING THIS GAP IN KNOWLEDGE FOR RURAL TEACHERS)

Notes: _____

30. *Script:* **How would you describe the professional development you receive as a high school chemistry teacher? Does your administration fund local, in-state, or national PD? Can you describe the types of PD you receive? Do you find the PD beneficial to teaching chemistry, specifically?**

(RQ3: SOME DISTRICTS DO NOT SUPPORT THEIR TEACHERS WITH MONEY FOR PD, WHICH IS NEEDED TO HELP COME UP WITH IDEAS. ESPECIALLY NEEDED IF NO OTHER CHEMISTRY TEACHERS NEARBY OR IN THE DEPARTMENT. HOPE TO DETERMINE IF THIS IS TRUE AT ALL SCHOOLS OR DISTRICTS.)

31. Notes: _____

32. *Script:* **What do you think can be done to improve the quality and quantity of PD for rural chemistry teachers in Georgia?**

(RQ1 AND RQ3: WANT TO KNOW HOW TO IMPROVE CHEMISTRY EDUCATION PD IN GEORGIA BASED ON TEACHER VIEWS)

33. Notes: _____

34. *Script:* **Thank you very much for your willingness to speak to me today. I know that your time as a teacher is very valuable, but I wanted to stress how much praise I have for you and the work you are doing in rural education and for the lives of the students with whom you come into contact. Is there anything that you would like to add?**

(CLOSING AND ANY FINAL INFORMATION THAT THE TEACHER MAY FIND IMPORTANT.)

35. Notes: _____

Appendix D.**Codebook**

Hierarchical Node	Node	Definition
Experience	0-5 Years	Participant mentioned having taught in the classroom for 0-5 years overall or at one particular school.
	6-10 Years	Participant mentioned having taught in the classroom for 6-10 years overall or at one particular school.
	11-20 years	Participant mentioned having taught in the classroom for 11-20 years overall or at one particular school.
	20+ years	Participant mentioned having taught in the classroom for 20+ years overall or at one particular school.
	Industry	Participant stated having worked in industry for some amount of time. Example: worked for a chemical company.
	Laboratory Experience	Participant discussed or mentioned having previous laboratory experience in industry or in college. Example: worked in a lab before teaching.
	Life Experience	Life experience outside of teaching was mentioned by the participant. Example: growing up on a farm.
	Other Experience	Experience not specifically coded for was mentioned by the participant. Example: Parent was a teacher or a hobby that related to teaching.
	Multiple Schools	Participant mentioned having worked in multiple schools. Example: Worked

		at school A for 3 years and then moved and worked at school B.
	Multiple Districts	Participant mentioned having worked in multiple districts Example: changed states because we moved or changed districts due to X reason.
	Multiple States	Participant mentioned having worked in multiple states Example: I started working in Arizona and then moved to Virginia.
	Switched Career	Participant stated having had a previous career before becoming a teacher. Example: may have gone through alternative certification program or currently going through the program.
	Private School	Participant stated having worked at a private school or brought up the topic in general. Example: compared private to public or mentioned working at a private school.
Mentor	Co-Worker as Mentor	Participant stated or implied that a co-worker served as a mentor in some way. Example: could be a past coworker or current.
	Previous Teacher as Mentor	Participant stated or implied that a previous teacher or professor served as a mentor in some way. Example: high school teacher stood out to him or her.
	Other Mentor	Participant stated or implied that a mentor existed in another form. Example: an administrator or parent was a mentor.

	Dynamic Science Teacher as Student	Participant stated or implied that having a dynamic teacher when he/she was a student helped to serve as a mentor for his/her own teaching career. Example: college professor or high school teacher that instilled a love for learning, science, or inquiry.
Resources/Money	School/District Funded	Participant list schools or districts when it comes to funding or money. Example: my school makes sure that I have plenty of resources.
	State Funded	Participant bring up the idea of the state funding something. Example: if the state could provide us with lab ideas, or kits for take home labs, it would be great.
	Teacher Self-Funded	Participant mentions spending his or her own money on supplies. Example: it takes three weeks to get a purchase order approved so I just go buy the stuff I need from Target.
	Grants	Participant makes mention of grants, whether local, state, or national. Example: there's a guy in our department who is great at writing these things, but I just do not have the time right now.
	Community/Business Funded	Participant describes how community organizations or businesses funded certain supplies for their students or classroom. Example: the churches in our area have closets for teachers and students for classroom supplies and backpacks and such.
	Donation	Participant in some way describes a donation given to the school or a

		particular classroom. Example: we send out donation letters with the students and try to collect an optional lab fee.
	Equipment Repair	Participant makes mention of equipment and repairs needed. Example: we bought all of the pH probes but didn't buy the solution to keep them in so they need to be repaired now and I do not have time for that.
	Technology	Participant in some way makes mention to technology, whether computers, cell phones, or laboratory equipment. Example: I would love for my students to be able to do this lab, but we just don't have the microscopes for it.
	Request for Supplies	Participant in some way describes a request for supplies. Example: I put in my request to my department head who always comes back and asks me to trim it down even more.
	Money	Participant make specific reference to money. Example: we just don't have the money for that.
	Resources	Participant describes resources, whether they be supplies, money, or manpower. Example: resources are definitely limited here.
	Fundraisers	Participant describes current or past fundraisers and attempt to get money for science supplies. Example: I sold candy to get all of this lab equipment.
Support	PD/Training	Participant describes professional development or training in general.

		Example: our district has professional development over the summer.
	Specialized PD	Participant described makes mention of specialized professional development in a particular content area. Example: I really need chemistry or inquiry training.
	Relevant PD	Participant makes mention of professional development or training that would be relevant to some topic as part of their narrative. Example: none of the training I received this past year was relevant to me or what I teach.
	Lab PD	Participant describes the need for laboratory specific professional development. Example: most teachers walk into a lab and have no idea what some of the equipment is or how to use it. We need more training in that sort of thing.
	Autonomy/Lack of in PD	Participant makes mention of having choice in the professional development. Example: everyone had to go to that and it was a waste of time.
	General Lack of PD	Participant describes lack of professional development received. Example: I have not been involved with PD in years, besides required PD.
	Generic PD	Participant describes the professional development as lacking any specification at all. Example: we learned about differentiation once a year for the past three years.

	PLC	Just spent makes mention of their professional learning community. Example: we get together for those PLC groups every two weeks.
	Multiple Chemistry Teachers	Participant describes there being more than one chemistry teacher at a particular school. Example: both of us teach chemistry, but he gets all of the honors kids.
	Isolation/Feelings of Being Alone as Teacher	Participant explicitly mention or implies that they are isolated or feel like they are alone in teaching their content. Example: I am the only chemistry teacher at this school and no one else here as ever taught it.
	Parental Support/Involvement	Participant describes or mentions parental support or involvement in regard to general support in chemistry course. Example: the parents of all of my kids are great and make sure we have whatever we need in class.
	Sharing/Communicating with Other Teachers	Participant describes how sharing communicating with other teachers makes them feel supported. Example: the chemistry Facebook group has saved my life more than once.
	Support from Administration	Dissipate describes the support received from their administration. Example: having a principal whose kid went through my class really helps because he understands how I teach and run my class.
	Support from Department	Participant describes the support received from their science department. Example: the other

		members of the department all come together and work as a team.
	Support from Other Teachers/PLC	Participant describes support received from other teachers or from their professional learning community as a means of feeling supported. Example: I could not have made it with the help of Mrs. X.
	Support from State/District/School	Participant makes mention of support from the school, district, or state as a means of feeling supported. Example: I really felt like the school had my back on this issue.
	Few Teachers/Substitutes	Participant makes mention of the fact that they are very few teachers or substitutes even if the teacher desired to take time off. Example: I really wanted to go to that conference, but I could not find a sub or the school could not send all of us at one time.
	Common Planning/Lack of	Participant describes or makes mention of lack of a planning. In general or lack of common planning with other science teachers. Example: we had common planning two years ago, but this new superintendent wanted to change the schedule so now I never see the other department members unless there's an emergency.
	Multiple Preps	Participant brings up teaching multiple courses in the span of a year. Example: I taught four preps that year.
	Autonomy in Teaching/Content/Curriculum	Participant makes mention of autonomy or choice in their teaching or content as a means of support. Example: when I wanted to try X I

		was allowed to because I earned support through the years.
Laboratory Experiments or Investigations	Virtual Labs	Participant states that some of the lab experiments are virtual ones or simulations that could be completed online. Example: I use PhETs to complete that standard.
	Lab Experiments or Investigations	Punishment makes mention of anything having to do with a lab experiment or investigation, which would be considered a hands-on activity. Example: I have my students complete this lab in stations.
	Teacher Guided Labs	Participant describes or makes mention of labs or activities given to students to perform as being teacher guided. This means that the teacher may give them instructions, or the teacher may provide some structure in the process. Example: The students had the labs but must gather materials and set things up on their own.
	Lab Budget	Any mention of lab budget. Example: I do not know my school's lab budget.
	Lab Supplies	Participate in some way describes lab supplies or those supplies needed to perform laboratory experiments. Example: I must put in a purchase order to get what I need for this lab or that lab.
	Lab Technique	Participant brings up lab technique as part of their narrative, which includes how labs are performed, either by students or teachers. Example: by the end of the semester my students can

		light a Bunsen burner, set up a filtration device, etc.
	Lack of Prior Knowledge	Participant makes mention of lack of prior knowledge with regard to laboratory experiments, either in the students or the teacher. Example: I just do not feel comfortable because I do not really know what I am doing in lab.
	Demos	Participant makes mention of laboratory experiment or demonstrations which are experiments done in front of the class as a large group by the teacher. Example: I do the flame test lab as a demo so that no one gets hurt.
	Few Labs	Participant describes or explicitly states that very few labs were done, whether in the past or present. Example: I did not do many labs with this year's group because COVID happened.
	Kitchen Chemistry	Participant makes mention of kitchen chemistry or using household products to perform laboratory experiments. Example: I will run to Walmart and grab lab supplies.
	Lack of Return from Labs	Participant describes how the amount of knowledge gained from the lab doesn't equate to the time or resources put into the lab. Example: I set this all up, but I do not have time to grade it in time and then my students do not get back what they need from it.
	Large Class Size	Participant makes mention of class-size particularly large class size as

		impacting the ability to do labs. Example: my classes went from 26 to 34 students, which makes doing labs a nightmare.
	Lab Safety Issues	Participant list safety as an issue when it comes to doing labs in the course. Example: I do not like my students messing with fire because it scares me.
	Lab as Culminating Activity	Participant makes mention of using lab as a culminating activity within the unit. Example: After we test I like to let them experiment with the concepts to see how them at work.
	Lack of Connection by Students	Participant brings up a lack of connection by students between labs and the coursework. Example: they just do not get what the lab is trying to convey so why do it at all?
	PCOI	Mention of students either planning or carrying out an investigation. Example: four labs in the course I have my students actually plan out what they are going to do.
	Inquiry	Participant makes explicit mention of inquiry or describes inquiry when it comes to laboratory experiments in the course. Example: I want my students to find the answer for themselves and discover the meaning in lab.
	Lack of Curiosity	Participant states that a lack of curiosity on the part of the students affects laboratory experiments. Example: they do not care about doing it and just want the right answers.

	Lack of Time	Participant brings up lack of time when it comes to laboratory experiments. Example: we just do not have enough time to get to that.
Standards	Phenomena	Participant makes mention of phenomena as part of teaching the chemistry course. Example: I start off each unit with a phenomenon.
	Standards	Participant explicitly states or allude to standards, whether GSE or NGSS. Example: you know these standards that we have to teach...
	Curriculum as Big Ideas	Participant makes mention of their curriculum or standards as a group together in big ideas. Example: our department went through all of the standards and grouped them into X big ideas that we use to teach and test the students on.
	Power Standards	Participant specifically points out that certain standards are used more or are focused on more in their course. Example: you know that stoichiometry and balancing equations are used to much in college and I make sure to focus on those, but do not focus on electrochemistry as much.
	GSE vs. GPS	Participant discusses in some way the difference between the old and new standards, whether that be through language or expectations. Example: the new standards really force the students to be active participants in their learning.

	High-Stakes Testing/EOC/Standardized Test	Participant brings up standardized testing in some form. Example: you know we lose weeks in the spring due to these state tests that they have to take.
Factors Affecting Instruction/Education	Single Parent Home/Broken Home	Participant brings up students coming from single-parent homes or broken homes. Example: the amount of students coming from homes with just one parent or no parents at home is so much higher than you would believe.
	SpEd	Participant brings up special education, IEPs, or 504s as part of the discussion. Example: in the same class I have kids who have accommodations, some that are gifted without accommodations, and others with an IQ of 60.
	Schedule: Period vs. Block	Participant makes mention of their schedule or how the scheduling has impacted things that they do. Example: I used to do more labs when I was on block, but I barely have time to think on periods.
	Student Apathy	Participant brings up or mention student apathy or the lack of care or motivation that they see in students. Example: I spend so much time working up labs and coming up with activities, but they just do not care.
	Student Misbehavior	Participants list student misbehavior whether in lab or class as a factor affecting their education. Example: I used to have this density lab, but students kept stealing parts of it that I just stopped doing it.

	Support from Administration	Participants discuss the support received from administration. Example: they support me in what I want to do in the classroom.
	Support from Department	Participant discusses the science department and the support given to each other within that context. Example: my department comes together each week and makes plans about how to improve student learning.
	Support from Other Teachers/PLC	Participant brings up other teachers and support received. Example: I just do not know how I would have made it without X to help me.
	Support from State/District/School	Participant mentions the support received from his or her school, district, or state. Example: my district has never denied a request I put in for X.
	Teacher Anxiety/Stress	Participant either explicitly mentions teacher anxiety or stress or their narrative is one that the researcher senses the anxiety or stress and what is being told. Example: I am just struggling to keep my head above water.
	Validation from Students	Participant mentions students talking about the course years after or students liking a particular activity as impacting education in their chemistry course. Example: my students loved doing this activity, so I try to use it each unit to give them something they like with each new unit.
	Poverty	Participant makes mention of the school, students, or community as

		being impoverished or lacking in money. Example: some of the conditions these kids live in would scare you; it's bad.
	Racial Divide	Participant mentions race or ethnicity when it comes to students or the tension between different races. Example: we had poor blacks with rich whites and it just was not a good mix. The tension was so high every day.
	Math Skills Lacking	Participant lists the lack of math skills in their students or lack of prior knowledge in math as being an impacting factor upon their education. Example: I do not know what these kids learned in middle school or their high school math classes, but they seem to know nothing when they get to me.
	More than School / Life Issues	Participant brings up the topic of caring for the students and their well-being more than the chemistry content in the course. Example: they cannot learn this material unless they are fed, cared for, and know that this is a safe space for them.
	Motivation	Participant makes mention of motivation whether in teachers or students as a factor impacting education. Example: my students were so excited to learn X that we just kept going with it.
	Relationships	Participant explicitly states or implies through their narrative that relationships with students and the bond developed in the course impacts

		education. Example: my students know I care about them and they act in a way that shows me they care as well.
	Relate to Students	Participant discusses relating the content to students or relating particularly to them in their situations as impacting the education of the chemistry course. Example: I try to bring up relevant YouTube videos or songs so that I can make it apply to their worldview.
	Chemistry as a Required Course	Participant explicitly states or implies that chemistry being a required course in their school in some way impacts how students view the course or in how the teacher has to teach it. Example: since every 11th grader has to take this we get many students who probably should not take it based on their interests or skill level.
	Appreciation	Participant makes mention of the appreciation for the course or for activities done within the course as being a factor that impacts education. Example: they are just so happy that someone is doing labs with them.
Place-Based Education	Place-Based Education	Participant brings up the location of their school as somehow influencing education. Example: my school has great support even though there is not much industry here.
	Rural vs. Urban/Suburban	Participant explicitly brings up or implies that there is somehow a difference between the rural school that they are currently teaching at and urban or suburban schools that they

		may or may not have thought out in the past. Example: at my previous school we had fully stocked labs and four other science teachers, but it was in a wealthy suburb of Atlanta. Now, here in X we have two science teachers and my lab is rarely ever stocked.
	Teacher Pay/Salary	Participant brings up teacher pay or salary in any regard. Example: we don't even get a local supplement at X school.
	Trouble Finding Science Teachers	Participant makes reference to difficulties in rural schools in finding science teachers. Example: my school had to hire back a teacher who retired because we could not find anyone for the position.
	Lack of Rural Internet Access	Participant explicitly states or implies lack of appropriate or adequate Internet access in rural areas. Example: I live in a nice area here in X, but our Internet is satellite and stops working when the wind blows, or a light rain comes through.
	Long Bus Routes for Rural	Purchase makes reference to or mentions the length of time students in rural counties or school district spend on buses to get to school or back from school. Example: some of these kids are on buses at 6:15 or 6:30 to get to school by 7:30 and that is just a long time for these kids.
	Equity/Inequity	Participant mentions or implies there being an equity issue with something related to their students or schools. Example: schools like X can do this

		activity because their students have Internet access or lab kits to take home, whereas mine do not have these things so they cannot do the activities and fall behind.
Teacher Methods	Spiral/Cumulative	Participant brought up spiraling the curriculum or mentioned the course being cumulative in their discussion. Example: each unit we cover X, Y and Z and make sure to come back around to things learned at the beginning.
	Storyline	Participant brings up storylines as a topic in chemistry or mentions it as part of another curriculum. Example: I wish someone had storylines in chemistry.
	Student Centered	As part of the discussion either the participant explicitly mentions being student centered or their narrative is deemed as being student centered by the researcher. Example: students are given autonomy in class or the teacher is seen as a facilitator.
	Teacher Centered	As part of the discussion either the participant explicitly mentions being teacher centered or their narrative is deemed as being teacher centered by the researcher. Example: students are given instructions for lab and then carry them out. Little deviation is normal on the part of the students.
	Struggle, Try, Fail for Science	Participant discusses students having to struggle or try or even fail for science to be learned as a method of teaching science. Example: students are not used to failing or struggling so this content can really get them, but it

		is good for them to actually learn the science.
	Shift in Teaching Style	Participant mentions the teaching style now versus when they first started or a shift in how they teach versus how they were taught or even how they are teaching now versus how they want to teach. Example: I am more student-centered now, but I used to be more teacher centered.
	Science as a Foreign Language	Participant brings up having to learn terms in science or understand words and the thinking behind chemistry almost as if learning a foreign language. Example: students have to relearn what terms like hypothesis and theory are in science versus how they are used in everyday speech.
	Hands-on	Participants mention their class as being hands-on or an activity as being hands-on where students are engaged in manipulating objects or being active in their learning. Example: we use stations and really want the students to get their hands on the equipment.
	Virtual Learning	Participants bring up teaching students virtually whether that be through labs or videos or a flipped classroom. Example: making videos for students to help them understand or giving them online labs to work through.
	Focus on Basics	Participant brings up or implies that one of their methods of teaching chemistry is to focus on the basics of chemistry. Example: students can't learn about complex chemistry

		concepts unless they know simple terms and lab equipment with their uses.
	Practical Chemistry	Participant brings up practical chemistry or the application of chemistry in everyday life as being an influence for their methods or goal of their methods. Example: I want students to be able to use the material they learn here for whatever else they decide to do in life.
	Preparation for College Chemistry	Participant brings up preparation for college chemistry when discussing their methods. Example: I teach it to them this way because this is what they will get when they go off to college.
	Sharing/Communication SciMethod	Participant discusses sharing and or communication to the scientific method as being one of their goals in the course or methods of teaching the chemistry content. Example: students must share out after each lab to communicate properly what they have learned.
	Literacy/Vocabulary/Reading	Participant explicitly states or alludes to chemistry content with regard to literacy vocabulary and reading, whether that be a deficit mindset of the students or one of the goals that they are trying to achieve. Example: I start off with vocabulary because they need to know terms before I can teach them anything else.
	Measurements	Participants listed measurement as being a student activity or as prior knowledge as students need to have

		for their class or as a motivation for their methods. Example: students measuring is a skill they do not come to me with.
	Chunking Strategy	Participants listed chunking or breaking material up into sections to allow for greater student understanding of the content. Example: splitting the class up into big ideas or power standards helps my students compartmentalize some of the difficult sections.
	Calculator Instruction	Participant listed calculator instruction as being part of their curriculum or that students needed calculator instruction to be able to understand how to mathematically solve problems and understand concepts within the course. Example: I have whole sections and weeks devoted to using calculators in class.
	Construct Argument	Participant mentioned students constructing arguments as being an important aspect of the course or listed this is being a goal to which the methods for the course for designed. Example: I make sure students can construct arguments based on evidence in my class.
	Discussions	Participant listed or mentioned discussions as being a factor in the class war in labs and influencing the methods being taught. Example: X didn't work out the way we expected in lab, so we discussed it.
	Non-College Bound Students	Participants discussed or mentioned teaching methods being influenced by

		the number of students not attending college. Example: we do not cover that concept because I want my students to focus on things they will have in life or in their job since most of my students do not go on to college.
	College Bound	Participant mentioned students going to college as a reason for covering material or focusing on certain concepts. Example: covering balancing reactions will help them during those first two months of college chemistry, which can be stressful to students.
	Consistency	Participant mentioned or implied that teaching methods were influenced by or there to promote consistency for their students. Example: students need consistency, so I teach this way to give it to them.
	Meeting Needs of Students	Participant mentioned or implied meeting the needs of the students as influence teaching methods. Example: may have mentioned review or bolstering prior knowledge.
	Application of Material	Participant mentioned application of material guiding their teaching methods. Example: I spend most of my time on X because they will need this when they are working in their jobs or dying their hair.
	Encourage Women in STEAM	Mentioned encouraging women in STEAM careers as influencing teaching and motivation. Example: I want these girls to see that a woman

		can work in a mostly male-dominated field and I try to empower them.
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Appendix E.

Interview Consent Form

SIGNED CONSENT FORM

Title of Research Study: Rural High School Chemistry Teachers' Views and Implementation of Inquiry-Based Laboratory Instruction as Set Forth in The Next Generation Science Standards

Researcher's Contact Information: Robert Bice, (404) 939-2423,
rbice2@students.kennesaw.edu

Introduction

You are being invited to take part in a research study conducted by Robert Bice of Kennesaw State University. Before you decide to participate in this study, you should read this form and ask questions about anything that you do not understand.

Description of Project

The purpose of the study is to determine chemistry teachers' views, methods, and funding sources for teaching standards that seem to imply using more resources than previous standards in Georgia public high schools.

Explanation of Procedures

During an audio recorded interview, participants will be asked to describe your views and methods of teaching resource-heavy standards in a Georgia public high school chemistry classroom.

Time Required

The interview should take no longer than 1 hour.

Risks or Discomforts

There are no known risks or anticipated discomforts in this study.

Benefits

An honorarium of \$25 in the form of an Amazon gift certificate will be awarded to those who complete the interview. In addition, the researcher will learn more about how chemistry standards are being implemented in Georgia. Participants may realize that they may or may not be focusing on certain elements and standards in teaching and may decide to include those in the future or seek funding for interesting activities to be done.

Compensation

An honorarium of \$25 in the form of an Amazon gift certificate will be awarded to those who complete the interview.

Confidentiality

The results of this participation will be confidential. All participants will be given a pseudonym and identifiable information such as district and school will not be provided so that they are not identifiable from information used.

Inclusion Criteria for Participation

Participants must be a teacher who has taught chemistry within the last year at a rural high school in Georgia who is at least 18 years of age.

Signed Consent

I agree and give my consent to participate in this research project. I understand that participation is voluntary and that I may withdraw my consent at any time without penalty.

Signature of Participant or Authorized Representative, Date

Signature of Investigator, Date

PLEASE SIGN BOTH COPIES OF THIS FORM, KEEP ONE AND RETURN THE OTHER
TO THE INVESTIGATOR

Research at Kennesaw State University that involves human participants is carried out under the oversight of an Institutional Review Board. Questions or problems regarding these activities should be addressed to the Institutional Review Board, Kennesaw State University, 585 Cobb Avenue, KH3417, Kennesaw, GA 30144-5591, (470) 578-6407.

Appendix F.**Audit Trail**

Month	Action	Details
February	IRB Approval and Survey Distribution	Began passing out information at the GSTA Conference in Columbus, Georgia
March	Continued Survey Distribution	Utilized social media and network contacts to send survey out to as many Georgia rural teachers as possible.
April	Survey continued. Interview participants purposefully sampled and contacted.	In order to try and reach as many rural public high schools as possible the survey remained open. Interview participants were contacted, and just a few interviews set up.
May	Survey closed. Interview participants purposefully sampled and contacted.	Number of participants eclipsed 170 and decision was made to close survey and complete the drawing. Some participants cancelled and others had to be selected and contacted.
June	Interviews ended after the eighth.	Interviews reached a saturation point in the data.