Examining the Influence of a PLC-based Intervention on the Local Adoption of the New Pennsylvania Science Standards via the Concerns Based Adoption Model

by

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ABSTRACT

The Pennsylvania Department of Education recently adopted the new academic standards for Science, Technology & Engineering, and Environmental Literacy and Sustainability (STEELS). Scaling STEELS across the commonwealth is a challenging endeavor that depends upon local school districts' implementation of STEELS-based instruction. Therefore, it behooves local school districts to develop strategies supporting local STEELS adoption. The current action research study examined the influence of an intervention built around a Professional Learning Community (PLC) to support a local school district's implementation of STEELS guided by the Concerns Based Adoption Model (CBAM; Hall & Hord, 2020). Four secondary science teachers from the Bellwood-Antis School District participated in a PLC. The implementation process of the PLC group was measured via the three diagnostic dimensions of CBAM: Innovation Configurations (IC), Stages of Concern (SoC), and Levels of Use (LoU). A concurrent mixed-methods action research design was employed to collect and analyze CBAM measures. The SoC dimension was measured quantitatively via the Stages of Concern Questionnaire. Individual scores were converted to a whole-group PLC SoC Profile for analysis. SoC, LoU, and IC dimensions were assessed qualitatively via semi-structured interviews. Meta-inferences were developed from combined data analysis of quantitative and qualitative data. A CBAM diagnosis for the PLC group was the primary outcome of this action research cycle, which indicated that the PLC members moved into the early phases of implementation during the intervention. Findings from the current cycle of action research informed an updated intervention game plan to be used in the next phase of implementation.

DEDICATION

To the greatest teachers in my life:

My daughter, Payton

My son, Niels

My wife, Allura

My mother, Mary Lou

My sister, Cindy

My aunt, Karen

You have taught me the meaning of compassion, kindness, and virtue.

All the goodness in me is because of you.

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STUDY CONTEXT AND PROBLEM OF PRACTICE

Ideas are easy. Implementation is hard.

—Guy Kawasaki, *Forbes*

Introduction

During the summer of 2020, I served on the Pennsylvania Science Standards Writing Committee to write the new state standards for Science, Technology & Engineering, and Environmental Literacy & Sustainability. I felt a sense of duty and optimism that our work would make a real difference for science teachers across the state. Our committee constructed an initial draft of the science standards during several meetings. I vividly recall asking myself during one writing session, is the purpose of developing new standards if not implemented in the classroom? This moment of critical reflection ignited my inquiry into the implementation process.

As I learned more about the implementation process, I imagined standing on the edge of a precipice. I looked down and saw a deep chasm separating another steep cliff. Atop the other cliff edge were many of the well-intended but failed change programs I have experienced in my career. A leap across would be in vain. I realized the void separating change programs and my instructional practice was a phenomenon known as the implementation gap. In the case of STEELS, making the haphazard, giant leap from standards to practice will doom yet another well-intended change program. Crossing the implementation gap first requires building a solid bridge. The current action research study tells the story of how designing a bridge across the implementation gap and taking the first steps towards connecting standards and practice. The story begins by establishing a context for the study.

Science literacy empowers individuals to unmask ignorance and facades of understanding. Embedded in science literacy is “a knowledge of science, as well as the scientific framework by which people make decisions based on facts, research, and knowledge, not opinion or hearsay” (SDN, 2018, p. 15). Scientifically literate individuals comprehend not just the basic concepts but also the importance of the falsifiability of hypotheses and theories and understanding the problem-solving nature of scientific inquiry (Zen, 1990). Public education can provide opportunities for students to develop these skills and become scientifically literate. However, this theory alone will not make manifest the outcome. Only through the implementation of theory may scientifically literate students be produced.

The current study aims to understand the practice of implementing a program for improving science literacy in the school setting. The following chapter provides historical context and historical analysis of science literacy policy in public schools. The theory-practice gap is explained as a potential factor for inhibiting science literacy policy into instructional practice. The chapter concludes with an introduction to the intervention plan for implementing new state science standards into local school science instruction.

Historical and National Context

Hurd (1958), McCurdy (1958), and the Rockefeller Brothers Fund (1958) introduced the term science literacy to educational research. Even though a clear definition of the term was not widely accepted, it became a rallying point to improve science education in public schools (Bybee, 1997). Nevertheless, this debate focused more attention on science education reform from the public and government sectors, especially during the second half of the 20th Century (DeBoer, 1991).

Sputnik: The Launch of Science Education Reform in the U.S.

Reform efforts to improve scientific literacy in public schools can be traced back to the launch of Sputnik in 1957. Many Americans feared the United States was losing the innovation race, and the nation's attention turned towards improving science education (Roos, 2019). Over the next sixty years, many nationwide reform efforts emerged. One prominent example was Project 2061 *Science For All Americans*, which called for standards-based science curricula (American Association for the Advancement of Science, 1989). The National Research Council (NRC) responded to this publication by developing the National Science Education Standards (NSES, 1996).

NSES succeeded in being the first major program to unify science education in the United States. However, expectations exceeded reality for effecting change within public science education as student achievement lagged behind many of the nation's global economic competitors. States have significant control over school curricula and tend to "jealously guard" these rights, resisting external attempts at reform by the federal government (Champagne, 1997, p. 1). Over the early portion of the 21st Century, ridged boundaries existed between states' learning communities. In 2007, the National Academies of Science and the National Academies of Engineering issued an influential report on the state of science education in America titled *Rising Above the Gathering*

Storm: Revisited. This document helped persuade the federal government to increase funding for science education reform through the America COMPETES Act of 2010. Science education was primed for another major reformation.

Reform in the 21st Century (So Far)

Proponents of national education standards pointed to a need for consistency in state assessments to compete with the international job market (Chen, 2023). A lack of STEM-qualified college graduates was cited as a concern for meeting the demands of the job market. However, it was specific to the labor sector and area of qualification (U.S. Bureau of Labor Statistics, 2015). In addition to international economic competition, support for nationalized science standards in the early part of the 2010s emphasized a need to update the NSES due to new insights into how people learn science and how to improve instruction (Quinn et al., 2013). A breakthrough was occurring in the push for nationalized science standards.

K-12 Framework for Science Education

In 2009, the Carnegie Foundation and the Institute of Advanced Studies issued a proclamation for improving the nation's science education. The report, entitled *The Opportunity Equation,* was a call to action for re-tooling the science education system with innovations to improve student learning. In 2012, the National Research Council (NRC) answered the call by developing *A Framework for K-12 Science Education* (the *Framework*). The *Framework's* vision was "to actively engage students in science and engineering practices and apply crosscutting concepts to deepen their understanding of the core ideas in these fields" (p. 10). The overall vision of the *Framework* was to shift the "inch deep and a mile wide" paradigm in traditional science education to a more depth over breadth study of science (p. 23).

The Three-Dimensional Model. Born out of the vision were the three dimensions of science and engineering literacy: (1) Science and Engineering Practices (SEPs), (2) Crosscutting Concepts (CCs), and (3) Disciplinary Core Ideas (DCIs). SEPs focused on how scientists and engineers carry-out investigations and design solutions. CCs provided ways for students to connect knowledge from the various disciplines into a view of the world. DCIs were the important concepts from each of the disciplines such as Physical Science, Life Science, and Earth and Space Science.

SEPs. **"**Learning science by *doing* science" was a motto emphasized by the NRC when describing their vision for the future of science education. The SEPs represented what scientists *do* to investigate the natural world, and what engineers *do* to design and build systems. The *Framework* identified eight specific SEPs that were essential for students to learn and apply science content: (1) Asking questions and defining problems, (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 and designing solutions, (7) Engaging in argument from evidence, (8) Obtaining, evaluating, and communicating information.

CCs. Understanding the natural world drives scientific study. One of the most important steps to becoming scientifically literate is connecting concepts from various scientific disciplines. The *Framework* outlined seven CCCs that bridge the disciplinary boundaries in science: Patterns, Cause and Effect, Mechanism and Explanation, Scale, Proportion and Quantity, Systems and System Models, Energy and Matter, and Structure and Function. Engagement with CCCs can help students fill gaps in knowledge and construct explanations for phenomena without gaps in knowledge.

DCIs. *The Framework* organized scientific study into four disciplines or domains-Physical Sciences, Life Sciences, and Earth and Space Sciences. Each domain includes essential ideas all students should know by graduation, known as DCIs. The DCIs' role aligns with the Framework's vision by equipping students with sufficient knowledge to acquire new knowledge in the future.

Next Generation Science Standards

The Framework was the first phase in addressing the need for reform. *The Opportunity Equation* emphasized improved science standards as crucial to improving science education in the country; thus, the NRC developed a set of standards based on the *Framework's* three-dimensional model- Next Generation Science Standards (NGSS Lead States, 2013). Until the development of NGSS, existing science standards viewed the three dimensions as mutually exclusive; however, 21st-century students need the ability to contextualize their understanding of scientific knowledge, practice how scientific knowledge is obtained, and connect acquired knowledge across disciplines. NGSS addressed the need by incorporating the three-dimensional model.

The NGSS incorporates the three dimensions-SEPs, CCs, and DCIs-from the *Framework*. Specific SEPs, CCs, and DCIs are selected for each standard. The designers of NGSS wrote Performance Expectations (PEs) into each standard for clarity. PEs were developed as statements of what students should be able to know and be able to do after engaging in science instruction. (NGSS Lead States, 2013, “How to read” section). The statement blends statements from a standard’s SEPs, CCs, and DCIs. In other words, the PE represents the big idea of the standard. PEs were grouped according to science discipline and level of student development. NGSS designers intended that PEs should be attainable by all students in a particular subject and grade level regardless of academic aptitude. Furthermore, NGSS only provides a foundation for student learning, and teachers have the ability to tailor curricula using NGSS accordingly.

State and Local Context

Whether the intentions were implicit or explicit, national science education reform efforts had the intention of changing classroom practice. National standards-based reform established a pathway through the states during the late 20th century and into the 21st century. The following section outlines standards-based reform within the state of Pennsylvania. Local context is also provided for the school district in which the study took place.

Pennsylvania Science Standards Reform

Developing NGSS was a collaborative, state-led process, and as of 2021, the NGSS has influenced standards in 44 states (NSTA, 2021). Pennsylvania followed suit and commenced revising the state’s science standards in 2020. The Pennsylvania Department of Education (PDE) initiated a multi-phase plan to update the existing science standards originally adopted in 2002. The process consisted of a stakeholder review of the current standards, creating an updated set of standards from stakeholder recommendations, best practices, and current research; legislative review of the updated standards, and issuing the updated standards for use by schools statewide (PDE, State Board of Education, 2020). The PDE unveiled the revised state science standards with a goal to "serve as the substantive underpinning for high-quality instruction and assessment" (Pennsylvania Bulletin, 2022, Academic Standards and Assessment). In other words, the standards are a guide for what students should learn in the science classroom. How they learn it rests upon the classroom teacher.

According to the Pennsylvania Department of Education (PDE, 2020), the *Framework* and the NGSS served as the foundation for crafting the *Science, Technology & Engineering, and Environmental Literacy & Sustainability Standards* (STEELS). The basic anatomy of STEELS mirrored the NGSS by incorporating CIs and PEs derived from the three dimensions of *the Framework*- SEPs, DCIs, and CCCs (see Figure 1). Specific aspects of each dimension elaborated on the intent of the PE. It was important for the developers to integrate PA Connections to promote state ownership and relevance. Connections to state ELA, math, and technology standards were included for coherence across disciplines. Final ratification of STEELS occurred in June 2022. The PDE announced a three-year implementation window with full classroom integration by the 2025-26 school year (PDE, 2023).

Figure 1

Example of STEELS Standard

Science, Technology & Engineering, and Environment Literacy & Sustainability (STEELS)

Grades 6–8

3.2.6-8.L Physical Science: Energy

Students who demonstrate understanding can *construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass and to the speed of an object.*

Clarifying Statement: Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a wiffle ball versus a tennis ball.

Assessment Boundary: N/A

Science and Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)
Analyzing and Interpreting Data Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Analyze and interpret data to determine similarities and differences in findings.	**PS3.A: Definitions of Energy** • Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed.	**Scale, Proportion, and Quantity** • Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.

Pennsylvania Context: Examples of Pennsylvania context include but are not limited to Pennsylvania's amusement or theme parks.

PA Career Ready Skills: Analyze various perspectives on a situation.

Connections to Other Standards Content and Practices

Standard Source	Possible Connections to Other Standard(s) or Practice(s)
Agriculture (AFNR)	CS.01.02.01.a: Research technologies used in AFNR systems.
Science, Environmental Literacy and Sustainability (NAAEE)	5-8 Strand 2.1.A. Earth's physical systems: Learners describe the physical processes that shape Earth, including weather, climate, plate tectonics, and the hydrologic cycle. They explain how matter cycles and energy flows among the abiotic and biotic components of the environment. They describe how humans affect and are affected by Earth's physical systems.
PA Core Standards: ELA	CC.3.5.6-8.A: Cite specific textual evidence to support analysis of science and technical texts. CC.3.5.6-8.G: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
PA Core Standards and Practices: Math	MP.2: Reason abstractly and quantitatively. CC.2.1.6.D.1: Understand ratio concepts and use ratio reasoning to solve problems. CC.2.1.7.D.1: Analyze proportional relationships and use them to model and solve real-world and mathematical problems.

Note. From *Science, Technology & Engineering, and Environmental Literacy & Sustainability Standards* (STEELS) by Pennsylvania Department of Education, 2023, (https://bit.ly/3WYMVYk).

Local District Overview

The Bellwood-Antis School District is in central Pennsylvania, Blair County. The district is divided into three buildings: one elementary school (grades K-4), one middle school (grades 5-8), and one high school (grades 9-12). The National Center for

Education Statistics (NCES, 2021) categorized the locale as small and suburban and serves 1,247 students in grades K-12. School demographic data expresses limited student diversity (96% white; 98.1% are English-only speaking). According to the Bellwood-Antis School District's website, the district employs 92 teachers, five administrators, and 24 support personnel (https://www.bwld.k12.pa.us).

Teachers at the Bellwood-Antis School District deliver science education curricula in every grade. In grades K-6, the responsibility for science instruction is shared amongst grade-level teachers in addition to math, language arts, and social sciences. Currently, there are six certified secondary science teachers. Beginning in seventh grade, science instruction is departmentalized into the following sequence: Life Science (Grade 7), Physical Science (Grade 8), Earth and Space Science (Grade 9), Biology (Grade 10), Chemistry (Grade 11), Physics (Grade 12). All middle-school students are required to complete Life Science and Physical Science in their respective grades. In the middle school, only the 7th-grade teacher instructs science-only courses. The 8th-grade teacher also instructs a course in American Cultures. Due to graduation and college admission requirements, high school students may or may not take Chemistry or Physics. The current graduation requirement is three courses of science.

Theory-Practice Gap

Organizational systems suffer from a disconnect between theory and practice. Previous research indicated that the failure to follow through with strategic planning is widespread across organizational systems. (Knight et al, 2008; Supovitz & Weinbaum, 2008; Sharma, 2018). Like other organizational systems, public education has not been immune to the effects of the separation between theory and practice. Dewey (1904) was a pioneer in studying the theory-practice gap, and for more than a century, reform efforts have fallen short of bridging the gap. The following section provides historical context regarding the evolution of the theory-practice gap within educational reform.

Genealogical Analysis

In the aftermath of Sputnik, the federal government funneled significant amounts of money and resources into developing new curricula, especially for mathematics and science. It was the idea that these new curricula if appropriately promoted, would immediately transform classroom instruction (Hall & Hord, 1987). This naïve approach to implementing theory into practice may be explained through genealogical analysis and examining the hierarchy embedded in the educational system.

What is the current state of the theory-practice gap? In the breath of Foucault, one may address this question through genealogical analysis. Foucauldian genealogy is described as tracing the "erratic and discontinuous process whereby the past becomes the present… shaped by power relations and struggles" (Garland et al., 2014, p. 372). The application of Foucauldian genealogy seeks not to find the origin of present-day social phenomena (e.g., modern practices and institutions); instead, it provokes history and extracts the agents of struggle, power, and knowledge the emergent phenomena depend upon for their existence. The concept of Power/Knowledge pervades genealogical analysis. In general, Power/Knowledge does not allude to the common notion that knowledge is power; however, it pertains to how the use of knowledge by power influences our present (Foucault, 1980). Through genealogical analysis, understanding the theory-practice gap of the present is understanding the dominant forces in educational research and practice of the past.

Positivist perspectives once saturated educational paradigms. Educational theory was based on wanting to know the truth when the truth was rigidly certain (Walshaw, 2007). A top-down approach to knowledge diffusion from theory to practice became the norm. Educational theory was best constructed and critiqued by academics in universities and other higher education entities, and the classroom teacher's role was viewed as the vessel for indiscriminately implementing theory into classroom practice (Glenn et al., 2017). The work of theorists resided in the “high, hard ground” of theory, and the work of teachers camped in the “swampy lowlands” of practice (Schon, 2016, p. 42). Interpretivism eventually supplanted positivism as the dominant framework within educational research (Walshaw, 2007). This subjective, student-centered pedagogical paradigm had little effect on the hierarchical structure of theory and practice (Deacon, 2006). The concepts may have changed regarding classroom practice, but academics still held authority over theory.

Genealogical analysis of the divide between theory and practice in education cannot ignore the influence of government policy. In this context, 21st Century educators are far too familiar with the failure of policy implementation. For example, the No Child Left Behind Act of 2001 (NCLB) promised 100% student proficiency in mathematics within 12 years. By 2013, the National Assessment of Educational Progress reported that students nationwide scored at proficiency levels of 35% in mathematics and 36% in reading (NAEP, 2022). Another recent example of the breakdown between policy and practice was the Common Core math and English standards released in 2010. Common Core was implemented by many states in 2014; however, by 2016, 14 states had suspended or withdrawn participation in the program (Bentsen, 2016). NCLB and Common Core were two major policy reform efforts necessary in a recent genealogy of the theory-practice gap. A third and prevailing policy, ESSA, is of equal worth to assessing the theory-practice gap.

As an attempt to modify the shortcomings of NCLB and Common Core, ESSA promised to deliver an evidence-based framework for reversing the track record of failure in low-performing schools (U.S. Dept. of Education, n.d.). ESSA redirected scaling efforts locally and encouraged school districts to adopt evidence-based intervention. However, there were holes in its implementation as ESSA only required the interventions to meet the lowest of the law's top three evidence tiers and need not be new (Lester, 2018). The law failed to address one of its original goals of balancing federal and state authority over school accountability (Saultz et al., 2019). At the local district level, ESSA has done little to temper the attitudes towards high-stakes state-standardized testing. A recent survey conducted by Stanford (2023) found that a majority of teachers did not perceive standardized tests as a valid measure of school success. However, they still felt pressure for students to meet proficiency expectations.

ESSA represented a step in the right direction for public educational reform, but the policy left a sobering void in school improvement. The causality for such failure has been an enigma for educational leaders (Supovitz & Weinbaum, 2008). However, there is a growing awareness that a policy does not fail based on its own virtues; instead, its fate may rest on implementation (Hudson et al., 2018). Failures in educational improvement reform allude to an *implementation gap*, a phenomenon observed when the rules on paper differ from the rules in practice (World Bank Group, 2015). Change through policy often dissolves prior to implementation, leaving the change process only halfway finished (Hess, 2013). Therefore, the link between system-change goals and results breaks, and the vicious cycle of failed reform continues in educational reform.

Barriers to Scale

The implementation gap is made manifest by the barriers to change at various levels of scale. Change leaders are better equipped to handle these challenges by identifying barriers at each level. Action research provides change leaders with a systematic, cyclical process for investigating the problems facing implementation. Reconnaissance is an important phase in action research because it can provide valuable information for refining a problem of practice and developing a research plan (Mertler, 2020). Reconnaissance in the current study uncovered potential barriers to scaling STEELS down to the local level across Pennsylvania. These barriers alluded to an ideology known as the Problem of More which is discussed in more detail in the following section. Specific local barriers found during reconnaissance are also presented below.

The Problem of More

Usually, only a subset of individuals within an organizational system exhibits the behaviors associated with a change effort. The challenge for organizational systems lies in disseminating ideal behaviors among the rest of its people. Sutton and Rao (2014) referred to the phenomenon as the *Problem of More*—spreading these behaviors to "*more* people and *more* places" is exasperated by the negative effects of bureaucracy, inconsistency, and inferior quality (p. x). Implementing STEELS statewide is susceptible to the Problem of More as implementation programs must reach more than 500 school districts across Pennsylvania (PDE, 2023). According to Sutton and Rao, scaling relies on individuals at every level of an organization system, not just the executives. "It is impossible to spread excellence without the zeal, efforts, and imagination of people throughout an organization" (p. xv). Scaling may begin at the top with the PDE, but the individual schools, administration, and teachers affect the change needed to implement STEELs. Effective local district implementation may serve as a solution. However, pause must be taken before district implementation can take place because barriers exist at even the lowest levels of scale.

Local Reconnaissance

Scaling outcomes of STEELS ultimately rely on local district implementation. Thus, it is imperative to understand the barriers facing local implementation. Therefore, two cycles of local reconnaissance were performed in the current action research study. During the first phases of reconnaissance, Cycle 0 and Cycle 1, semi-structured interviews were conducted with district science teachers. A common observation was the lack of knowledge about NGSS and STEELS. Many teachers admitted that science standards play no role in their daily instruction. Another observed barrier was a lack of resources for instructing or learning about NGSS or STEELS. Teachers expressed time as the most limiting resource for reflection and collaboration. The second phase of reconnaissance, Cycle 1, piloted an important assessment measure for the current study, the Stages of Concern Questionnaire (SoCQ). The SoCQ provided data for identifying participating teachers' concerns about the intervention. Three of the four teachers in Cycle 1 also participated in the current study. It was important to include these teachers since data from the Cycle 1 SoCQ helped the current study's intervention game plan.

Reconnaissance into the state and local implementation barriers provides a unique and essential context for the current action research study. Genealogical analysis of the theory-practice gap, including the challenges of the Problem of More and assessment of local barriers, set the backdrop for understanding the theory-practice gap, painting a picture of the current study's problem of practice.

Problem of Practice

Science education in the United States has undergone several reform efforts culminating in standards-based reform of the late 20th and early 21st centuries. Overcoming the barriers produced by the theory-practice gap has remained a perennial battle for researchers and teachers alike. Genealogical analysis and local district assessment provided insight regarding the present-day ineptitude of theory and policy in classroom implementation. This indication in advance is a call for policymakers and educational leaders to take pause and develop implementation strategies with focused intent. Special attention is paid to the states adopting the Framework for K-12 Science Education and NGSS for the revision of science standards.

Across the Commonwealth of Pennsylvania, science teachers can look forward to an updated set of standards for planning and delivering instruction, known as STEELS. Since these standards do not represent a particular curriculum or instructional methodology, a significant challenge lies ahead for state and local education officials and teachers to implement STEELS into teaching practices. STEELS represents a philosophy for developing scientifically literate students by moving away from rote memorization of facts and towards learning that involves productive classroom discourse and sustained investigation, empowering students with the capability of more sophisticated thought (PDE, 2023). The current practices at the Bellwood-Antis School District do not align with the intent of STEELS. The situation is ripe for an intervention that bridges the theory-practice gap and moves the Bellwood-Antis School District closer to the state's vision for improving science education through STEELS. The current action research cycle will explore the influence of a district-level intervention for participating science teachers to support STEELS implementation.

Intervention- a Brief Introduction

The new standards bring the promise of improving student learning, but the intentions of the standards only come to fruition through classroom instruction. Historically, a divide exists between such theory and practice. To address potential barriers, a Professional Learning Community (PLC) for science teachers was initiated at the Bellwood-Antis School District. The Concerns Based Adoption Model (CBAM) pioneered by Hall and Hord (2020) served as a guide for monitoring and mapping the intervention via three diagnostic dimensions: Stages of Concern (SoC), Innovation

Configuration (IC), and Levels of Use (LoU). The SoC dimension addresses the change process's personal side (e.g., feelings, thoughts, attitudes). The IC dimension is a tool that operationalizes the ideal behaviors for implementing an innovation. The LoU dimension provides insights into teachers' actions during the implementation process and can answer questions such as: Are the teachers working collaboratively to address students' learning needs while using a change program? Each dimension provides measures for diagnosing the needs of implementers and helping change facilitators improve the implementation process.

Hall et al. (2015) metaphorically described the relationship between the three dimensions of CBAM and the change process as an Implementation Bridge (see Figure 2). Measurements of the three dimensions are used to develop a CBAM diagnosis. The CBAM diagnosis describes the location of participants on the Implementation Bridge. As the implementation progresses, participants should exhibit diagnostic measures that indicate movement across the Implementation Bridge. Within the context of the current action research cycle, the intervention provided support for participates' journey across the Implementation Bridge and targeted the three diagnostic dimensions of CBAM.

Figure 2

The Implementation Bridge

Stages of Concern (SoC)						
0	1	2	3	4	5	6
Unconcerned	Informational	Personal	Management	Consequence	Collaboration	Refocusing

Levels of Use (LoU)							
0	I	II	III	IVA	IVB	V	VI
Nonuse	Orientation	Preparation	Mechanical	Routine	Refinement	Integration	Renewal

Innovation Configurations (IC Map)		
Old Practices		New Practices

Notes. Adapted from "Implementing change: Patterns, Principles, and Potholes" by G.E. Hall and S.H. Hord, 2020.

Purpose of the Study and Research Questions

The current action research study investigated the influence of a PLC-based intervention on implementing the new Pennsylvania science standards (STEELS) by participating science teachers at the Bellwood-Antis School District. Guiding the study were three research questions; each used to examine the relationship between the PLC and one of the three diagnostic dimensions of the CBAM. The research questions aimed to provide a CBAM diagnosis, which served as an indicator of implementation progress. This diagnosis will inform future iterations of research and help further the implementation process. The following research questions guided the study:

Research Question 1

How does engaging in the PLC-based intervention support the development of a district-level *Innovation Configurations*?

Research Question 2

How and to what extent do the school district's science teachers' *Stages of Concern* profiles change as they engage in the PLC-based intervention?

Research Question 3

How do participating teachers express STEELS-related *Levels of Use* after engaging in the PLC-based intervention?

Chapter 1 introduced the concept of science literacy in society, and the struggles science education has endured to produce scientifically literate students. The history of science education reform in the U.S. was presented through a narrative timeline. Genealogical analysis of the implementation gap in education is fundamental to the current study's PoP and brought attention to the need for an intervention on a local scale for implementing STEELS through a PLC. Chapter 1 concluded with the research questions directing the investigation of the intervention. Chapter 2 elaborates on the framework of the current study with an emphasis on reviewing CBAM and PLC literature.

CHAPTER 2

REVIEW OF SCHOLARLY KNOWLEDGE INFORMING THE STUDY

> Leaders in a culture of change value and almost enjoy the tensions inherent in addressing hard-to-solve problems because that is where the greatest accomplishments lie.
>
> —Michael Fullan (2001)

Enabling change has been an enigma for schools since the dawn of major education reform in the mid-20th Century (Fullan, 2015). An influx of research coincided with reform efforts, and the conclusions were sobering. School improvement through educational reform has been challenging or, in most cases, a failure (Goodman, 1995; Weston & Bain, 2009). There was a formidable gap between policy and practice. It was not enough to only understand the change process but to improve change processes in schools.

Change leaders in schools are left with the dilemma of choosing a model for change. It may be beneficial to approach this problem with the fable words of statistician George E.P. Box: "Essentially, all models are wrong, but some are useful” (2005, p. 440). Within the context of his work, Box did not necessarily downplay the use of models; instead, he sent a message to pay heed when adopting models for change. Change leaders should be aware of the nature of the decision-making process within schools. Cohen (1972) described the decision-making processes in organizations, especially schools, as *organizational anarchies*. In these environments, decisions are based upon trial and error, the accidental successes of past practices, and practical necessity rather than theoretical rationality. Organizational anarchies rarely align solutions with problems, if any solutions are offered at all. This void is where change leaders can find opportunities.

Change leaders make better decisions when leaning on guidance from research, patterns from other organizations, and quantitative and qualitative data analysis from their own organizations (Sutton & Rao, 2014). Thus, choosing change models congruent with these basic principles was important to frame the present investigation. The Concerns Based Adoption Model (CBAM) and Professional Learning Communities (PLCs) served as the frameworks for implementing change in the current action research study. Chapter 2 constitutes a review of the literature relevant to CBAM and PLCs. The first section is devoted to examining the basis of CBAM: the ten principles of change and the three diagnostic constructs. The second section examines the literature in support of PLCs as a vessel for catalyzing change.

Concerns Based Adoption Model

Beginning in the late 1970s, the Research and Development Center for Teacher Education (R&DCTE) at the University of Texas at Austin launched a multiyear investigation to understand the implementation process and how to implement change in schools successfully. R&DCTE researchers, led by Gene Hall and Shirley Hord, assembled over 40 years of research findings and implications into a series of publications. Their work served as the essential resource for framing the current study's change model, the Concerns Based Adoption Model (CBAM). The next section outlines the principles of change from which CBAM was born.

Principles of Change

Hall and Hord (2014) led a collaborative team of international researchers to investigate how engaging in the change process affects schools and educators. Several patterns and themes about the change process emerged from their observations. Hall and Hord's research team derived a set of change principles from their analyses. The change principles are discussed below with supporting literature and examples.

Principle One: Change is process, not an event.

One of the first patterns Hall and Hord noticed about change was an underappreciation for the complexities and timeline of implementation. Previous studies have indicated a timeframe of 3 to 5 years for implementing change (George et al., 2000; Hall & Loucks, 1977), especially for change programs based on improving science instruction (Shymansky et al., 2013). School leaders expect change to occur within a much shorter timeframe. One reason is the pressure to increase student achievement due to high-stakes standardized tests (Holbein & Ladd, 2017). Another less apparent reason is the school leader's approach to implementing change. Too often, schools begin with solutions rather than taking the time to identify and diagnose the problem (Cohen et al., 1972).

Principle Two: Change is accomplished by individuals.

Hall and Hord found that the success or failure of the change process depends upon the success or failure of the individuals. Schools are said to change only when individuals change. Rao and Power (2020) explained that collective action stems from the simultaneous change of the individual and their community. Change can permeate a school through collective action.

Principle Three: Change is a highly personal experience.

The subjective experience of an individual going through the change process cannot be ignored for successful implementation. Hall and Hord emphasized resistance by individuals as a persistent obstacle to change. Being empathetic to the individuals involved with change helps identify potential barriers. Ng and Leicht (2019) examined a phenomenon known as *struggles of engagement*. Teachers struggle with beliefs regarding old and new practices and their role in change. By addressing these struggles, change facilitators can encourage change in teacher knowledge and the transformation of old to new practices.

Principle Four: Change involves developmental growth.

New teachers are not expected to step into their roles as veterans. The same should be said for *any* teacher, irrespective of experience, encountering a change program for the first time. Katz (2005) supported a teacher development model characterized by sequential phases. Through each phase, teacher growth was facilitated by developmental tasks and training needs.

Principle Five: Change is best understood in operational terms.

In the classic 1993 novel *The Giver*, author Lois Lowry used the phrase “the precision of language” or choosing the most appropriate term to convey exactly what you mean. Though a work of fiction, Lowry’s use of language expressed the essence of principle 5. Hall and Hord (2020) explained the importance of communicating change so that teachers can relate to their everyday practice. Operational terms answer the questions about the reality of a change program (i.e., What does change look like in my classroom? How do I go about performing a particular classroom practice?).

Principle 6: The focus of facilitation should be on individuals, innovations, and the context.

Hall and Hord (2020) noted that schools too often focused improvement efforts on developing new curricula, new textbooks, new technologies, etc. These entities often forget that tangible resources cannot directly make change happen. It is the people in the school who need to change by modifying their behavior. Change leaders facilitate behavior modification by implementing innovations, which should be adapted to the context of the group targeted for change.

By understanding how change worked in schools, Hall and Hord developed CBAM to aid the implementation process in schools systematically. The next section dives deeper into CBAM by exploring the three diagnostic dimensions that give change leaders the tools for guiding and sustaining the implementation process.

Three Dimensions of CBAM

CBAM employs a three-dimensional framework for implementing change. The dimensions are Innovation Configurations (IC), Stages of Concern (SoC), and Levels of Use (LoU). Each dimension is measured at various stages of implementation, and the results are used to monitor progress and inform decision-making during the change process (Hall & Hord, 2020, p. 52). Together, they can be a powerful, dynamic tool for effecting school change. The following section describes the role of IC, SoC, and LoU dimensions within the CBAM framework.

Innovation Configurations

Hall and Hord (2020) concluded that architects of change programs in education (i.e., policymakers) invest highly in ideas for change without considering the actual implementation of change. As a result, what is envisioned often does not represent what is done. The problem lies with inconsistency in the operation of change practices (p. 58). In other words, implementers of change (i.e., teachers) do not speak the same language regarding an innovation. The Innovation Configurations (IC) dimension provides change facilitators and implementers with a tool for constructing a collective understanding of an innovation and measuring the implementation process. Previous research supported IC Maps as a stimulator of collective understanding and measuring aid for the implementation of programs (Arrowsmith et al., 2021; Fernando, 2010). The process of developing IC Maps in collaboration with implementers can spark collective understanding by initiating conversations (Swain, 2008).

Change programs need to be guided by more than just goals and objectives. Goals provide teachers with a purpose for using an innovation but do not fill the void of how it will be implemented. Hord et al. (2014, p. 13) stated, “To be truly helpful to teachers, you must be able to describe how a program will look in actual practice in the classroom.” Furthermore, it is important to acknowledge that different teachers will use an innovation in separate ways. The IC process accounts for both clarity and adaptation in practice by mapping the innovation in what is naturally called an IC Map. Two elements of the IC Map help communicate what an innovation should look like or not look like in practice: *components* and *variations*. Components are the major operational features of an innovation and are often based on materials, teacher behaviors, and student activities. Variations are the many ways teachers can operationalize a component. The variations are increasingly sequenced toward the ideal implementation of a particular component, helping to maintain the fidelity and quality of an innovation (Hall & Hord, 2020). Thus, implementation can be consistent and align with best practices.

Stages of Concern

A scattering of emotions and feelings will accompany change in schools. Feelings and perceptions can either help or hurt the change process (Hall & Hord, 2020). Researchers began looking into feelings and perceptions as influential factors of change in the 1960s. Frances Fuller (1969) coined the term *concerns* as it relates to feelings and perceptions within educational change. Culminating from her pioneering research were four major categories of teachers' concerns: Unrelated, Self, Task, and Impact. Fuller's work opened a new research paradigm for understanding the concerns of individuals engaged with the change process (Rakes & Dunn, 2010; Persichitte & Bauer, 1996; Shieh, 1996; Van den Berg & Vandenberghe, 1983). The developers of CBAM incorporated Fuller's four categories of concerns and further divided the four types of change concerns into seven subcategories known as Stages of Concern (SoC; Hall & Hord, 2020). Table 1 outlines the SoC stages and provides the typical expressions that teachers may express at each stage.

Table 1

Stages of Concern and Typical Expressions of Concern

	Stages of Concern	Typical Expressions of Concern
IMPACT	6 Refocusing	I have some ideas about the innovation that may work better.
	5 Collaboration	I am concerned about relating what I am doing with what my co-workers are doing.
	4 Consequence	How is my use affecting the students?
TASK	3 Management	I seem to be spending all my time getting materials ready.
SELF	2 Personal	How will using it affect me?
	1 Informational	I would like to know more about it.
UNRELATED	0 Unconcerned	I am more concerned about other things.

Note. Adapted from "Implementing change: Patterns, Principles, and Potholes" by G.E. Hall and S.H. Hord, 2020.

Self-Concerns. As teachers first engage with change, they often exhibit uncertainty about an innovation. Uncertainties about an innovation stem from Stage 1 Informational concerns (i.e., wanting to know more about an innovation) or Stage 2 Personal concerns (i.e., lacking confidence in executing an innovation properly). If Self-concerns are not addressed in the beginning, they have the potential to derail the entire implementation process. Arousal of Self-concerns can cause resistance to change (Hall & Hord, 2020). Teachers may feel threatened by an innovation and become defensive about holding onto their current practices. Stage 1 and Stage 2 concerns are often entangled, and a failure to address one stage can cause more intense concerns in the other.

Task Concerns. Teachers often share concerns about the pace of planning, classroom management, or having the necessary resources (Hord et al., 2006). These

Task concerns are categorized as Stage 3 Management. Time management is a crucial indicator for Task concerns during the change process (Farmer & Roth, 1998). For example, teachers may feel that implementing an innovation inhibits their responsibility for delivering the entire curriculum within a school year. In addition, teachers may express concerns about time constraints on self-reflection of implementation.

Impact Concerns. Impact concerns are most intense after implementers have spent some time using an innovation. Watzke (2007) described that the impact phase "represents teachers' emergence from the process of survival into an advanced developmental stage." Impact concerns usually pertain to how the innovation will affect student performance, working with other teachers regarding the innovation, and improving the innovation (Hord et al., 2014, p. 32).

The SoCs reflect the development growth principle of CBAM. As implementers progress through sustained implementation, higher-level concerns should increase in intensity. Each SoC is not in isolation, and implementers will exhibit concerns across the SoC continuum. Previous research supports the diversity of SoCs among participants. However, the most intense concerns should be addressed within any given timeframe. It may be challenging to identify a single, most intense SoC in a study, so facilitators need to be prepared to address two or more SoCs (Fisher et al., 2019). Support helps an implementer move through the SoCs; however, support must be focused and sustained throughout the implementation process, or SoC regression may occur (Conner et al., 2021; Hord et al., 2014).

The SoC dimension is a tool for change facilitators to measure and guide the implementation process. Determining the SoC stages of participants is a good predictor of conceptualizing an innovation (Teerling et al., 2020). Focused, sustained support is essential to move implementers through the SoC stages. The individual stages of SoCs should be used in coordination with the IC dimension and the third dimension, Levels of Use.

Levels of Use

Two common indicators are used for evaluating implementation programs: (1) whether innovations (i.e., new classroom practices) are used in classrooms, and (2) to what extent an innovation is used in classrooms (Roach et al., 2009). Hall and Hord (2020) noticed that change facilitators in schools had difficulty finding evidence for these indicators. In the schools they studied, change facilitators relied too heavily on new materials (i.e., textbooks, classroom technology) and one-shot professional development programs. Little attention was paid to how implementers (teachers) changed practices as a result of having new knowledge or materials. The Levels of Use (LoU) dimension was developed by Hall and Hord to address this deficiency and support change facilitators to inform indicators of successful implementation (p. 107). When in place as a change-facilitation tool, the LoU dimension has positively impacted change programs in education (Matar, 2017).

LoU dimension is a tool for measuring how and to what extent implementers use an innovation. As the implementation process unfolds, implementers exhibit behaviors such as orienting, managing, and integrating the use of an innovation (Hord et al., 2014).

The LoU dimension consists of eight levels, from Level 0 to Level VI. Each level is defined by specific behavioral characteristics pertaining to change implementation (see Figure 3). LoU Levels 0-II describe non-users of an innovation, while LoU Levels III-IV describe users of an innovation.

Figure 3

Levels of Use of the Innovation

Users	VI	**Renewal:** State in which the user re-evaluates the quality of use of the innovation, seeks major modifications or alternatives to present innovation to achieve increased impact on clients, examines new developments in the field, and explores new goals for self and the system.
	V	**Integration:** State in which the user is combining his or her own efforts to use the innovation with related activities of colleagues to achieve a collective impact on clients within their common sphere of influence.
	IVB	**Refinement:** State in which the user varies the use of the innovation to increase impact on clients within immediate sphere of influence. Variations are based on knowledge of both short- and long-term consequences for clients.
	IVA	**Routine:** Use of the innovation is stabilized. Few if any changes are being made in ongoing use. Little preparation or thought is being given to improving innovation use or its consequences.
	III	**Mechanical Use:** State in which the user focuses most effort on the short-term, day-to-day use of the innovation, with little time for reflection. Changes in use are made more to meet user needs than client needs. The user is primarily engaged in a stepwise attempt to master the tasks required for the innovation, often resulting in disjointed and superficial use.
Nonusers	II	**Preparation:** State in which the user is preparing for first use of the innovation.
	I	**Orientation:** State in which the user has recently acquired or is acquiring information about the innovation and/or has recently explored or is exploring its value orientation and its demands upon user and user system.
	0	**Nonuse:** State in which the user has little or no knowledge of the innovation, is not involved with the innovation, and is doing nothing toward becoming involved.

Note. Adapted from Matar, 2017, CC BY 3.0 AT.

Hall and Hord (2020) developed guiding principles for the LoU dimension from their studies. Individuals participating in the implementation of an innovation will express behaviors indicative of a particular LoU. A first-time user of an innovation should not be categorized as LoU III Mechanical Use. Likewise, an individual with experience using the innovation should not be assumed to be at LoU III Mechanical Use. To assess an individual's LoU, a change facilitator should use an established interview protocol. It is appropriate to use information about an individual's LoU from sources other than the established protocol to guide the implementation process; however, only information gathered from the established interview protocol should be used to evaluate an individual's LoU. Some individuals may follow the LoU sequentially, while others may bypass or regress in LoU.

Implementing change in schools is a challenging endeavor. CBAM provided a framework for the current study to implement change systematically. When utilized appropriately, the three diagnostic dimensions of CBAM can work harmoniously to measure, evaluate, and guide the implementation of an innovation in practice. CBAM measures alone cannot accomplish change, however. PLCs can provide the means for upholding the principles of change. The following section discusses the essential concepts of PLCs cited in relevant literature.

Professional Learning Communities

Collaborative study by teachers as part of Professional Learning Communities (PLCs) was one of the first reform efforts of the post-Sputnik era (Joyce, 2004). Researchers and scholars touted the benefits of PLCs for school improvement (Gregory

& Kusmich, 2007; Kaplan, 2005). PLCs infiltrated school systems domestically and internationally (Antinluoma et al., 2021; Stoll et al., 2006). One would be hard-pressed to find a medium of change as popular as the PLC framework. However, it is incumbent upon any change leader to take a critical stance when adopting any framework as the basis for a study. The following section reviews the literature aligning with a successful PLC model.

Characteristics of a Professional Learning Community

The meaning of PLCs became diluted with widespread implementation. Terms commonly lose meaning when used repetitively (Jakobovits, 1962; Black, 2003). A study by DuFour (2004, p. 6) declared that the term PLC "has been used so ubiquitously that it is in danger of losing all meaning." Applying a definition of PLCs to the current study does not wholly address this problem, but it can help point the direction. The current action research study embraced the following definition of PLCs: "…a collegial space for teachers to engage in dialogue and reflect collectively as they support their own and others' practice" (Glenn et al., 2017, p.3). This definition embodied the principles of effective PLCs.

Reiterating DuFour, the reality of PLC often does not align with the definition, and this loss of meaning within education calls for a more robust explanation, specifically of effective PLCs. According to Hall and Sommer (2008), the principles of effective PLCs are shared beliefs, values, and vision; shared and supportive leadership; collective learning and its application; supportive conditions; and shared personal practice. Each attribute plays a vital role in producing sustained success of a PLC. The subsequent section characterizes the five components put forth by Hall and Sommer with supporting literature.

Shared Beliefs, Values, and Vision

Kotter (2012) describes a vision of change as “a picture of the future with some implicit or explicit commentary on why people should strive to create that future.” According to Kotter, a vision supports the change process: (a) clarifying the direction of change, (b) motivating action in the direction of change, and (c) coordinating the actions of individuals to lead an organization toward change.

Imagine an ideal PLC meeting. What are the group members doing? What type of problem are they trying to solve collectively? Are they focused on *student learning*? How does each group member participate in the dialogue? This mental picture should serve as the basis for the PLC’s vision. It is not just the group’s vision but that of all stakeholders in a student’s education (i.e., parents, administration, support personnel, community members, and school board) (Hord & Sommer, 2008).

Shared Supportive Leadership

A top-down hierarchy based on authority and tradition is commonplace within educational institutions. The staff views the principal as omniscient, wielding the sole decision-making power (Carmichael, 1982). To implement a PLC structure, schools need to unshackle themselves from the mentality that “teachers teach, students learn, and administrators manage” (Kleine-Kracht, 1993, p. 393). The responsibility for school improvement is delegated throughout the group and does not rest solely on the administrator. In this way, all members work towards being leaders of change.

Successful PLCs foster a *culture of collegiality*. Barth (2006) identified four primary behaviors of individuals in a culture of collegiality: (a) talking with one another about their practice; (b) sharing their craft knowledge; (c) observing one another while they are engaged in their practice; and (d) rooting for one another's success. In a culture of collegiality, teachers take ownership of the current state of a problem and work to form a solution (Hord & Sommers, 2008).

Collective Learning and Its Application

Improving student learning requires a consensus of lifelong learning at every level in schools. "Improvement is based on change that is based on learning" (Hord et al., 2008, p. 77). If the PLC is to improve student outcomes, the teachers need to engage in professional development. The PLC should function as an incubator of learning by building shared knowledge bases. Shared learning is catalyzed by collegial inquiry, self-reflection, and dialogue about their reflection (Hord & Sommers, 2008).

Supportive Conditions

Stanford psychologist Lee Ross uncovered an intriguing pattern among studies on human behavior. According to Ross, people often overlook the situational forces influencing another person's behavior. Ross referred to this phenomenon as Fundamental Attribution Error. Heath and Heath (2010, p. 180) explained that the "error lies in our inclination to attribute people's behavior to the way they are rather than to the situation they are in.” If you want people to change, then clear a path by providing them an environment to change their situation.

PLCs operate at their best in a supportive environment, and quality PLC leaders work to minimize logistical barriers for members, improving their situations. Hord and Sommers (2008) argued that time is one of the most challenging factors facing PLCs. By designating time out for PLCs to meet, schools can enhance the value of PLCs. Besides time, other critical supportive factors include (a) resource availability, (b) schedules and structures that reduce isolation, and (c) policies that provide greater autonomy and promote communication through collaboration (Boyd, 1992). Administrators have authority over providing many of the conditions for a supportive environment. Teachers, as PLC leaders, need to develop positive relationships with administrators and advocate for the needs of PLC members.

Human relational factors are at the epicenter of PLC effectiveness. Mutual respect and trust-building among members have a positive effect on PLC members’ learning via feedback facilitation (Bryk & Schneider, 2002). Individuals are more likely to give and accept feedback from other PLC members when they respect and trust each other. Building a supportive environment of respect and trust takes considerable time, which alludes to the importance of breaking down logistic barriers (Hord & Sommers, 2008).

Shared Personal Practice

Feedback is an essential mechanism for learning within PLCs. When PLC members are afforded the opportunity to observe each other’s instruction and provide feedback, they create a shared personal practice. Teachers can have a hand in helping their peers work to learn a new innovation. Shared personal practice can help build warm relationships between teachers (Wignall, 1992). Thus, shared personal practices and supportive conditions are complementary PLC components (Hord & Sommers, 2008). Strong ties between members of the PLC build psychological stability within PLCs (Mitchell & Sackney, 2000). Shared personal practice galvanizes PLCs by enhancing professional learning and fostering positive relationships between members.

Chapter 2 reviewed CBAM and the six principles of change in conjunction with the five principles of effective PLCs. The literature underscored their ideologies for providing comprehensive frameworks for managing change in educational settings. Chapter 3 describes the integration of CBAM into a mixed methods action research approach for examining the influence of the study's PLC-based intervention.

CHAPTER 3

METHODS

> The value of an education…is not the learning of many facts, but the training of the mind to think something that cannot be learned from textbooks.
>
> —Albert Einstein, *Einstein: His Life and Times*

Measuring the teachers' journeys across the implementation bridge was a dynamic undertaking. A myriad of variables on many scales of change may influence the outcomes of the intervention (e.g., theory-practice gap, Problem of More, local district factors). CBAM provided the framework for developing a research plan for targeting these variables. Specifically, implementation measures were derived from the three diagnostic dimensions of the CBAM framework: Innovation Configurations, Stages of Concern, and Levels of Use (Hall & Hord, 2020). The CBAM framework fits within the action research paradigm.

A PLC was established with five secondary science teachers, including the change facilitator at the Bellwood-Antis School District. Two PLC members represented the Bellwood-Antis Middle School. Three teachers represented the Bellwood-Antis High School. The courses taught in high school included Biology, Microbiology, Physiology and Anatomy, Chemistry, Environmental Science, and Physics. The PLC served as a platform for applying and examining the current study's intervention.

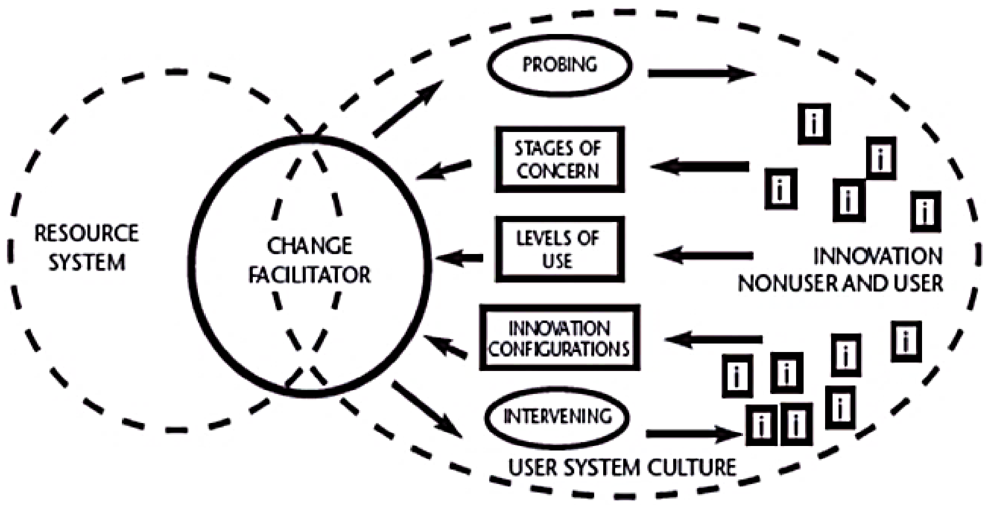
Chapter 3 discusses how the CBAM framework was integrated within the PLC to support the adoption of the new Pennsylvania state science standards by participating teachers. The first section provides an overview of how the PLC and CBAM frameworks were utilized for the intervention. A subsection is devoted to explaining the development of an implementation game plan. The final sections describe the role of the three dimensions of CBAM within the intervention, including the methodology for measuring the SoC and LoU dimensions.

The Intervention

An intervention is defined as a planned process aimed at producing intended outcomes (Adelman & Taylor, 1994). The present action research study's intervention was a process of informed action based on the CBAM framework with the intended outcome of moving participating teachers across the Implementation Bridge. The CBAM framework considers how the system's conditions influence the outcomes of an intervention. A PLC was established with participating teachers to facilitate supportive actions. The following sections elaborate on CBAM framework and PLC theoretical concepts, and how they underpinned the present action research cycle's intervention. Specifically, the sections cover how PLC members co-constructed an IC Map for STEELS-based instruction using a professional book study as a guide. A section also describes the role of the researcher through participatory action research theory.

Figure 4

The Concerns Based Adoption Model



Note. From: "Taking Charge of Change," by S.M. Hord, W.L. Rutherford, L. Huling, and G.E. Hall, 2006, p. 10. Copyright 2006 SEDL. Used with permission.

The intervention was a system similar to a feedback loop regulated by the *change facilitator*. One of the most important actions of the change facilitator was to monitor participating teachers' implementation progress via the three diagnostic dimensions of CBAM. From the information gathered, the change facilitator consulted and utilized the resource system. The PLC served as the backdrop for the User System Culture. During the intervention, the change facilitator strived to provide an ideal context for change by integrating the six strategies to support change: a shared vision of the change, opportunities for professional learning, an implementation plan and required resources, implementation progress, ongoing assistance; and a context that supports change (Hord et al., 2014).

Building the CBAM framework required the efforts of all PLC members involved in the intervention. From the change facilitator to the participating teachers, each PLC member played an integral role in maturing the study. In such a dynamic and democratic model, the roles of PLC members may overlap through shared leadership and learning. The researcher's role had a dual purpose as both a PLC member and a study observer, which is described in the following section.

Role of the Researcher

As a science teacher at Bellwood-Antis School District, I shared the responsibility of learning and implementing the STEELS along with his colleagues. It was incumbent upon me to engage in the intervention alongside his colleagues. Thus, I assumed the roles of both change facilitator and PLC member. Adopting the role of *participant-as-observer* during the intervention study, I was an active participant in the central activities of the PLC. I developed relationships with the participants over the course of the intervention (Baker, 2006). In addition, the participants were aware of my responsibility as a researcher. Assuming the role of participant-as-observer may increase the likelihood of obtaining more reliable data and a deeper understanding of the concepts under investigation (Takyi, 2015). My stance as participant-as-observer was influenced by Participatory Action Research (PAR). A hallmark attribute of PAR is building alliances between the researcher and participants in planning, implementing, and disseminating the research process (McIntyre, 2008). Living in the boundary between the observer and the observed, I hoped to marry the roles of researcher and participant to promote collegiality.

Innovation Configurations Map

Previous research uncovered two trends regarding the use of CBAM in schools: (1) Teachers had difficulty describing precisely what the innovation was used for in practice; (2) Teachers were using parts of the innovation in diverse ways (Hord et al., 2006). These factors can inhibit the implementation of innovations in schools. In response, the developers of CBAM introduced the Innovation Configurations (IC) dimension to convey "what constitutes the ideal in terms of the innovation and to anticipate the variety and diversity of how individuals may implement it" (p. 4). The IC dimension addresses the need to clarify what the following section outlines for the design of an IC Map.

IC Map Design

Like roadmaps, an IC Map provides teachers with different routes for how to implement an innovation. An IC Map is not a step-by-step procedure; instead, it describes the operational forms of an innovation or visual references for how the innovation would look in practice. IC Maps are built with components and variations (Hord et al., 2006; Hall & Hord, 2020). Components are statements about an innovation, such as materials used, teacher behaviors, or student activities. Variations described the different ways implementers may use an innovation. For example, McNeill et al. (2014) mapped instructional practices for integrating SEPs into lessons. The eight SEPs represented components, and each component had four variations. The variations described levels of sophistication in implementing a SEP into instruction.

The present study incorporated an IC Map into the intervention plan. An IC Map played a more nuanced role than merely as a tool for reference. It drove knowledge dissemination and professional development inside the intervention PLC. The following sections describe the format and roles of an IC Map within the context of the present study. The first section explains the overall design of an IC Map, and the second section discusses the applications of IC Maps in research and the current intervention.

Applications of IC Maps

IC Maps can be used as a multi-tool for implementing an innovation. An IC Map served two essential and interwoven roles in the current intervention: (1) as a tool for disseminating information about the innovation and (2) as a tool for professional development (Hall & Hord, 20. IC Map applications are explained in subsequent paragraphs.

A tool for Innovation Dissemination. Saywell and Cotton (1999) defined dissemination as the mechanisms by which information is transmitted. A significant barrier to dissemination is user comprehension. IC Maps aim to enhance user comprehension by creating clear mental pictures of an innovation. Previous research examined the application of IC Maps as a tool for disseminating knowledge during the implementation of school programs. Mitchell (1988) found IC Maps as an important tool for describing multiple educational innovations. Kacer and Craig (1999) developed IC Maps for the Kentucky Education Reform Act (KERA). IC Maps were distributed across the state, providing schools with clear descriptions of the KERA innovation. Donovan et al. (2014; 2022) developed an IC Map to help school officials and teachers understand the ecology of a 21st-century classroom and app integration into instruction. The findings from the Cycle 1 pilot study indicated that participating teachers may need more information about the innovation. Through clear, operationalized descriptions, participating teachers could visualize what the innovation looks like in practice. An IC Map could help communicate the innovation to other school entities and future science teachers.

Professional Development Application. Researchers foresaw IC Maps as a prospective tool for professional development (Hord & Loucks, 1980; Hall & Loucks, 1981). Ensuing research explored the application of IC Maps to support learning of innovations. Richardson (2007) trained school leaders to implement the National Staff Development Council Standards for Staff Development through IC Maps. Towndrow and Fareed (2015) found IC Maps useful for planning professional development to improve professional and classroom practices. The process of developing an IC Map may provide a pathway for professional development. Kistler and Baird Wilkerson (2018) led teachers in the creation of an IC Map for a mathematics education innovation in Jackson County, Kentucky. Participating teachers reported that the process of creating an IC Map provided opportunities for learning collaboratively and through self-reflection.

The critical role of an IC Map in the current intervention was as a professional development tool. Teachers co-constructed an IC Map for implementing STEELS in classroom instruction. Hall and Hord (2014) stressed the importance of teamwork while constructing an IC Map. During each of the PLC meetings, teachers engaged in dialogue with other PLC members about their understanding of the innovation. Dialogue is characterized by active listening, suspending judgment, providing the audience time to reflect upon responses, and the sharing of information (Hord & Sommer, 2008). Meaning, understanding, and clarification are supported through dialogue (Isaacs, 1999). Knowledge creation is correlated with dialogue and professional networking (Hargreaves, 1999). Dialogue would allow teachers to develop a shared language about the innovation. This could pay dividends for the PD of teachers participating in the current study since the study's participants co-constructed an IC Map for implementing STEELS into classroom instruction. Participants need a guide for developing an IC Map, and the PLC book study filled this role.

PLC Book Study

Implementation relies on teacher change, which relies on professional development. Therefore, the professional learning strategies in the game plan are essential to the intervention outcomes. The current intervention prioritized a PLC book study as a professional learning strategy for two reasons: (a) to provide participating teachers with information about STEELS and (b) to provide a framework for learning how to use this information in practice. *Ambitious Science Teaching* by Windschitl et al. (AST, 2018) was the selected text for the PLC book study. The authors of AST recognized a need to improve students' experiences learning science competencies outlined by the NGSS. Through years of research, they developed the AST framework to address this need based upon four instructional practices: (1) Planning engagement with big science ideas, (2) Eliciting student ideas, (3) Supporting ongoing changes in student thinking, and (4) Drawing together evidence-based explanations. The AST framework guided professional development through a professional book study. The first section discusses book studies as a professional development activity. The second section discusses AST as the guiding framework for professional development. The final section describes the framing of the IC Map around the AST framework.

Book Studies & Professional Development. Professional book studies are a familiar yet relatively unstudied approach to professional development. Previous research is limited but shows promise for professional book studies as an effective professional development activity for PLCs. The personal reactions of participants elicited by a book study spark deep group discussions and self-reflection (Burbank & Kauchak, 2010). Professional book studies enhanced the co-construction of knowledge (Grierson et al., 2012). Teachers had more favorable perceptions of professional book studies compared to traditional professional development activities, and the professional book study model fostered the construction of a knowledge community (Blanton et al., 2020). Knowledge construction in the context of a community was an essential mechanism for professional development in the current intervention.

The AST Framework. NGSS was the model for STEELS. NGSS provides valuable learning goals for science instruction but lacks efficacious descriptors of classroom implementation (Windschitl et al., 2012). The developers of AST hoped the AST instructional practices would fill this void. The AST instructional practices can help teachers design and implement NGSS-based units (Windschitl, 2018). For example, *planning for engagement in big science ideas* begins with identifying the relevant content and grade-level standards. Teachers derive the big ideas for the unit from the standards'

DCIs and PEs. In this way, a teacher positions the unit plan to align with the standards. The AST framework also supports the implementation of the SEP dimension of NGSS into science lessons. For example, *drawing together evidence-based explanations* is an instructional practice that encourages students to construct and evaluate claims from evidence. Students revisit and revise their initial explanatory models based on the claims. This instructional practice reinforces SEP #6, Constructing Explanations and Designing Solutions, SEP #7, Engaging in Arguments from Evidence, and SEP #8, Obtaining, Evaluating, and Communicating Information (NGSS Lead States, 2013).

Applying the AST framework to professional development is a novel strategy that recently emerged in the literature. Thompson et al. (2019) examined PLC-mediated professional development of AST instructional practices. Researchers concluded that iterative cycles of coplanning, coteaching, and codebriefing helped participating teachers understand and implement AST instructional practices. In other settings (e.g., online workshops and college courses), teachers and teacher candidates experienced positive effects on their professional development of AST instructional practices. (Mourlam & Hoefert, 2023; Tanis Ozcelik, 2016; Williams & Mourlam, 2022).

Professional development strategies should align with student learning (Hord & Sommers, 2008). As such, it is essential to define what student learning should look like in practice. Students should be afforded opportunities for deep learning orchestrated by metacognition, executive function, and self-regulation (Shepard, 2000; National Academies of Science, Engineering, and Medicine, 2018). In self-regulation, for example, students work harder to learn when the content is connected with their motivations rather than their anxieties. Implementing AST instructional practices fosters deep learning through a classroom culture of respect, responsibility, and improvement (Shepard, 2021). Thus, professional development of AST instructional practices can help teachers provide students with profound learning opportunities and enhance student learning outcomes.

STEELS x AST. An appealing motif of the book was the operationalization of the AST framework, or describing what it looks like in practice. To complement the four instructional practices, the book described seven broad operations inherent to the AST framework. The authors of AST intentionally limited the number of instructional practices and generalized the operations. Local adaptation of the AST framework becomes more focused and easily adapted to the needs of district communities. Previous studies found that local adaptation of new programs can lead to positive intervention outcomes if grounded in a guiding framework. (Blakely et al., 1987; Barrea et al., 2017). The ease at which AST can be operationalized for local adaptation is advantageous for how PLC participants would engage in professional development.

PLC members co-constructed an IC Map for implementing STEELS into their classroom instruction (STEELS x AST; see Appendix A). The AST framework guided the process of designing STEELS x AST. The AST book study facilitated the process. The four AST instructional practices served as the IC Map components. Prior to each PLC meeting, teachers read a selection from the AST book based on one of the four instructional practices. Time was reserved for teachers to engage in dialogue about how to operationalize an instructional practice. Only the first two instructional practices were addressed in the current iteration of the intervention. Time was expected to be a limitation, so there was no set goal regarding the breadth of the framework to be covered. As the well-known adage states, it is about the process.

The process of designing STEELS x AST invoked the principles of effective PLCs, especially Shared Leadership, Collective Learning, Supportive Conditions, and Shared Personal Practice. All PLC members were called upon to operationalize the AST framework. In addition, a consensus was taken when deciding what operations to include in STEELS x AST. Collective Learning was mediated by the process of designing STEELS x AST. This process made information and professional development about implementing STEELS accessible to PLC members. Discourse and dialogue among PLC members could reinforce factors of Supportive Conditions. Now and in future iterations of STEELS x AST development, teachers can engage in Shared Personal Practice. PLC members can give and receive feedback about how STEELS x AST is incorporated into classroom instruction.

MMAR Study Design

CBAM was built to assess and inform the implementation process. Each dimension of CBAM is unique in how it measures implementation and the information it provides to improve the implementation process. Therefore, it is essential to adopt a research methodology that is congruent with the three dimensions of CBAM. A mixed methods action research (MMAR) approach fits the aims of the CBAM framework and action research. The following section outlines and discusses the current study's MMAR design for measuring the implementation process.

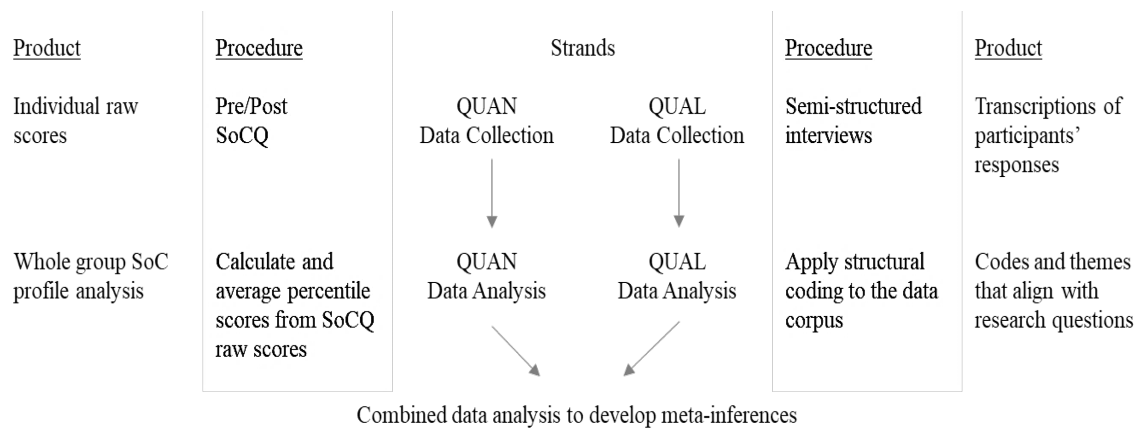
MMAR, in general, utilizes both quantitative and qualitative methodologies (Johnson et al., 2007). Each methodology is referred to as a *strand* in MMAR design. Two core MMAR designs include concurrent and sequential (Creswell, 2003). The current study adopted a concurrent MMAR design, which is characterized by distinct quantitative and qualitative strand data collection and analyses. Findings from each strand are brought together using combined data analysis to form meta-inferences (Ivankova, 2015). Combined data analysis involves comparing the results of the quantitative and qualitative strands to explain research questions jointly.

Implementing a concurrent MMAR approach may prove advantageous for the current study. Compared to single methods studies, MMAR studies may produce findings that lead to a better understanding of intervention outcomes (Fetters, 2020). By augmenting quantitative research with qualitative findings, researchers can gain insight into context-specific factors which is especially valuable for intervention studies in STEM (Fabregues et al., 2022). MMAR designs are particularly well-suited for PAR studies (Ivankova, 2015). The findings of MMAR-PAR studies can allow the researcher to proclaim a “call for change” and “take a stand for improvement” (Creswell, 2022, p. 66). MMAR can confer benefits on the current study by providing a better understanding of intervention outcomes and promoting the agency of the participant-as-researcher role.

The current action research study employed the concurrent MMAR design illustrated in Figure 5. The quantitative strand for the current study involved conducting pre- and post-intervention Stages of Concern Questionnaires to measure changes in PLC members’ SoCs during the intervention. The qualitative strand consisted of conducting post-intervention semi-structured interviews with PLC members to gain insight into PLC members' lived experiences while engaging in intervention activities. Specifically, the semi-structured interviews were a qualitative tool for measuring PLC members' SoC, LoU, and IC dimensions. The results from each strand were jointly compared to develop meta-inferences, informing the current action research study's research questions and subsequent intervention cycle. The following sections provide more detail regarding the current action research study's concurrent MMAR design, including descriptions of the quantitative and qualitative strand data collection and analysis.

Figure 5

Visual Diagram of the Concurrent MMAR Design



Quantitative Strand

The purpose of the quantitative strand was to gather information on participating science teacher's SoCs. Measuring the SoC dimension provided data about the affective factors that may have influenced the implementation process. The following section describes how SoC data were collected and analyzed in accordance with the CBAM framework.

Data Collection

SoCQ. The Stages of Concern Questionnaire (SoCQ) was the primary instrument for measuring participating teachers' SoCs. The four teachers participating in the study completed the SoCQ pre- and post-intervention. Previous research demonstrated the reliability and validity of the SOCQ (Barucky, 1984; Hall et al., 1979; Hall et al., 1991; Jordan-Marsh, 1985; Kolb, 1983; Martin, 1989; Van den Berg & Vandenberghe, 1983). The SoCQ showed good reliability for Cronbach's alpha of α=0.64-0.83 and good test-retest reliability of r= 0.65-0.86 (Saunders, 2012). The survey contained a cover letter and introductory page followed by 35 response items representing one of the seven SoCs, five statements per SoC (see Appendix B). Participants responded to each item on a seven-point Likert scale (0-7) based on their familiarity.

Data Analysis

Quantitative data analysis was performed on participants' scores from the SoCQ. Data analysis aimed to derive SoC findings that apply to the PLC group. The developers of CBAM found that whole-group analysis is possible through the transformation of individual scores. The following sections provide an overview of quantitative data analysis as a more detailed explanation is provided in Chapter Four.

SoC Profiles. George et al. (2006) provided a protocol and template to standardize SoCQ data analysis. Participants' SoC profiles were constructed by following the protocol in three steps: (1) Calculating and totaling the raw scores for each SoC stage; (2) Converting the totals to percentile scores using the conversion chart provided in the

SoCQ manual; (3) Transcribing percentiles into a line graph that served as participants' SoC profiles.

Group SoC Profile Interpretation. Analysis of the individual SoC profiles provided insight into the current and future cycles of an intervention study. According to the SoCQ Manual, the peak profile score was essential for profile analysis. To provide a point of reference for analyzing the PLC as a whole group, a SoC Profile was developed for the combined group PLC. The SoCQ Manual recommended calculating a mean from the individual raw scores and translating the means into the provided percentile table. The percentile scores were transcribed onto a line graph to form the PLC SoC Group Profile.

Qualitative Strand

According to the Hall et al. (2013), educational programs fail not because of the quality of an innovation but an impotence of using an innovation to change classroom practices. The LoU dimension was measured to address this potential implementation barrier. LoU represented the degree and fidelity with which participating science teachers were using the innovation to augment classroom practice. Gathering more information on how and to what extent the innovation changed science teachers' instructional behaviors via LoU, combined with SoC data, painted a more complete picture of the implementation process (George et al., 2013).

Data Collection

Semi-structured interviews were conducted post-intervention with the four participating teachers. Conducting semi-structured interviews allowed for probing specific topics of the investigation while providing space for participants to share their perspectives on their intervention experiences (Galletta, 2013). A phenomenological approach was assumed during the interviews to “understand the meaning of [the teachers'] experience, to walk in their shoes, to feel things as [they] feel them, to explain things as [they] explain them” (Spradley, 1979, p. 34). Acquiring abstractions of meaning can provide valuable insights into how the participants perceived their intervention experience rather than relying solely on objective data.

An interview guide was framed around the CBAM dimensions and PLC principles (see Appendix C). Before the interview, informed consent was obtained for recording the interview. An electronic application, Voice Recorder, recorded and transcribed the interview on a password-protected smartphone. Transcriptions were uploaded into HyperRESEARCH (2023) on a password-protected computer. The uploaded data underwent intelligent verbatim transcription to improve readability by editing for punctuation and omitting verbal fillers (e.g., um, like) (Bucholtz, 2000; McMullin, 2023).

Data Analysis

Semi-structured Interviews. Transcripts were coded and categorized via structural coding (Saldana, 2021). The codebook included concepts that aligned to the study’s research questions. Two cycles of coding refined the codebook by grouping similar initial codes into subcodes. supported the application of structural coding as an analytic strategy for semi-structured interviews and studies with multiple participants. Furthermore, structural coding will allow for ease of access to the data in subsequent iterations of action research. The current section provided an overview of qualitative data analysis, and a more detailed explanation is provided in Chapter Four.

Game Planning with the CBAM Framework

Measuring the implementation process provides valuable information for monitoring the intervention's progress. The change facilitator can make informed decisions when planning and carrying out the intervention activities (Hord et al., 2006). The change facilitator approaches the intervention analogous to how an athletic coach prepares for a game. A coach prepares a game plan by assessing their opponent and developing strategies for their team accordingly. Similarly, the change facilitator uses data collection and analysis to assess the implementation process. From this information, the change facilitator develops an intervention game plan.

The intervention game plan was organized into a diagram outlining long-range strategies and supporting actions. The six strategies aligned with the characteristics of authentic PLCs from Hord and Sommers (2016). Supporting actions coincided with the CBAM diagnosis or the current extent or quality of the implementation process (American Institute for Research, 2015). The CBAM diagnosis was derived from a Cycle 1 pilot study and pre-intervention SoC measurement data. Group measures for SoC and LoU were used to address the needs of the PLC. Incidents were included in the game plan within the corresponding strategy and diagnosis. Hord et al. (2014, p. 83) described incidents as the “specific supportive actions that make it possible to accomplish the larger strategy.” A PLC group diagnosis was derived from the data analysis of SoC and LoU measurements complemented by the IC.

The Cycle 1 pilot study and pre-intervention SoC results informed the current study's initial intervention game plan (Table 2). Cycle 1 and pre-intervention SoC profiles expressed similar trends in participants' concerns. Participants exhibited concerns relative to a non-user of an innovation due to the most intense concerns peaking in Stage 0 Informational and Stage 1 Personal (George et al., 2006). LoU measures were not used in the diagnosis since this was the first time the innovation was introduced. The initial game plan included more incidents about SoC Stages 0, 1, and 2. The goal was to target these stages during the present study but maintain an awareness of the other stages. Throughout the intervention, the game plan was updated to address the ongoing needs of the PLC. A professional book study was a prominent incident for the intervention because it connected many other incidents in the game plan and provided the framework for the IC Map operational forms. The professional book study is further explained below in the game plan.

Table 2

Initial Intervention Game Plan

	Diagnosis		
Strategies	SoC 0, 1, 2 LoU 0, I, II Incident(s)	SoC 3 LoU III Incident(s)	SoC 4, 5, 6 LoU IVA, IVB, V, VI Incident(s)
A Shared Vision of Change	☐ Develop a shared vision of change ☐ Revisit and revise throughout intervention		
Professional Learning	☐ Book Study- AST ☐ Co-construct IC Map ☐ Example lessons ☐ Discuss K-12 Framework during PLC meetings	☐ Suggest utilizing only one IC for an entire unit	☐ Create opportunities by carving time outside of regular schedule for PLC meetings
An Implementation Plan and Required Resources	☐ Introduce the IC to the PLC ☐ Conduct PD		
Implementation Progress	☐ SoCQ ☐ Semi-structured interviews		
Ongoing Assistance	☐ Support through PLC meetings ☐ One-legged interviews		☐ Conduct PLC meetings as often as possible
A Context That Supports Change	☐ Remind teachers of the impending ratification of the new state science standards ☐ Express enthusiasm for teachers' involvement	☐ Determine most efficient platform of communication (i.e., Teams, Email, Slack) ☐ Develop a schedule for teachers	☐ Celebrate PLC collaboration efforts

Chapter 3 described the current study's research methodological design. A concurrent MMAR design was adopted for collecting and analyzing data from quantitative and qualitative strands. Chapter 3 concluded by presenting the initial intervention game plan. Chapter 4 elaborates on quantitative and qualitative strand analysis and the primary findings. Meta-inferences from integrated findings are also discussed in Chapter 4.

CHAPTER 4

DATA ANALYSIS AND FINDINGS

This action research study examined the influence of a PLC-based intervention to support the local implementation of the new Pennsylvania academic standards for Science, Technology and Engineering, and Environmental Literacy and Sustainability (STEELS). A concurrent mixed methods action research (MMAR) design was adopted for data collection and analysis. In a concurrent MMAR design, quantitative and qualitative strand data collection and analysis are performed separately (Ivankova, 2015). Then, the findings from the quantitative and qualitative strands are integrated to develop meta-inferences. The data were sourced from four teachers participating in the PLC-based intervention in the quantitative and qualitative strands. The quantitative strand consisted of collecting and analyzing Stages of Concern (SoC) data via participants' responses to the Stages of Concern Questionnaire (SoCQ). Quantitative analysis of SOCQ data produced pre- and post-intervention PLC SoC group profiles. The qualitative strand consisted of collecting data via semi-structured interviews with participating teachers, and the interview data were deductively analyzed via structural coding. Combined data analysis of the quantitative and qualitative findings produced meta-inferences to inform the current study's research questions.

Concurrent MMAR data analysis and findings are reported in the following sections. The first section describes data analysis and findings from the quantitative strand. The second section describes data analysis and findings from the qualitative strand. The third section presents meta-inferences by combining quantitative and qualitative strand findings.

Quantitative Strand Analysis

Data were processed and analyzed to develop pre- and post-intervention PLC SoC group profiles. The profiles were developed from participants' responses to the pre- and post-intervention SoCQ. The SoCQ contained 35 statements based on a seven-point Likert scale. Each of the seven SoC stages represented five questions on the SoCQ. SoCQ data were analyzed using the following conventions outlined in the SoCQ Manual (George et al., 2006).

1. Participants' individual responses to the SoCQ were scored and categorized into corresponding SoC stages.

2. Scores were summed, yielding participants' individual raw scores for each SoC stage.

3. Mean SoC stage scores were calculated from individual raw SoC stage scores to develop group scores for each SoC stage.

4. Mean SoC scores were converted into percentile scores provided by the SoC Manual. These percentiles were derived from analyzing SoCQ responses by 830 educators representing elementary, secondary, and university levels.

5. Percentile scores were plotted against corresponding SoC stages to produce a PLC SoC group profile. Percentile scores are expressed as the relative intensity of a corresponding SoC stage.

Quantitative analysis focused on “establishing a holistic perspective” of the “description of the relative intensity of the Stages of Concern about a particular innovation for the respondents” (p. 52). In other words, the individual SoC stage score assessment should be contextualized with other SoC stage scores. This assessment is primarily accomplished through complete SoC profile analysis, including peak SoC scores and profile interpretation. Peak score analysis identified the first- and second-highest SoC scores. Profile interpretation involved comparing the plots of the pre-and post-intervention PLC SoC profile scores to the typical SoC profiles referenced in the SoC Manual.

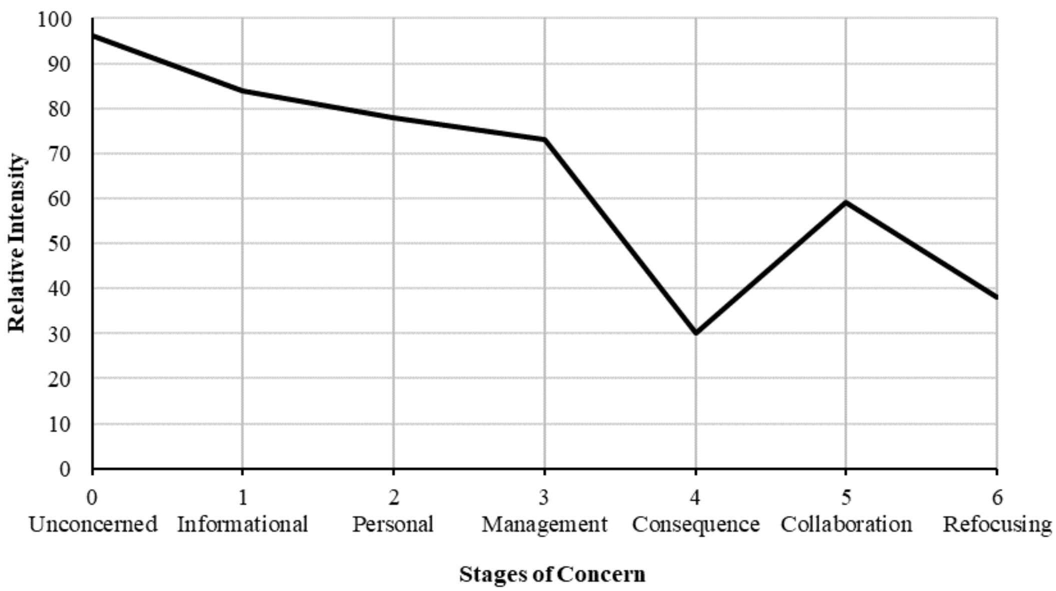
Quantitative Strand Findings

Quantitative data analysis of pre-and post-intervention PLC SoC group profiles yielded findings to inform the study’s research questions and guide future cycles of the implementation process. The findings are presented in three sections. The first section presents the analysis and findings of the pre-intervention PLC SoC group profile. The second section presents the analysis findings of the post-intervention PLC SoC group profile. The third section presents a comparison analysis of pre- and post-PLC SoC group profiles.

SoCQ data are most commonly displayed and analyzed using line graphs (George et al., 2006). The seven SoC stages are plotted along the horizontal axis, and the relative intensity of each stage is plotted along the vertical axis. Relative intensity is derived from the conversion of SoCQ raw scores into percentiles. The percentile scores are connected to form a line graph known as an SoC profile. Interpretation of the SoC profile is primarily based on the highest scores, or peaks, of the SoC profile; however, SoC profile analysis can provide insights into the "affective stance", feelings and emotional intensities, implementers are taking towards an innovation (p. 37). Gauging the affective stance through the SoC profile can help inform the design of future intervention cycles.

Figure 6

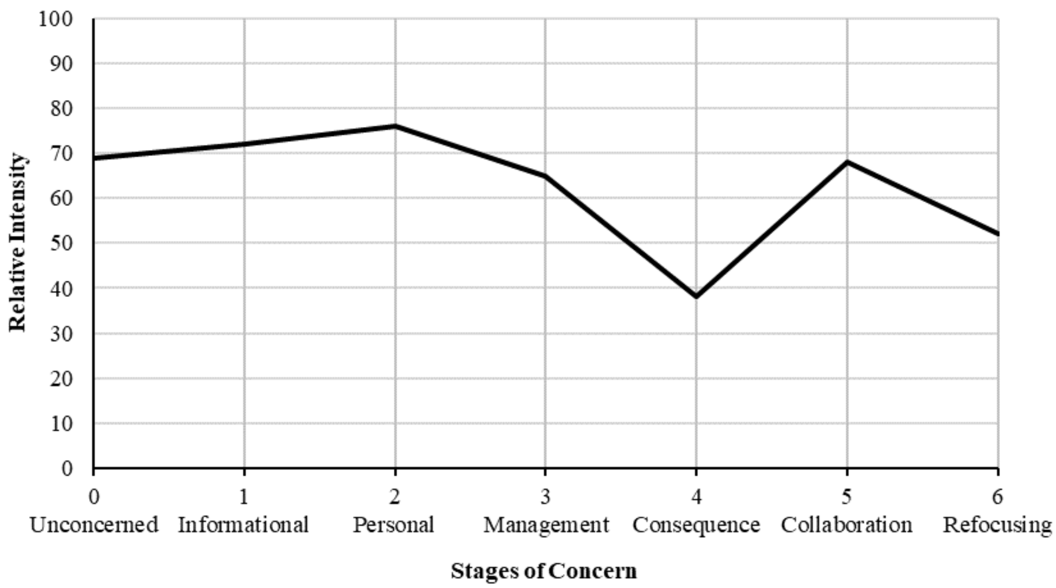
Pre-intervention PLC SoC Profile



The pre-intervention PLC SoC group profile is illustrated in Figure 6. Peak score analysis showed the most intense concerns at Stage 0-Unconcerned. High Stage 0 scores indicated that the PLC group was more concerned about other teaching responsibilities rather than implementing STEELS (p. 48). The PLC group expressed the second highest intensity at Stage 1-Informational. High Stage 1 scores indicated concerns about seeking more information about implementing STEELS. According to the SoCQ Manual, most non-users of an innovation score highest in Stages 0, 1, and 2. High Stage 0 and Stage 1 scores from the pre-intervention SoCQ analysis suggested that the PLC group had little to no experience implementing STEELS at the beginning of the intervention. Overall, the pre-intervention PLC SoC group profile resembled the typical non-user profile of an innovation according to the SoCQ Manual (p. 38).

Figure 7

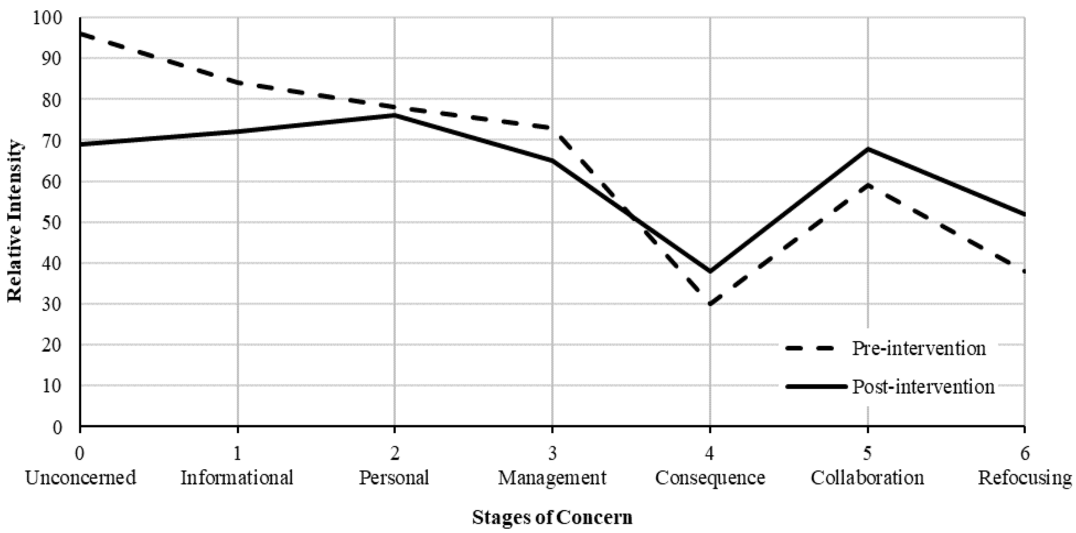
Post-intervention PLC SoC Profile



The post-intervention PLC SoC group profile is illustrated in Figure 7. Peak score analysis showed the most intense concerns at Stage 2-Personal. High Stage 2 scores indicated that the PLC group had intense concerns about the consequences of implementing STEELS. The PLC group expressed the second highest intensity at Stage 1-Informational. High Stage 1 scores indicated concerns about seeking more information about implementing STEELS. Overall, the post-intervention PLC SoC profile resembled the typical profile referred to as a *negative one-two split* (p. 40). This profile suggested that the PLC group has personal concerns that may override their interest in learning more about the innovation.

Figure 8

Movement of PLC Members' Concerns Pre- and Post-intervention



The relationship between pre-and post-intervention PLC SoC profiles is illustrated in Figure 8. Comparison indicated decreased concerns for Stage 0-Unconcerned, Stage 1-Informational, Stage 2-Personal, and Stage 3-Management and increased concerns for Stage 4-Consequence, Stage 5-Collaboration, and Stage 6-Refocusing. The SoC Manual recommended using the group average raw SoCQ scores for comparison analysis. Stage 0, 1, 2, and 3 decreased in group average raw SoCQ scores by 33%, 0.05%, and 24%, respectively. Stage 4, 5, and 6 groups increased average raw SoCQ scores by 36%, 24%, and 29%, respectively.

Qualitative Strand Analysis

Semi-structured interviews were recorded and transcribed via the iOS application Audio Recorder. The transcribed data was uploaded into HyperRESEARCH (Version 4.5.6, 2023) qualitative analysis software. Participants were randomly assigned T1, T2, T3, or T4 labels for confidentiality. Qualitative analysis was conducted via the coding process. According to Saldana and Osmata (2018), the coding process involves essence-capturing and assigning words as symbols to the data corpus in portions. Synthesis brings these portions together based on degree of similarity, which helps to form meanings to codes. Qualitative analysis took a deductive approach to coding and synthesizing the interview data in the current study and is described in more detail in the following section.

Deductive Approach

A deductive approach to coding was adopted in the current study because it was essential to identify participants' expressions of CBAM and PLC theoretical concepts. Deductive approaches align data with pre-determined, or a priori, codes (Saldana, 2021). The advantage of a deductive approach is in using pre-determined, or *a priori*, codes that help narrow the focus of the analysis. Codes based on these concepts can improve the recognition of related expressions in the interview data, aligning the qualitative analysis with the study's research questions (Bingham & Witkowsky, 2022). To get there, a strategy known as structural coding was adopted with a deductive approach.

Structural Coding. According to Saldana (2021, p. 129), structural coding "applies a content-based or conceptual phrase representing the topic of inquiry to a segment of data to both code and categorize the data corpus." Researchers develop codes from a study's theoretical or conceptual framework concepts or inquiry topics sourced from a study's research questions. In essence, the structural coding process frames qualitative analysis around a study's research questions. As a deductive approach, structural coding can aid the researcher in identifying relevant data and aligning analysis to the aim of the study.

The structural coding process started with listing the current study's research questions (Saldana, 2021). Two cycles of coding were applied to the data using the pre-determined codebook. The first cycle of coding consisted of developing and attaching structural codes to each of the present study's research questions. The structural codes were derived from the primary topics in the research questions. The data corpus was categorized under the corresponding research question and structural code. Second cycle coding further refined the segmented data by assigning subcodes for each research question.

Structural Codebook. The structural codes and subcodes were developed *a priori* from the theoretical concepts embedded in the research questions (see Table 3). Research Question #1 structural code PLC IC was broken down into subcodes representing the five principles of effective PLCs. Developing the IC Map anchored the PLC activities during the intervention. Research Question #2 PLC SOC structural code refined into subcodes representing the seven SoC Stages of CBAM. Research Question #3 LOU structural code refined into subcodes representing the eight Levels of Use of CBAM.

Table 3

Structural Codebook

Research Question	Structural Code	Subcodes
How does engaging in a Professional Learning Community support the development of a district-level Innovation Configurations Map?	PLC IC	SHARED BELIEFS SHARED LEADERSHIP COLLECTIVE LEARNING SUPPORTIVE CONDITIONS SHARED PERSONAL PRACTICE
How and to what extent do the school district's science teachers' Stages of Concern profiles change as they engage in the Professional Learning Community?	PLC SOC	UNCONCERNED INFORMATIONAL SELF MANAGEMENT CONSEQUENCE COLLABORATION RECONFIGURATION
How do participating teachers express STEELS-related Levels of Use after engaging in the Professional Learning Community?	PLC LOU	NONUSE ORIENTATION PREPARATION MECHANICAL ROUTINE REFINEMENT INTEGRATION RENEWAL

Examples of coding results are presented in Table 4 and are provided for the analysis process's transparency. The complete coding report was omitted to maintain conciseness and clarity of writing (American Psychological Association, 2020).

Table 4

Examples of Qualitative Analysis Findings

Structural Code-Subcodes	Examples of Teacher Quotes
PLC IC-SUPPORTIVE CONDITIONS	T2: "In a perfect world where there's lots of time, and people are free."
PLC SOC-CONSEQUENCE	T3: "I don't necessarily think it's easier for me... but I think it's easier for the students."
PLC LOU-REFINEMENT	T4: "…it's self-reflection because I'm thinking about it, but I'm getting some outside judgment from the students."

In summary, quantitative and qualitative data analysis was performed separately in the study's concurrent MMAR design. Quantitative analysis was conducted on SoCQ data to produce pre- and post-intervention PLC SoC Profiles. Predetermined, or *a priori*, structural codes and subcodes were applied during first cycle and second cycle coding, respectively. The subcodes represented essential theoretical concepts of CBAM and PLC, which were extracted from the study's three research questions. Combined data analysis of quantitative and qualitative findings was conducted to produce meta-inferences. The following section reports these meta-inferences and aligns them with the study's research questions.

Meta-inferences

Meta-inferences were developed by integrating the results of quantitative and qualitative strand analysis. Two integration strategies were considered for the current

MMAR design: combined data analysis and merged data analysis (Ivankova, 2015). Combined data analysis involves comparing the results of the quantitative and qualitative strands to explain research questions jointly. In contrast, merged data analysis involves transforming quantitative data into qualitative data or vice versa. Combined data analysis can help confirm findings from each design strand and provide additional information valuable for study implications. Combined data analysis was deemed appropriate for developing meta-inferences because it confirms and provides a deeper understanding of explanations to research questions.

Findings from combined data analysis are aligned with the current study's three research questions below. The research questions headline each section and are explained through meta-inferences from combined data analysis. The explanations include findings from individual quantitative and qualitative data analysis.

Research Question 1

How does engaging in a Professional Learning Community support the development of a district-level Innovation Configurations?

A goal for the current action research cycle was to gauge how the PLC-based intervention helped participating teachers develop an IC Map for implementing STEELS-based instruction. Using the IC Map was not a goal for the current action research cycle. Instead, analysis of interview data identified the principles of effective PLCs to inform a connection between IC Map co-construction and PLC involvement. Therefore, findings may help inform future PLC intervention activities. These findings are explained in the following sections based on themes of effective PLC principles.

Shared Beliefs. PLC members expressed beliefs that align with the philosophy of STEELS, which prioritizes students participating in authentic science discourse and practices rather than the memorization of facts (PDE, 2023). PLC members described how their beliefs align with the STEELS learning philosophy. Teacher 1 explained STEELS-based learning as "investigative" and not "just stand and deliver just to provide lecture." Teacher 2 emphasized the practices of science "...because that's what scientists are doing, and that's what is going to make them better scientists, better students." Teacher 3 explained STEELS-based instruction: "…actually has a bigger purpose as to the importance of how this pertains to the real world". These excerpts provided evidence of Shared Beliefs among PLC members regarding how STEELS-based instruction can influence student learning. Shared Beliefs can foster a common vision, which can drive implementation progress.

Collective Learning. If Shared Beliefs shape desired student outcomes, Collective Learning was how PLC members will facilitate these outcomes. PLC members specifically mentioned phenomenon-based learning in their responses. Teacher 1 stated: "Trying to think about is there some type of anchoring phenomena? Is there something that will catch the students' interest that they want to be more investigative research oriented?" Teacher 2 stated: It "means that we're taking a whole bunch of big science ideas, and we're trying to connect them together, intertwine them together." These responses do not indicate intent, but they show that PLC members know how phenomenon-based learning is at the core of the AST framework. Teacher 1 described using an anchoring phenomenon for a genetics unit, and Teacher 2 described using an anchoring phenomenon for a periodic table trends unit. Teacher 3 explicitly mentioned using an anchoring phenomenon about deer-antler growth and shedding during a genetics unit. These findings suggested that PLC members understood the application of phenomena into instruction, but the application may be only surface level, or the analysis was only surface level. High Stage 1 Informational Concerns may support the former interpretation.

Shared Leadership. During the intervention, the co-construction of the IC Map required shared decision-making among PLC members. The decision of what to include in the IC Map was shared among PLC members. The PLC members did not mention shared decision-making during the interviews. However, PLC members expressed value in the development of an IC Map. PLC members critiqued the current format of STEELS as impractical for implementation. When speaking of NGSS, the basis for STEELS, Teacher 4 stated: “I don’t think NGSS tells you what to do at the classroom level. It sets goals and…It tells you kind of what it should look like, but it doesn't tell you how to get there… AST gives you a tool for that.” Teacher 2 also critiqued the STEELS format, stating that it “is concise and straight to the point, but it filters out a lot of important stuff.” Teacher 1 expressed the IC Map construction as a tool that is “purposeful.” In short, data reveal the benefit of having an instructional guide such as the IC Map for the implementation of STEELS.

Supportive Conditions and Shared Personal Practice. Interview analysis identified relational and structural factors related to the Supporting Conditions of the PLC. PLC members reported the existence of positive relational factors within the PLC.

Even though Teacher 1 stated that they “struggle” with implementing STEELS and AST practices, they feel “supportive or encouraged by others.” Time was a structural factor identified in PLC members’ responses. For example, when asked how the PLC could be modified to improve PLC members’ professional development, Teacher 1 suggested that the PLC could improve upon “…just the frequency, the amount of time” for PLC meetings. Teacher 2 requested that another PLC member observe their instruction and provide feedback “in a perfect world where there’s lots of time, and people are free.” Here, Teacher 2 situated the PLC principle of Supportive Conditions within Shared Personal Practice. This was the only response coded as Shared Personal Practice from PLC members. They may or may not be aware of the value of receiving feedback from other teachers, they may not know how to do so, or it was not a focus of the interview. Irrespective, the lack of data may suggest that Shared Personal Practice should be emphasized in future action research cycles.

Combined Data Analysis with SoC Findings. Hall and Hord (2020) recommended against combining SoC and IC measures when determining the fidelity of innovation implementation. However, the IC dimension was a vehicle for PLC development in the current intervention, not a measure of user fidelity as in Hall and Hord’s research. When the IC Map is completed and implemented, fidelity can become a variable for investigation. Integrating SoC measures may enhance understanding of the dynamic between PLC involvement and IC Map development. The relative decrease from pre- to post-intervention intensities of Stage 0 Unconcerned and Stage 1 Informational concerns may support the effectiveness of the PLC in general on the implementation process. For example, collective learning through the book study provided PLC members with information about STEELS through the AST framework. There was a secondary peak intensity score for SoC Stage 5 Collaboration. PLC members expressed positive relational factors but also concerns about Shared Personal Practice. According to Hall and Hord (2020), teachers with Stage 5 Collaboration concerns typically want to know how their implementation use relates to their colleagues. They are also concerned about coordinating time to learn with colleagues. Teachers expressed these concerns during the interview which may help explain the high intensity of Stage 5, and incorporating more time for Shared Personal Practice may help decrease these concerns.

In summary, there was evidence of positive relational factors among PLC members, and teachers shared common beliefs that align with the STEELS philosophy. Time was identified as a possible inhibitor of implementation. Allocating time for Shared Personal Practice is a potential solution for subsequent intervention phases. Encouraging Shared Personal Practice may also address Stage 5 Collaboration concerns, but the link between these elements requires further investigation. More information related to the current study's SoC findings is found in the next section.

Research Question 2

How and to what extent do the school district's science teachers' Stages of Concern profiles change as they engage in the Professional Learning Community?

Grounded in the CBAM framework, PLC members' concerns were measured quantitatively and qualitatively. The SoCQ and semi-structured interviews were the quantitative and qualitative measures, respectively. Findings from the SoCQ profiles and interviewee responses jointly contributed to assessing participating teachers' concerns. These meta-inferences were also used to connect SoCs with the PLC-based intervention. The following sections discuss the combined data analyses of PLC SoC Profiles integrated with the coded interview responses. The primary meta-inferential claim headlines each section followed by a discussion of combined data analysis.

Pre-intervention, the PLC group expressed concerns related to non-users of STEELS for science instruction. Before the intervention, PLC members' concerns were highest in Stage 0 Unconcerned, Stage 1 Informational, and Stage 2 Personal. High Stage 0, 1, and 2 concerns suggested that the teachers had limited STEELS experience (George et al., 2006). The whole profile analysis was consistent with the profile of a non-user. Though it was to be expected in the initial implementation cycle, the findings helped indirectly confirm the validity of the SoCQ. Also, it was essential to establish baseline SoCQ results for game planning the intervention. Results of the pre-intervention SoCQ were used to plan game plan incidents. For example, the non-users required more information about STEELS-based instruction, so planning professional learning activities was of a priority when planning the initial game plan.

Post-intervention, the PLC group expressed the most intense concerns at Stage 2 Personal, which alluded to changing instruction and risk-taking. The PLC group's concerns profiles moved post-intervention. Peak concerns shifted from Stage 0 Unconcerned to Stage 2 Personal concerns. High Stage 2 concerns suggested that PLC members were most concerned about how implementing STEELS would affect their personal position (George et al., 2006). Consequence concerns of implementing STEELS are limited to self-concerns and not consequences on students. High Stage 2 concerns may reflect an uneasiness but not necessarily resistance to change. Stage 2 Personal concerns about STEELS were expressed by participating teachers during the interviews. Stage Personal concerns are characterized by a PLC member wanting to know they will be affected by an intervention. A typical expression of Stage 2 Personal concerns was stated by Teacher 1: "How is what I'm doing part of this already, or what do I need to fix, change for the future?" Stage 2 Personal concerns were also expressed as risk-taking. For example, Teacher 2 described the implementation of STEELS and the AST framework as "taking some risks, taking some steps…not normally have done in a traditional classroom". Though Stage 1 Information concerns were of the highest intensity, PLC members' responses provided valuable insight for targeting and reducing these concerns.

Post-intervention, Stage 1 Information concerns remained the second highest degree of intensity for the PLC group, and these concerns related to wanting more information about phenomenon-based learning. Stage 1 Informational concerns decreased intensity from pre- to post-intervention SoCQ, but it remained the second highest degree of intensity. High Stage 1 Informational concerns suggested that PLC members still wanted to know more about STEELS implementation (George et al., 2006). The AST framework is driven by phenomenon-based learning. PLC members engaged in professional learning of AST as an instructional framework; however, PLC members expressed a need for more information about how to implement phenomenon-based learning. Teacher 2 requested the following as a future professional development activity: "I would like to see it from the beginning and show me that phenomenon. Show me some activities that I'm participating in… Give me some assessment. Give me a grade for that assessment." The teacher wanted to gain information and learn about implementing the instructional framework from a student's perspective. Teacher 3 expressed similar concerns about needing more information about implementing the AST framework. Teacher 3 found anchoring phenomena "hard to find and make a connection" with lesson activities. Qualitative findings revealed specific areas of concern that may have contributed to the quantitative intensity of Stage 1 Informational, helping to point the direction of future intervention strategies.

Explaining the movement of SoC Group Profile from pre- to post-intervention. Whole group SoC profile analysis showed a negative one-two split where Stage 2 Personal concerns are higher than Stage 1 Informational concerns. From a holistic perspective of SoC profile analysis, Stage 2 Personal concerns remained relatively consistent for the duration of the intervention, while Stage 1 Informational concerns decreased during the intervention. Applying general, non-threatening intervention strategies has caused Stage 2 Personal concerns to remain high while reducing Stage 1 Informational concerns (George et al., 2006). Also, providing PLC members with professional learning of STEELS-related instructional practices through the AST book study may have influenced the reduction of Stage 1 Informational concerns. Teachers may need more support to objectively assess an innovation such as STEELS-based instruction within this context. Moving teachers across the implementation bridge towards higher SoC stages would require the development of objective assessment of STEELS-based instruction.

Research Question 3

How do participating teachers express STEELS-related Levels of Use after engaging in the Professional Learning Community?

Findings from qualitative analysis of interview responses provided insight into participating teachers' LoUs. The findings represented claims for PLC members' use or nonuse of STEELS for science instruction and are listed below. In addition, the use or nonuse claims are elaborated through discussion of specific LoU behaviors expressed by PLC members.

Teachers reported behaviors that correspond with users of STEELS for instruction. PLC members reported behaviors representing LoU III Mechanical Use and LoU Refinement IVB, both LoU levels of users (Hall & Hord, 2020). LoU III Mechanical Use of STEELS is characterized by implementing STEELS-based instruction in a stepwise manner, leading to "disjointed or "superficial" implementation (Hord et al., 2006, p. 55). Teacher 3 implied their instruction was stepwise or "straight from the 5E model", but instruction evolved discontinuously by "throw[ing] things in and then have to remember to get back on track…I just go out of order". Teachers exhibiting LoU Management III Use begin to examine their use of the innovation with respect to the general reactions of students (Hall & Hord, 2020). Teacher 2 reported implementing a unit based on the AST framework for the first time. At the end of the unit, Teacher 2 conducted a student survey to acquire feedback. Teacher 2 also requested information about the stepwise implementation of STEELS and the AST framework. Teacher 4 expressed behaviors corresponding to LoU Refinement IVB Use. At this LoU, a PLC member will adapt to increase the impact of their instruction on students. The following statements by Teacher 4 exemplified LoU Refinement Use: “If [students] can start talking about ‘oh, when we did this, and we measured this,’ then I'm thinking, OK, I'm hitting that [practice]. I self-reflect, and I try to ask questions. I can see if they're adopting the language.” These statements illustrated self-checks and assessing student feedback, which can allow Teacher 4 to adapt instruction to meet the needs of students.

The PLC group took the first steps across the Implementation Bridge. According to Hall and Hord (2020), there may be a correlation between PLC members’ LoU and SoC findings in the early stages of implementation. By analyzing large data sets, Hall and Hord predicted that SoC Stage 2 Personal concerns peak just before entering LoU Mechanical Use III. Combined data analysis of LoU and SoC findings from the current study were consistent with the trends found by Hall and Hord (2020). SoC and LoU data analysis from the current study showed peak SoC Stage 2 Personal Concerns, and PLC members reported behaviors coded as LoU III Mechanical Use. It is important to note, that this finding is consistent with Hall and Hord’s data trend analysis. Therefore, it can be predicted that the PLC group just entered or will enter LoU III Mechanical Use, the first LoU level for users of the innovation, STEELS, into instruction.

PLC group members reported behaviors representative of users of STEELS-based instruction (Hall & Hord, 2020; Hord et al., 2006). Combined data analysis of LoU and SoC findings suggested that the PLC group were novice users in the early stages of implementation. Action researchers have often utilized only one dimension of the CBAM framework or reported the implications of the three diagnostic measures in isolation.

Olson et al. (2020) employed an MMAR model that paralleled the concurrent MMAR design in the current study to study the implementation of a district's strategic plan. By integrating LoU and SoC findings, the researchers were engaged in "deeper dialogue" with school leaders. They provided feedback in a "meaningful and actionable way" that fits within the school context (p. 56). The findings from the combined data analysis were interpreted conservatively to maintain validity. However, communicating the findings from combined data analysis of LoU and SoC can serve as a gateway to dialogue with PLC members and school leaders about the nuanced connections meaningful to successful implementation.

In summary, Chapter 4 elaborated on the quantitative and qualitative data analysis process. Findings were reported and aligned to help explain the study's three research questions. Combined data analysis integrated quantitative and qualitative findings to confirm findings and provide a deeper understanding of the research questions. Chapter 5 concludes the action research report by explaining how the study's key findings were applied to an updated intervention game plan for the next intervention phase.

CHAPTER 5

DISCUSSION

> To finish the moment, to find the journey's end in every step of the road, to live the greatest number of good hours, is wisdom.
>
> —Ralph Waldo Emerson, *Essays: Second Series*

The current action research study employed the CBAM framework to measure the local implementation of STEELS into classroom practice via a PLC-based intervention. The study utilized a concurrent MMAR design to develop findings that informed the implementation process. Chapter 5 discusses key findings and implications for the next phase of local implementation. The implications section includes an updated intervention game plan to guide the next phase of local STEELS implementation with participating teachers. Study limitations are discussed following the implications section. Chapter 5 concludes with personal reflections on the current action research phase.

CBAM Diagnosis

Locating the PLC group on the implementation bridge was an essential outcome of the current action research cycle because it served as the baseline measure for the following action research cycle. Hall and Hord (2020) described the location of an individual or group on the implementation bridge is referred to as a CBAM *diagnosis*. The CBAM diagnosis process consists of measuring, interpreting, and identifying implementation. A diagnosis helps practitioners develop a treatment or intervention plan in both cases. The CBAM diagnosis of the PLC group was determined by measuring the three diagnostic dimensions of CBAM as reported in the current study and is best described from the position of the PLC group on the Implementation Bridge. To that end, the PLC group is in the early stages of the implementation process at SoC Stage 2 Personal and LoU III Mechanical Use. Intense Stage 2 Personal concerns suggested that PLC members may be uncertain about their capability in implementing STEELS-based instructional practices. At LoU III Mechanical Use, teachers may be focused on the day-to-day use of STEELS with limited time for reflection, and their instructional changes, if any, are made for the benefit of the teacher (George et al, 2006). It is important to note that CBAM diagnosis is not intended to evaluate teacher performance but as a progress gauge to inform implementation strategies (Hall & Hord, 2020; Hord et al., 2006).

The CBAM diagnosis provided a new starting point for the next cycle of action research by informing the strategies to incorporate in an updated intervention game plan. The following section reviews the format of the intervention game plan and explains how the findings of the study were used to update the initial game plan.

Updated Intervention Game Plan

Successful implementation of STEELS into classroom practice requires a well-informed game plan. The initial intervention game plan was updated to match the current CBAM diagnosis and address barriers uncovered through the current action research cycle. Intervention activities were added or modified from the initial intervention game plan. Recommendations for intervention activities garnered from the literature were adapted to the intervention context (Hall & Hord, 2020; Hord et al., 2006). Some intervention activities were carried over from the initial intervention game plan if they still served a purpose in advancing implementation. The implementation process will continue to be measured using the SoCQ and semi-structured interviews. The LoU Questionnaire will be employed in the next cycle to provide additional data to inform the implementation process. The CBAM game plan format was introduced by Hord et al. (2006) and has yet to be redesigned. Olson (2020) created a format for cross-referencing findings from CBAM action research, but it was developed for communicating findings rather than a practical tool for change facilitators. In future iterations of action research, when more data is processed, it may be helpful to augment the format.

Intervention activities fit into corresponding columns based on their targeted CBAM dimension. Some activities only target a specific SoC or LoU, while others may address both SoC and LoU dimensions. Using the descriptions of the strategies from Hord et al. (2006) and Hord and Sommers (2008), each activity was organized horizontally into a corresponding strategy. New strategies for the next cycle are italicized. The updated game plan title included a version number 2.0 for the purpose of tracking multiple game plans through iterative implementation cycles. The game plan is not meant to be immutable. It is intended to be flexible and responsive to changes during the intervention process. The game plan's purpose is to promote rationalized intervention strategies, informed by CBAM measures, that support the needs of the PLC in the most effective way possible.

With guidance from Hall and Hord (2020) and Hord et al. (2006), intervention incidents were added or modified from the initial game plan to address the CBAM diagnosis of intense Stage 2 Personal concerns and advance the PLC group out of Mechanical III Use. In addition, addressing intense Stage 1 concerns is imperative during the subsequent implementation phase. These types of concerns can fester and permanently block advances in implementation. In addition, the PLC group appears to be on the cusp of moving into LoU III Mechanical Use. Intervention activities that address higher SoC stages and LoU levels were included because not all teachers will progress simultaneously. The updated intervention game plan is presented in Table 5 below along with an explanation of modified strategies.

Table 5

Intervention Game Plan 2.0

	Diagnosis		
	SoC 0, 1, 2 LoU 0, I, II	SoC 3 LoU III	SoC 4, 5, 6 LoU IVA, IVB, V, VI
Strategies	Incidents	Incidents	Incidents
A Shared Vision of Change	☐ Revisit and revise throughout intervention		
Professional Learning	☐ *AST Book Study-Instructional Practices 3 & 4* ☐ *Continue co-construction of IC Map*	☐ *Create a resource library for the PLC* ☐ *Emphasize the storyline of STEELS-based instruction* ☐ *Target appropriate student assessment* ☐ *Encourage peer-to-peer assessment of lessons*	
An Implementation Plan and Required Resources	☐ *Construct the game plan from current cycle findings and recommendations from the literature*		
Implementation Progress	☐ SoCQ ☐ LoUQ ☐ Semi-structured interviews ☐ 1 v. 1 check-ins		
Ongoing Assistance	☐ Support through PLC meetings ☐ Perform scheduled, weekly check-ins with participating teachers		☐ *Schedule at least two more PLC meetings during marking periods 3 and 4*
A Context That Supports Change	☐ Continue to build rapport with participating teachers ☐ *Clarify how STEELS relates to priorities demanding time and energy* ☐ *Share findings and gameplan with administration*	☐ *Advocate for time for self-reflection, meetings, and peer-to-peer observations*	☐ Celebrate PLC collaboration efforts *and wins from previous cycle* ☐ *Advocate for Consequence concerns*

Game Plan 2.0 Strategies

- Continue our AST book study and co-construction of the IC Map as our primary professional development activity. The PLC spent considerably more time than anticipated on the first two AST instructional practices. What was sacrificed in completing the IC Map was gained in meaningful dialogue amongst PLC members. With Peak Stage 2 Personal concerns and high Stage 1 Informational concerns, it is critical to provide Professional Learning for PLC members. The goal is to pilot the IC Map for use before the end of the current school year, 2023-2024.
- Share Implementation Game Plan 2.0 with PLC members to prepare for the next intervention cycle. Feedback will be solicited from PLC members to support Shared Leadership. PLC members should feel their needs are being addressed by the actions of the PLC.
- Schedule weekly check-ins with PLC members to provide ongoing assistance and try to tailor assistance to meet the specific needs of each PLC member. PLC members' needs may be assessed through individual SoC Profile analysis, LoU interviews, semi-structured interviews, and informal interviews.
- The CF will continue to build rapport with PLC members by practicing empathy for their concerns and describing how STEELS-based instruction can integrate into their current instructional practices. Actively listening to their concerns and practicing empathy rather than evaluating their use of STEELS-based instruction can build trust and promote a system of support for PLC members.

- Share the findings of the current cycle of action research and Intervention Game Plan 2.0 with the administration and solicit feedback. Support for change must come from the top because school leaders wield the authority and power to make decisions that foster a context supporting change.
- Advocate for resources necessary for implementation with district administration. Teachers' most common request for a resource was time to self-reflect and conduct meetings outside of time needed for instructional responsibilities. As a participating teacher recommended, online resources such as videos will be available for PD. For example, AST and NGSS websites provide these resources for teachers. Online resources can supplement in-person professional learning and help address PLC members' concerns between meetings.
- If time allows for peer observations, PLC members can visit each other's classrooms, assess instruction using the IC Map, and provide feedback. This incident has a two-fold purpose of fostering Shared Personal Practice and addressing Level III Mechanical Use. Teachers struggling with the day-to-day implementation of STEELS may benefit by observing other teachers that found solutions to similar problems.
- Teachers must not lose sight of the primary reason for changing practice—improving students' learning experiences. Therefore, the PLC group will be encouraged to make decisions based on student outcomes, which can foster Consequence concerns and move PLC members across the implementation bridge.

As the next cycle of the intervention unfolds, the implementation process will be continuously monitored using observations from check-ins and PLC meetings, and the game plan may be adjusted according to the needs of the PLC teachers. CBAM dimensions will be measured at the end of the next cycle to inform another phase of implementation beginning the 2024-2025 school year.

Study Limitations

The current cycle of action research incurred four primary limitations. First, sample size was a limiting factor. Only four teachers participated in the intervention which narrowed analysis and findings. I expected 8-10 teachers to participate, but one high school teacher and one middle school teacher elected not to participate. Another middle school science position was vacated, and a replacement was only found after the intervention was underway. Four district elementary teachers could not attend meetings due to other school policy implementation responsibilities. Second, group SoC profile analysis took precedence over individual SoC profile analysis. Though participants' individual SoC data were used for the analysis per the protocols outlined by the designers of CBAM, individual SoC data analysis may have provided another layer of insight into intervention outcomes. Group SoC data analysis was prioritized over individual SoC data analysis to establish a team-oriented mentality and avoid the perception of singling-out PLC members. Monitoring the intervention in the future may benefit from developing separate claims from SoC measures, and these findings may help tailor the intervention activities to individual participants. Third, there was no measure to assess my role as a change facilitator. Though I attempted to practice the behaviors of an effective change facilitator, I did not perform a formal self-assessment. A tool within the CBAM framework for such a measure is the Change Facilitator Style Questionnaire (CFSQ; Hall & Hord, 2020). The CFSQ was not included in the current action research cycle because I envisioned my role as more of a participant rather than a change facilitator when planning the intervention. Perhaps, I was too modest during this intervention cycle, and I was apprehensive about violating my participant-as-researcher role. However, I realized transparency in self-assessment as a leader would align with the characteristics of participant-as-researcher. The information from a CFSQ would help me find out more about myself as a change leader. As an alternative self-assessment, this dissertation concludes with a personal account of my experiences during the current action research cycle.

Self-Reflection

I described my role in the current study as participant-as-observer. This role included many responsibilities including performing action research, facilitating change through the intervention, and learning alongside participating teachers as a PLC member. No direct measures of my role were included in the study, so I offer self-reflection as a means of self-assessment through the lens of the *prizes of vulnerability* proposed by Bell (1998). Vulnerability is often tagged with negative connotations because it is associated with our primal stress response to an environmental threat. Researchers experience vulnerability in personal, social, and environmental contexts through perceived threats such as unrealistic research quality, self-doubt, and psychological triggers. By practicing self-reflection, these negative perceptions of vulnerability can transform into positive opportunities for self-improvement, which are the prizes of vulnerability. To conclude the dissertation, I reflect on my experiences with problems of vulnerability during the current cycle of action research and how I can turn these experiences into prizes of vulnerability. In the following paragraphs, I will outline some of the prizes of vulnerability that I identified through self-reflection, including opening lines of communication with my administrators and intellectual humility.

It is a precarious position to ask your administrators for resources that are not readily available, and I felt vulnerable to self-assertion. Even though I have a good relationship with the current administration, I still felt intimidated by asking them since they are my direct supervisor. Bell did not mention collegial relationships as a prize of vulnerability, but I will mention it here. I found that approaching my administrators opened a gateway of communication that fosters change. The scope of principals' responsibilities is broad, and their focus is spread thin. Engaging in dialogue with the principals made me realize they share many of the same aspirations for change. We also were able to understand each other's concerns better and find ways to find solutions cooperatively. Opening lines of communication with my administration will enhance future implementation efforts.

Two threats of vulnerability identified by Bell, the threat of doubt and unrealistic quality standards, crept in at times during the intervention. At our second PLC meeting, I realized we could not construct a complete draft of the IC Map by the end of the current action research cycle. Did I fail as a change facilitator? Will I have enough to show for my dissertation? I took a step back, self-reflected, and realized my vulnerability. This self-doubt was a time when the research process taught me *intellectual humility*. Porter et al. (2022, p. 532) described intellectual humility as "recognizing one's ignorance and intellectual fallibility." No matter how much knowledge or confidence I have in executing the intervention, there are unexpected barriers to the implementation process. Here, the prize of vulnerability is learning how to improve as a change leader and being responsive to the implementation process. I was able to identify gaps in my plan as well as practice resilience. In addition, I found solace in being realistic about what outcomes I can expect from one implementation cycle. For example, I reconciled with the reality that a quality IC Map would take much longer than the time we had to construct a complete draft. Full implementation takes years to achieve, and improvement is ongoing. This phase is only a step on the Implementation Bridge for our PLC.

Guy Kawasaki was right—implementation is hard. It left me vulnerable to the many threats inherent in leadership and action research. Vulnerability is at "the core of shame and fear, but it is the birthplace of joy, creativity, and love" (Brown, 2010, 12:48). Surrendering to my vulnerability allowed me to not just see but embrace the imperfections in the implementation process. I learned the prizes of vulnerability await those who have the courage to lead change and show resiliency through self-reflection when confronted with the challenges of implementing change.

Summary of Action Research

There has been persistent pressure to improve science education in the United States, which led policymakers to enact a myriad of major reform efforts since the late 1950s. Left in the wake of reform was a phenomenon known as the implementation gap between theory and practice. Genealogical analysis of this implementation gap suggested that many factors, such as researcher-educator hierarchy and problems of scaling reform across the vast educational system, contributed to the implementation gap. Shifting the implementation process paradigm to focus on local implementation efforts may help bridge this implementation gap. The recent adoption of the new Pennsylvania academic standards for Science, Technology and Engineering, and Environmental Literacy and Sustainability (STEELS) provided an opportunity to examine how local implementation efforts can help support classroom adoption of STEELS.

The current action research study investigated how a PLC-based intervention supported the implementation of STEELS in the Bellwood-Antis School District. PLC members participated in a professional book study as the primary professional learning activity. The book explained the Ambitious Science Teaching (AST) framework for science instructional practices that align with the philosophy of STEELS-based instruction. PLC members began co-constructing an Innovation Configuration to help science teachers visualize the AST framework in practice. Implementation progress was measured by employing the three diagnostic dimensions of the Concerns Based Adoption Model (CBAM), and the measures were collected and analyzed using a concurrent mixed methods action research design. Quantitative and qualitative data analysis results were merged to produce meta-inferences about the outcomes of the PLC-based intervention and implementation progress. Results indicated that the PLC members have moved onto the implementation bridge and are considered users of STEELS-based instructional practices. Though Stage 1 Informational and Stage 2 Personal concerns decreased during the intervention, these concerns remained relatively intense. The meta-inferences informed the current study's research questions and game planning subsequent action research cycles.

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APPENDIX A

STEELS X AST IC MAP DRAFT

Core Practices	Operations
#1 Planning engagement with important science ideas	☐ Teacher derives important science ideas (big ideas) for the unit from the DCIs. ☐ A phenomenon anchors student learning of important science ideas. ☐ Anchoring phenomenon elicits feelings of wonder, curiosity, and mystery. ☐ Anchoring phenomena allow for different types of explanations and models. ☐ Multiple DCI (science ideas and big ideas) connections are needed to explain the anchoring phenomenon. ☐ Plan learning experiences that support student understanding of connected DCIs. ☐ Plan learning experiences that generate evidence to explain the anchoring phenomenon. ☐ Construct essential questions to guide learning experiences that help students generate evidence related to DCIs. ☐ Check how learning activities align with the gapless explanation and the relevant standard.
#2a Eliciting student ideas	☐ Teachers ask questions rather than explaining. ☐ Do not just "tell" students the answers; give them feedback through questions. ☐ Strategies allow students time to think during whole-class and small-group discussions. ☐ Students' puzzlement and ideas are treated as resources for learning the whole class. ☐ Students' everyday language for science content is recognized as legitimate, and the teachers sculpt their vocabulary to represent more precise scientific language.
#3 Supporting ongoing changes in learning	☐
#4 Pressing for evidence-based questions	☐

APPENDIX B

STAGES OF CONCERN QUESTIONNAIRE

Stages of Concern Questionnaire

Study ID: ____

The purpose of this questionnaire is to determine what people who are using or thinking about using various programs are concerned about at various times during the adoption process.

The items were developed from typical responses of school and college teachers who ranged from no knowledge at all about various programs to many years' experience using them. Therefore, **many of the items on this questionnaire may appear to be of little relevance or irrelevant to you at this time.** For the completely irrelevant items, please circle "0" on the scale. Other items will represent those concerns you do have, in varying degrees of intensity, and should be marked higher on the scale.

For example:

This statement is very true of me at this time.	0	1	2	3	4	5	6	(7)
This statement is somewhat true of me now.	0	1	2	3	(4)	5	6	7
This statement is not at all true of me at this time.	0	1	(2)	3	4	5	6	7
This statement seems irrelevant to me.	(0)	1	2	3	4	5	6	7

Please respond to the items in terms of **your present concerns,** or how you feel about your involvement with **Pennsylvania standards for Science, Technology & Engineering, Environmental Literacy & Sustainability (STEELS)**. We do not hold to any one definition of the innovation so please think of it in terms of your own perception of what it involves. Phrases such as "this approach" and "the new system" all refer to the same innovation. Remember to respond to each item in terms of your present concerns about your involvement or potential involvement with the innovation.

Thank you for taking time to complete this task.

0	1 2	3 4 5	6 7
Irrelevant	Not true of me now	Somewhat true of me now	Very true of me now

Circle one number for each item.

1. I am concerned about students' attitudes toward the innovation.	0	1	2	3	4	5	6	7
2. I now know of some other approaches that might work better.	0	1	2	3	4	5	6	7
3. I am more concerned about another innovation.	0	1	2	3	4	5	6	7
4. I am concerned about not having enough time to organize myself each day.	0	1	2	3	4	5	6	7
5. I would like to help other faculty in their use of the innovation.	0	1	2	3	4	5	6	7
6. I have a very limited knowledge of the innovation.	0	1	2	3	4	5	6	7
7. I would like to know the effect of the innovation on my professional status.	0	1	2	3	4	5	6	7
8. I am concerned about conflict between my interests and my responsibilities.	0	1	2	3	4	5	6	7
9. I am concerned about revising my use of the innovation.	0	1	2	3	4	5	6	7
10. I would like to develop working relationships with both our faculty and outside faculty using this innovation.	0	1	2	3	4	5	6	7
11. I am concerned about how the innovation affects students.	0	1	2	3	4	5	6	7
12. I am not concerned about the innovation at this time.	0	1	2	3	4	5	6	7
13. I would like to know who will make the decisions in the new system.	0	1	2	3	4	5	6	7
14. I would like to discuss the possibility of using the innovation.	0	1	2	3	4	5	6	7
15. I would like to know what resources are available if we decide to adopt the innovation.	0	1	2	3	4	5	6	7
16. I am concerned about my inability to manage all that the innovation requires.	0	1	2	3	4	5	6	7
17. I would like to know how my teaching or administration is supposed to change.	0	1	2	3	4	5	6	7
18. I would like to familiarize other departments or persons with the progress of this new approach.	0	1	2	3	4	5	6	7

0	1 2	3 4 5	6 7
Irrelevant	Not true of me now	Somewhat true of me now	Very true of me now

Circle one number for each item.

19. I am concerned about evaluating my impact on students.	0	1	2	3	4	5	6	7
20. I would like to revise the innovation's approach.	0	1	2	3	4	5	6	7
21. I am preoccupied with things other than the innovation.	0	1	2	3	4	5	6	7
22. I would like to modify our use of the innovation based on the experiences of our students.	0	1	2	3	4	5	6	7
23. I spend little time thinking about the innovation.	0	1	2	3	4	5	6	7
24. I would like to excite my students about their part in this approach.	0	1	2	3	4	5	6	7
25. I am concerned about time spent working with nonacademic problems related to the innovation.	0	1	2	3	4	5	6	7
26. I would like to know what the use of the innovation will require in the immediate future.	0	1	2	3	4	5	6	7
27. I would like to coordinate my efforts with others to maximize the innovation's effects.	0	1	2	3	4	5	6	7
28. I would like to have more information on time and energy commitments required by the innovation.	0	1	2	3	4	5	6	7
29. I would like to know what other faculty are doing in this area.	0	1	2	3	4	5	6	7
30. Currently, other priorities prevent me from focusing my attention on the innovation.	0	1	2	3	4	5	6	7
31. I would like to determine how to supplement, enhance, or replace the innovation.	0	1	2	3	4	5	6	7
32. I would like to use feedback from students to change the program.	0	1	2	3	4	5	6	7
33. I would like to know how my role will change when I am using the innovation.	0	1	2	3	4	5	6	7
34. Coordination of tasks and people is taking too much of my time.	0	1	2	3	4	5	6	7
35. I would like to know how the innovation is better than what we have now.	0	1	2	3	4	5	6	7

Please complete the following:

1. How long have you been involved with the innovation, not counting this year?

Never ___ 1 year ___ 2 years ___ 3 years ___ 4 years ___ 5 years or more ____

2. In your use of the innovation, do you consider yourself to be a:

non-user ___ novice ___ intermediate ___ old hand ___ past user ____

3. Have you received formal training regarding the innovation (workshops, courses)?

Yes ____ No ____

4. Are you currently in the first or second year of use of some major innovation or program other than this one?

Yes ____ No ____

If yes, please describe briefly:

____

____

____

Thank you for your help!

Stages of Concern Questionnaire (SoCQ 075) is available in the following AIR publications:

George, A. A., Hall, G. E., & Stiegelbauer, S. M. (2006). *Measuring implementation in schools: The stages of concern questionnaire* (Rev. ed.) (Appendix A, pp.79-82 and as a PDF document on an accompanying CD-ROM.) Austin, TX: Southwest Educational Development Laboratory.

George, A. A., Hall, G. E., & Stiegelbauer, S. M. (2006). *Stages of Concern Questionnaire (SoCQ) online.* Available from http://www.sedl.org/pubs/catalog/items/cbam21.html

Hord, S. M., Rutherford, W. L., Huling, L., & Hall, G. E. (2006). *Taking charge of change* (Rev. ed.) (pp. 48-49). Austin, TX: Southwest Educational Development Laboratory.

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SEMI-STRUCTURED INTERVIEW GUIDING QUESTIONS

Semi-structured Interview Guiding Questions

What does STEELS mean to you as a science teacher?

What does AST mean to you as a science teacher?

How has taking part in the PLC affected your implementation of STEELS and AST?

What role do STEELS and AST play in your daily instruction?

How did you learn to integrate STEELS into your instruction?

How would you implement STEELS into a lesson or unit?

What resources are available for teachers in order to support standards-based instruction for our students?

APPENDIX D

IRB APPROVAL LETTER

Type of Review:	Initial Study
Title:	Exploring the Concerns-based Adoption Model (CBAM) and Professional Learning Community (PLC) as intervention strategies to assess new science standards implementation at a local district
Investigator:	Amanda Boutot
IRB ID:	STUDY00017945
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• Implementation Game Plan for PLC Meetings.pdf, Category: Other; • Innovation Configurations, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • Permission Dr. Tom .pdf, Category: Off-site authorizations (school permission, other IRB approvals, Tribal permission etc); • TMartin Supporting Documents_LoU INFORMAL Interview Questions.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • Travis G Martin IRB Protocol_Modified_May4.docx, Category: IRB Protocol;

	• Travis Martin IRB Recruitment Consent Form Final Study Phase May 4.pdf, Category: Consent Form; • Travis Martin Supporting Documents SoCQ.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • Travis Martin supporting_documents SEMI STRUCTUREDinterview questions.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions);

The IRB determined that the protocol is considered exempt pursuant to Federal Regulations 45CFR46 (1) Educational settings, (2)(ii) Tests, surveys, interviews, or observation (low risk) on 5/5/2023.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

If any changes are made to the study, the IRB must be notified at research.integrity@asu.edu to determine if additional reviews/approvals are required. Changes may include but not limited to revisions to data collection, survey and/or interview questions, and vulnerable populations, etc.

Sincerely,

Travis Martin

IRB

Administrator

cc:

APPENDIX E

IRB RECRUITMENT CONSENT FORM

Dear Colleague:

My name is Travis Martin, and I am a doctoral student in the Mary Lou Fulton Teachers College (MLFTC) at Arizona State University (ASU). I am working under the direction of Dr. Amanda Boutot, a faculty member in MLFTC and my dissertation chair. For my dissertation, I am conducting a research study on the implementation of the new Pennsylvania standards for **Science, Technology & Engineering, Environmental Literacy & Sustainability** (STEELS) into our instructional practices. The purpose of this study is to understand better how an intervention may support our district's science educators to implement STEELS.

I am asking for your help which will involve your participation in an intervention to help support the implementation of the new science standards. The intervention consists of participating in a professional learning community (PLC) with other science teachers at our school district. Your participation in the PLC will consist of in-person meetings, a book study, online discussions using the district's virtual platform Microsoft Teams, a maximum of two interviews and two questionnaires (pre/post format).

In-person meetings will be held on a monthly basis during in-services and departmental meetings, schedule permitting. The focus of in-person meetings will be professional development and engaging in conversations regarding the implementation of the new science standards and the Ambitious Science Teaching framework. I anticipate the in-service meetings to last a maximum of six hours and will be held Aug 22, Sept 29, Oct 27, Nov 7, and Feb 16. Online discussions are voluntary, so the amount of time spent on these activities will vary. You can engage in any discussion (online or in-person) at your leisure. Data will be collected from the content of our in-person and online activities. The information you provide in-person or online may be used as feedback for improving our PLC activities. The information may be used for my action research report.

Data will be collected in the form of one semi-structured interview, up to and not exceeding two interviews, and one pre-questionnaire and one post-questionnaire. I anticipate interviews to last a maximum of 25 minutes. I anticipate the pre-questionnaire to be completed within 10-15 minutes. I anticipate the post-questionnaire to be completed within 10-15 minutes. The interviews will not be recorded without your permission. Audio recordings will be deleted from the original recording device upon transfer to the password protected computer and then deleted from computer/could technologies once transcribed. Please let me know if you do not want the information you provide to be recorded; you also can change your mind after the intervention starts, just let me know.

Your participation in this study is voluntary. If you choose not to participate or withdraw from the study at any time, there will be no penalty whatsoever. You must be 18 years of age or older to participate.

The benefit to participation is the opportunity for you to reflect on and think more about implementing science standards into the instructional practices. Interview responses will also inform future iterations of the study. Thus, there is potential to enhance the experiences of our school district's teachers and students. There are no foreseeable risks or discomforts to your participation.

Your responses to the interviews and questionnaires will be confidential. Results from this study may be used in reports, presentations, or publications but your name will not be used. The interview recordings and questionnaires will be labeled with a randomized study ID rather than your name. The information you provide will be transferred to a password protected computer, and deleted from the original recording device. Any information you provide during online or in-person discussions will remain anonymous using randomized study IDs.

If you have any questions concerning the research study, please contact the research team – Amanda Boutot at amandaboutot@asu.edu or (602) 543-3446 or Travis Martin at tgmartin@blwd.k12.pa.us or 814-934-3253.

Thank you,

Travis Martin, Doctoral Candidate
Amanda Boutot, Dissertation Chair

Please let me know if you wish to be part of the study and will let me audio record your responses by verbally indicating your consent.

If you have any questions about your rights as a participant in this research, or if you feel you have been placed at risk, you can contact Amanda Boutot at (602) 543-3446 or the Chair of Human Subjects Institutional Review Board through the ASU Office of Research Integrity and Assurance at (480) 965-6788.

APPENDIX F

COPYRIGHT PERMISSIONS

Dear Travis,

Thank you for your request to reprint the SEDL Stages of Concern Questionnaire in your dissertation. Use of this survey is limited to educational, research, and nonprofit use.

The American Institutes for Research (AIR), of which SEDL is an affiliate, grants you permission to reprint the survey, in whole or in part, in your dissertation and related research study. You may make minor word changes to the survey. For example, you may replace the word "innovation" with another word or phrase.

If you plan to make substantive changes to the survey, please send an email with a brief description of your proposed changes to the AIR Copyright and Permissions Help Desk at AIRCopyright@air.org.
Thank you, and we wish you the best in your scholarly

journey. Kind regards,

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The suggested citation is as follows. You may, however, modify the citation for another editorial style.

> Hord, S. M., Rutherford, W. L., Huling, L., & Hall, G. E. (2006). *Taking charge of change*. 2nd printing, with minor additions and corrections, 2008; revised PDF version uploaded on Lulu.com, 2014. SEDL. https://sedl.org/pubs/change22/taking-charge-of-change-2014.pdf. Used with permission.

We wish you much success as you work toward your doctorate. If we can be of further assistance, feel free to contact us.

Kind regards,

Kim O'Brien

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