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Science Instructional Leadership Knowledge: A Qualitative Case Study

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SCIENCE INSTRUCTIONAL LEADERSHIP KNOWLEDGE: A QUALITATIVE CASE STUDY

by

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ABSTRACT

This qualitative case study aimed to investigate instructional leaders' depths of science content knowledge and pedagogical content knowledge and how their depths of that knowledge supports effective instructional leadership. Implementation efforts around the Next Generation Science Standards (NGSS) have highlighted the need for science instructional leaders to have in-depth content and pedagogical knowledge to function as effective instructional leaders in secondary science classrooms across the United States. Semi-structured interviews with 19 teachers and instructional leaders in a public high school in the southern United States informed the study. The findings revealed that teachers expect instructional leaders to have higher levels of science content knowledge and pedagogical content knowledge to serve in their leadership roles. The findings also suggested science instructional leadership is directly related to instructional leaders' self-efficacies and self-perceptions. For practical implications, instructional leaders at the secondary level may consider these results for reflection on practice and future planning of professional learning for overall school improvement. Recommendations for future research include expanding the sample population to include multiple school districts, rural school districts, and across content areas.

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CHAPTER 1

INTRODUCTION

Science instructional leadership offers new challenges and opportunities stemming from implementing Next Generation Science Practices (Next Generation Science Standards [NGSS], 2021). For strong instructional leadership to be rooted in the sciences, instructional leaders need to work with teachers to promote a growth mindset, foster frequent and ongoing opportunities for feedback, sustain a commitment to teacher development over time, and engage in collaborative practices (Hallinger et al., 2020). The expectation for school leaders to serve as instructional leaders has become prevalent (Fuentes & Jimerson, 2020; Lochmiller & Cunningham, 2019; McBrayer et al., 2020; Yow et al., 2018). In United States public school systems, principals should implement reforms that require instructional leadership across subjects, not just a content-neutral approach (McNeill et al., 2018; Peacock, 2014; Sherman & MacDonald, 2008). Stein and Nelson (2003) demonstrated the challenges of providing high-quality instructional leadership across multiple disciplines. Implementation efforts around the NGSS have highlighted the need for instructional leaders to have in-depth content and pedagogical knowledge to function as effective instructional leaders in secondary science classrooms (Fuentes & Jimerson, 2020; Klein et al., 2018; Yow et al., 2018).

Background and Significance of the Problem

With science teachers striving to meet the goals of the National Science Education Standards (National Research Council [NRC], 2012), a consortium of educators and policymakers released the Next Generation Science Standards (NGSS, 2021), intending to clarify the vision for science education by focusing learning on fewer core concepts, providing a progression of ideas to support student learning, and emphasizing the roles of scientific inquiry and engineering design (Angelle & Teague, 2014; Klein et al., 2018; Peacock, 2014). Science education leaders should act to ensure that teachers and students thrive in this complex and fluid environment, providing ongoing support and guidance (Darling-Hammond et al., 2020).

Recent literature in science education leadership lays out specific challenges and goals for science education (Fuentes & Jimerson, 2020; Klein et al., 2018; Peacock, 2014; Peacock & Melville, 2018). For example, Peacock and Melville (2018) suggested approaches for science education leaders ranging from teacher leaders to principals to state-level administrators. They stated that instructional leaders need a vision that aligns with science practices but does not require (or have the time to obtain) the same level of expertise as the science teachers they lead (Handley et al., 2018; McNeill et al., 2018; Neumann et al., 2018). In the rural K-12 setting, Yow et al. (2018) described content-specific instructional leadership as an underserved and underrepresented area of need.

With the publication of *A Framework for K-12 Science Education* (NRC, 2012) and the release of the Next Generation Science Standards (NGSS, 2021), science teachers face a comprehensive curriculum reform that will shape science education for decades to come. This issue is particularly prominent at the secondary level, where the subject matter is more complex (Lochmiller & Cunningham, 2019; McNeill et al., 2018; Peacock & Melville, 2018; Steele et al., 2015). Science teachers understand the need for instructional leadership specific to science content (Yow et al., 2018). Instructional leaders need to know the "big ideas" and how they interrelate across the curriculum. They need to understand the concepts, skills, and pedagogical decisions necessary for best practices in assessment, pedagogy, and professional development (Lochmiller & Cunningham, 2019). Finally, Stein and Nelson (2003) agreed that school leaders have the authority to establish supportive organizations for learning, and principals can foster an environment that encourages self-reflection on personal classroom practice and the effects of their research efforts.

Problem Statement

The problem at the center of this study is the relationship between instructional leaders' science content knowledge and pedagogical content knowledge and its effects on instructional leadership efficacy in secondary science classrooms. Implementation efforts surrounding NGSS have highlighted the gap between instructional leadership content and pedagogical knowledge and leadership efficacy among secondary science classrooms (Fuentes & Jimerson, 2020; Klein et al., 2018; Yow et al., 2018). More needs to be known about the role leadership content knowledge plays in school leaders' efforts to function as instructional leaders or how teachers respond to the level of perceived leadership content knowledge among leaders (Fuentes & Jimerson, 2020; Klein et al., 2018; McNeill et al., 2018; Shulman, 2013; Yow et al., 2018). The problem is framed and studied through a constructivist lens. From a constructivist perspective, the effective instructional leader is perceived as strategically applying knowledge to solve contextually specific problems and achieve schooling purposes through others (Krug, 1992).

Purpose of the Study

This instrumental case study aimed to learn more about instructional leaders' depth of science content knowledge and science pedagogical knowledge and how their depth of both pedagogical and content knowledge supports effective instructional leadership.

Research Questions

RQ1: What are science teachers' expectations of instructional leaders' science content and science pedagogical knowledge?

RQ2: In what ways do instructional leaders' content-specific pedagogical knowledge and content knowledge affect instructional leadership efficacy?

RQ3: How do leaders perceive their science content and science pedagogical knowledge and its effects on instructional leadership in science?

Limitations

Even when rigorously designed, single-case studies present certain limitations. Because this was a case study and because there was no experimentation or quasi-experimentation, there was no attempt at drawing a random sample or a fully representative sample. Due to conflicting epistemological hypotheses and the intricacy characteristic of qualitative case studies, scientific thoroughness can be difficult to prove and cannot validate any resulting findings in the quantitative sense of internal, external, face, content, and construct validity (Baškarada, 2014; Hamel, 1993; Reis & Judd, 2021).

For this reason, the most notable limitations of this case study were the inability to claim cause and effect, the inability to claim correlation, the inability to claim external validity, and the possibility of unrecognized and unchecked researcher influence on the case study (Merriam & Tisdell, 2016; Reis & Judd, 2021; Stake, 1995; Yin, 1994).

The absence of systematic procedures for case study research is something that Yin (2014) saw as traditionally the most significant concern due to a relative lack of methodological guidelines. A qualitative study aims to acquire a unique understanding of the investigated phenomenon (Reis & Judd, 2021; Stake, 1995; Willis, 2014). However, the same researchers agree that qualitative research in case study is not conducive to predicting when events or behaviors will occur because no experimental treatment is applied to a dependent variable. Instead, case studies can understand the circumstances under which causal relationships can occur, thus understanding the "how" of causality. Nevertheless, due to a lack of actual experimentation in the case study method, no cause-and-effect relationship nor internal validity could be demonstrated.

While causality shows how one variable directly affects a change in another variable, correlation suggests an association between two variables. Although correlation may imply causality, it is different from a cause-and-effect relationship (Dowd, 2017). Dowd further asserts that correlation involves non-experimental research instead of actual experimentation, but it still requires the researcher to measure two variables and assess the statistical relationship between them. Using Yin's (2014) definition of a case study, he claims that it is an empirical inquiry investigating a contemporary phenomenon (the case) in depth and within its real-world context when the boundaries between phenomenon and context may not be clearly evident. Since the case study method only measures the phenomenon, no correlation could be made. Without the ability to claim causality or correlation, it was impossible to claim external validity.

The case study method's third and most prominent limitation was external validity or generalizability. Willis (2014) defines external validity of a study as the extent to which you can generalize your findings to different groups of people, situations, and measures, and the inability to generalize to a broader population after the study. Since case studies do not develop testable generalizations, Reis and Judd (2021) say they are often criticized for not being scientific enough. Merriam and Tisdell (2016) believe the question of generalizability has plagued qualitative inventions for some time. Part of the difficulty lies in thinking of generalizability in the same way investigators use experimental or correlational methodology. With the lack of causality or correlation in a case study, the situational factors and selection bias surrounding this case study made it difficult to have external validity and impossible to translate the findings to another context.

Finally, researcher influence and unintentional predisposition have limitations on case study methodology. As a clinical chemist and biologist for 23 years, the researcher's vast knowledge in the science field enabled specific pedagogical content in the science classroom. Having also taught inside the classroom and laboratory for 4 years, the researcher became aware that the need for instructional leadership with content-specific knowledge was tremendously lacking in many schools at the secondary level. Therefore, researcher positionality was efficacious in this study.

Ethics remained a top priority in this study. Following the methods outlined in Chapter 3 ensured validity and reliability of the study. A concern about case study research, particularly case evaluation, is what Lincoln and Guba (1985) refer to as "unusual problems of ethics" (p. 378). They both stated that an unethical case writer could so select from available data that virtually anything he/she wished could be illustrated (Lincoln & Guba, 1985). Reis and Judd (2021) further agree that both the readers of case studies and the authors themselves need to be aware of biases that can affect the final product. When conducting a case study, the author can form a bias. This bias can be for the subject, the form of data collection, or how the data are interpreted. This is very common since it is normal for humans to be subjective. It is well known that Sigmund Freud, the father of psychology, was often biased in his case histories and interpretations. The researcher can become close to a study participant or may learn to identify with the subject. When this happens, the researcher loses his/her perspective as an outsider (McLeod, 2019; Reis & Judd, 2021; Willis, 2014).

Given that this was a case study and that there was no experiment performed and no random assignments for participants, there was room for possible bias in the methodology. In addition to the methodological bias, the inability to claim causality or correlation and the inability to make generalizations for a broader population, McLeod (2019) affirms that the conclusions drawn from a particular case may not be transferable to other settings. While case studies do possess clear limitations, they can also be a segue to further research for multiple case studies or other methodological research. They also allow readers to make their own naturalistic generalizations, so the study should produce a rich, thick description of both the participants and the research context.

Delimitations

This study measured the relationship between instructional leaders' science content knowledge and pedagogical content knowledge and its effects on instructional leadership efficacy in secondary science. Delimitations in this study were chosen to clarify and narrow the focus of the study. The chosen delimitations include:

- This study was delimited to public high schools in the deep southern United States. This study excluded charter, private, and parochial schools serving K-8 or postsecondary students.
- This study was delimited to principals, supervisors, and science educators who had a minimum of 5 years' experience in their respective fields.
- This study was delimited to the content area of science education. All other content knowledge areas were excluded.

This rationale assumed that increased instructional leaders' science content and pedagogical knowledge improves instructional leadership efficacy.

Definitions

- *Leadership* is the process by which people's actions within a social organization are guided toward realizing specific goals (Krug, 1992).
- *Instructional leadership* defines the behaviors of school managers that directly or indirectly affect teachers' teaching status and students' learning status significantly (Yin, 1994). It is also a process whereby principals are expected to promote professional growth amongst their teaching staff (Sherman & MacDonald, 2008).

- *Leadership content knowledge* is the understanding of academic subjects that are used by administrators when they function as instructional leaders (Yin, 1994). It is the amount and organization of knowledge in the mind (Shulman, 2013).
- *Pedagogical content knowledge* goes beyond subject matter knowledge to the dimension of subject matter knowledge for teaching, including understanding what makes learning specific topics easy or difficult (Shulman, 2013).
- *Efficacy* is the measure of effectiveness or the ability of a product to produce the desired results or effects (Mojarad, 2018).
- *Self-efficacy* is the belief in one's abilities or the strength of people's convictions in their own effectiveness (Bandura, 1977).
- *Leadership self-efficacy* is a more specific strand of self-efficacy. It is the self-assessment of one's perceived ability to organize and implement action required to effectively lead organizational change to achieve a performance outcome (McBrayer et al., 2020).
- *Principal self-efficacy* describes a set of beliefs that enable a principal to enact policies and procedures that promote a school's effectiveness (Versland & Erickson, 2017).
- *Collective efficacy* describes the belief in the capability of one's peers in a larger group or organization (Angelle & Teague, 2014).
- *Science, technology, engineering, and math* (STEM) is experiential learning pedagogy. The application of knowledge and skills is integrated

through in-context projects or problems focused on learning outcomes tied to the development of important college and career readiness proficiencies (National Science Teaching Association [NSTA], 2020).

- *Next Generation Science Standards* are the K-12 science content standards that set expectations for what students should know and be able to do (NGSS, 2021).

Summary

School leaders play critical roles as instructional leaders in reform efforts, yet their backgrounds of scientific knowledge are insufficient to support their teachers (Fuentes & Jimerson, 2020; Klein et al., 2018; Lochmiller & Cunningham, 2019; McNeill et al., 2018; Yow et al., 2018). Content-specific instructional leadership is integral to improving science teaching in rural secondary schools (Steele et al., 2015). Additionally, instructional leaders often lack sufficient content knowledge in science to be effective in this role. School leaders' primary task is instructional leadership, but this work may be complicated when leaders and teachers do not share content area or grade level expertise (Steele et al., 2015).

Studying instructional leaders' depths of science content knowledge and science pedagogical knowledge by navigating through a constructivist lens can lead to understanding how their pedagogical and content knowledge supports effective instructional leadership. More needs to be known about the role leadership content knowledge plays in school leaders' efforts to function as instructional leaders and how teachers respond to perceived leadership content knowledge or lack thereof among leaders (Fuentes & Jimerson, 2020; Lochmiller & Cunningham, 2019; McNeill et al., 2018). The construct of effective science instructional leadership and the relationship between instructional leaders' science content knowledge and pedagogical content knowledge lead the literature review in Chapter 2.

CHAPTER 2

LITERATURE REVIEW

This instrumental case study aimed to learn more about instructional leaders' depth of science content knowledge and science pedagogical knowledge and how their depths of both pedagogical and content knowledge support effective instructional leadership.

Theoretical Framework

The development of sound theory and theory-based instruments is essential for studying instructional leadership's impact on student learning outcomes. From a constructivist perspective, the effective instructional leader is perceived as strategically applying knowledge to solve contextually specific problems and achieve schooling purposes through others (Krug, 1992). While the constructivist perspective has its roots in cognitive science, Kelly (1955) was among the first to draw attention to how people develop unique construct systems that they use to organize and anticipate events and which, in turn, influence the direction of behavior. Since then, beliefs, thoughts, and behavior interpretations have become increasingly legitimate and essential areas for study. Fuentes and Jimerson (2020) use the construct of pedagogical content knowledge through a leadership content knowledge lens, suggesting that focusing only on general instructional practices is insufficient for supporting robust instructional leadership.

School leaders cannot know everything about every content area, particularly in secondary schools. The framework does not negate that broader collaborative and pedagogical strategies can be constructive, but the practices are not mutually exclusive with leadership content knowledge (Fuentes & Jimerson, 2020).

Social Constructivist Theory

Knowledge is co-constructed, and individuals learn from one another (Vygotsky, 1962). It is called a social constructivist theory because the learner should be engaged in the learning process. Since learning happens with other people's assistance, this theory's social aspect is implicated in this study on instructional leadership. Interpretive research assumes that reality is socially constructed; there is no single, observable reality (Merriam & Tisdell, 2016). Instead, there are multiple realities, or interpretations, of a single event. Researchers do not find knowledge; they construct it. Constructivism is often used interchangeably with interpretivism (Merriam & Tisdell, 2016). The interpreter's role and gatherer of interpretations are fundamental (Stake, 1995). Most contemporary qualitative researchers nourish the belief that knowledge is constructed rather than discovered. Neumerski (2012) uncovered what scholars know and do not know in his study on rethinking instructional leadership. He paid particular attention to what scholars have learned about how work is done. Knowledge falls short of future studies' aspirations to address shortcomings around the "how" of instructional leadership that emerges across all theories and constructs.

A fundamental aspect of Vygotsky's social constructivist theory is the zone of proximal development (Vygotsky, 1962). This zone is a range of tasks that an individual cannot master alone but could be mastered with more skilled peers' assistance or guidance. Another part of this theory is scaffolding, which gives the learner the right amount of assistance at the right time. Sherman and MacDonald (2008) found that instructional leaders were recognized for their crucial roles in advancing their relationships with their teachers. Instructional leadership is a process whereby principals and other leaders are expected to promote professional growth amongst the teaching staff. By applying Vygotsky's theory, where one is in a deficit, others can come along and fill in the gap. From a constructivist perspective, the effective instructional leader may be perceived as one who strategically applies knowledge to solve specific problems and achieve the purpose of schooling others (Krug, 1992). However, instructional leaders who lack science content knowledge or pedagogical content knowledge might not be able to apply their experiences and skills as leaders in the diverse ways needed in the secondary classroom.

Leadership Content Knowledge

Leadership content knowledge is knowledge of academic subjects that are used by administrators when functioning as instructional leaders (Stein & Nelson, 2003; Yin, 1994). Content is at the base of the conceptual framework to represent the need for a solid foundation in content knowledge and is needed to ensure high-quality performance (Wake Forest University, 2021). Leadership content knowledge is a missing paradigm in school and district leadership (Yin, 1994). Also, applying subject matter knowledge in leadership is needed to understand science instructional leadership (Stein & Nelson, 2003). From the leadership content knowledge perspective, an instructional leader should combine knowledge of the subject matter taught, knowledge of how to teach that subject matter (i.e., pedagogical content knowledge), knowledge about teachers as adult learners, and knowledge and skills needed to build a learning community that draws on individual expertise to achieve common goals. Using the construct of pedagogical content knowledge suggests focusing only on general instructional practices and is insufficient for supporting instructional leadership (Fuentes & Jimerson, 2020). For that reason, leadership content knowledge is essential in seeding and strengthening instructional leadership efforts.

Instructional leadership literature provides a weak theoretical lens if one is provided at all (Klein et al., 2018). Without a baseline understanding of what good practice looks like and sounds like in a specific content and/or grade level, school leaders may fail to notice the presence or magnitude of instructional problems or be ill-equipped to support exemplary continued development teachers (Fuentes & Jimerson, 2020). By drawing on a robust and relevant theoretical framework for instructional leadership, more focus is on specific (often subject-specific) contexts (Klein et al., 2018). By examining Shulman's (1987) 'amalgam,' the relationship between leadership content knowledge and pedagogical content knowledge implies the requisite combination needed in instructional leadership. The concept of pedagogical content knowledge connects research on learning, thus helping determine constructivist approaches to learning content for teaching (Hausfather, 2001; Shulman, 1987, 2013).

Pedagogical Content Knowledge

Pedagogical content knowledge is knowledge of domain-specific teaching; it is what teachers know about their subject matter and how to make it accessible to students (Schneider & Plasman, 2011). Pedagogical content knowledge represents the blending of content and pedagogy to understand how particular topics, problems, or issues are organized, represented, and adapted to learners' diverse interests and abilities and presented for instruction (Shulman, 1987). Pedagogical content knowledge is the category most likely to distinguish the content specialist's understanding from the pedagogue's. Shulman (2013) insists pedagogical content knowledge goes beyond knowledge of the subject matter, as seen in leadership content knowledge. Instructional leaders need a sense of what makes learning specific topics easy or difficult for those they lead to be effective leaders.

In the past, educational administration scholars have not strongly associated research on instructional leadership with emerging understanding, particularly in secondary science (Lochmiller & Cunningham, 2019). Using the social constructivist theory through a collaboration of leadership content and pedagogical content knowledge lenses, this study aims to build practical and theoretical justifications for instructional leaders and give conceptual structure to elucidate their functions in leading secondary science teachers. Examining two distinct pathways in this study will explore the influence of leadership content knowledge and pedagogical content knowledge on vital instructional leader efforts and highlight the expectations from the science teachers they lead. The first pathway reviews instructional leadership efficacy in science. The second pathway explores the relationship between instructional leaders' science content and pedagogical content knowledge.

Effective Science Instructional Leadership

Influential instructional leaders at the secondary school level are increasingly perceived as critical because of the growing complexity in educational contexts, specifically science. Education contexts are getting increasingly problematic because the changes taking place within these contexts are characterized by growing intensity, rapidity, fluidity, and uncertainty (Hairon, 2017). Quality teaching and students stem from the instructional leader role (Fuentes & Jimerson, 2020). Schools are expected to satisfy the needs of multiple school stakeholders, which are increasingly getting more demanding and complicated – outside the school (e.g., social media, parental groups, private and government organizations) and within the school (e.g., teachers, students) (Fuentes & Jimerson, 2020; Hairon, 2017). Instructional leaders' primary focus is classroom practice and engaging their teachers to promote and support improved teaching (Fuentes & Jimerson, 2020). They are expected to be informed, organized, and focus on instructional improvement and classroom practice. Hairon (2017) further states school leaders thus should mobilize and optimize physical and human resources toward shared organizational goals in increasingly complex educational contexts, particularly in the secondary science classroom, where science historically presents unique challenges for teachers and administrators. Science is traditionally a content area where classroom teachers are not confident in their instruction, especially at the elementary level (Lochmiller & Cunningham, 2019). In an increasingly complex environment, it is no surprise that much of the decision-making power is devolved to school leaders and teachers who can respond to day-to-day demands and issues quickly and appropriately and are sensitive to schools' contextual uniqueness.

Lochmiller and Cunningham's (2019) study on leading learning in content areas explored leadership practices used in mathematics and science instruction to examine the relationship between effective instructional leadership practices and improved student outcomes. Scholars determined this relationship exists whether administrators engage in leadership individually or collectively, as in the case of distributed leadership. Historically, they have positioned mathematics and science instruction as more challenging subjects for administrators without content area expertise to lead (Lochmiller & Cunningham, 2019). It is possible different content areas might demand other leadership actions.

While acknowledging the literature gap where administrative scholars have not strongly associated research on instructional leadership with an emerging understanding of mathematics and science, they have called on the field to make more explicit connections between various leadership bodies (Neumerski, 2012). They aimed to understand and improve leadership efficacy related to mathematics and science instruction to engage leaders in systemic efforts to identify literature connections and focus on effective instructional leadership. Mathematics and science scholars agree that instructional leadership drives schools' content area leaders to facilitate high-quality instructional experiences for students and presume adequate supervision requires significant pedagogical and content area understanding (Jackson et al., 2015).

Lochmiller and Cunningham (2019) identified two themes. First, effective instruction rests on both subject matter knowledge and knowledge of pedagogy, which raises critical questions about how principals engage in classroom instruction. Next, the most challenging aspect of a leader's work requires an enhanced understanding of the content teachers are covering. Principals should have sufficient knowledge of both content and pedagogy to guide teachers toward improved instructional practices (Lochmiller & Cunningham, 2019). The need for quality guidance and support comes from the instructional leaders' levels of science efficacy, thus influencing their advice.

Principals should consult with other school staff to improve science instruction. However, this does not excuse them from knowing what good science instruction entails. Instead, principals should engage in content area instruction with intention and approach the work by supporting and inviting others to facilitate and guide the improvement effort (Lochmiller & Cunningham, 2019; Stein & Nelson, 2003).

McBrayer et al. (2020) investigated instructional leadership practices and the degree to which the practices predicted school leaders' self-efficacies. They discovered that supervision and evaluation of instruction and student progress monitoring were significant positive predictors of leadership self-efficacy for the entire sample of school leaders. Only supervising and evaluating instruction was a significant predictor for principals, and only coordinating curriculum was a significant predictor for assistant principals.

Klein et al. (2018) performed a multi-year, qualitative study of K-12 science teacher fellows to investigate teacher leaders' complex relationships using a distributed leadership framework. While distributed leadership framework is not being used in this dissertation, this research warrants being included because of the importance of leadership efforts with science teacher leaders. They explained, along with Wenner and Campbell (2017), teacher leadership happens amid a complex context of policy, content, students, peers, and administrators. Its enactment remains far messier than the literature has revealed. Most professional development programs do little to support teacher leadership or prepare teachers to spread their innovative practices beyond their classrooms (Klein et al., 2018). There is still a need to understand the support necessary to enact teacher leadership. Unfortunately, research in this field has moved little beyond self-reported studies and remains conceptually limited (Klein et al., 2018). The following gaps in the literature are highlighted.

- Teacher leadership literature often provides a weak theoretical lens, if one is provided at all, revealing a robust and relevant theoretical framework for teacher leadership.
- Little attention is paid to how different stakeholders interact with concomitant minimal analysis of those interactions. Instead, attention is focused on the nature of interactions among various stakeholders.
- In addition to how stakeholders interact with teacher leaders, research often fails to describe how teacher leaders react to the specific policies that are often filtered through subject-specific contexts. This opens the analysis of how teacher leaders react within specific (often subject-specific) contexts.
- Unlike much of the teacher leadership literature, analysis of university mentors' potential to provide support beyond traditional professional development and master's-level course work is needed.

Understanding teacher leadership as a series of interacting relationships in linked contexts is essential (Klein et al., 2018). Work context also needs to move to the forefront and use university mentors to understand play forces among participants. Engaging in teacher leadership support in the context where it happens was an important implication of them using the distributed leadership lens. Also, the policy context provided a particularly salient layer of pressure on administrators, who were less likely to support work that did not directly connect to the task of implementing the NGSS (Klein et al., 2018).

Secondary mathematics and science teacher perceptions of teacher leadership during the first year of a professional development program focused on preparing teacher leaders in rural schools (Yow et al., 2018). Following Wenner and Campbell's (2017) content-focus teacher leadership model, the findings below are identified.

1. Teachers are developing as teacher leaders whose focus is expanding beyond their classrooms.
2. Teachers are continuing, and more deliberately, serving as advocates for their students.
3. A more collaborative and comprehensive understanding of content-specific leadership is developing.
4. Teacher leadership roles in rural districts may be more natural to obtain given the context of a sometimes smaller familiar setting. Still, they may also be more challenging as these roles lead to other tensions, including feeling overworked and stressed.

Versland and Erickson (2017) contributed to the research on self-efficacy in instructional leadership using a qualitative case study of the influence of principal self-efficacy on collective efficacy. They sought to understand teachers' perceptions of how the principal's self-efficacy beliefs and actions contributed to the school's collective efficacy.

This single case study design used Bandura's (1997) self-efficacy theory, which presents self-efficacy to explain how people's beliefs about their capabilities influence their actions. Self-efficacy beliefs derive from four sources: enactive mastery experiences, vicarious/social modeling experiences, social persuasion, and arousal states (Bandura, 1997). Bandura also found in 1986 that a group's operative capacity was dependent on four factors: knowledge and competencies of individuals, how the group is structured, how the group is led, and how the group members interact with each other in a positive or negative sense. Collective efficacy is developed in a school led by a highly productive principal, and a principal's beliefs and actions contribute to the school's collective efficacy and, ultimately, high student achievement levels (Versland & Erickson, 2017).

Summary and Implications

While principals hold formal titles within schools, the position does share some important features with other teacher leaders (Peacock, 2014). Collectively, those instructional leaders use social constructivism and the leadership content and pedagogical knowledge theories to improve and enhance student learning and outcomes. Science education scholars do not excuse leaders from knowing what good instruction entails (Lochmiller & Cunningham, 2019). Instead, they describe the importance for principals and other instructional leaders to engage in content area instruction with intention, a conclusion consistent with prior research (Stein & Nelson, 2003). Possessing content-specific knowledge and its use promotes school leaders' self-efficacies, leading to collective efficacy within school systems.

Relationship Between Instructional Leaders' Science Content Knowledge and Pedagogical Content Knowledge

The relationship connecting instructional leaders' science content knowledge and pedagogical content knowledge presents a unique literature challenge. Wenner and Campbell (2017) noted the positive effects that leadership can have on schools. They stated leadership is second only to classroom instruction among all school-related factors contributing to students' learning. Focusing on content-specific issues is unique in that instructional leaders do not hold duplicate titles across schools. Within the literature, leaders are given titles such as coordinator, coach, specialist, lead teacher, department chair, and mentor teacher, just to name a few (Neumerski, 2012). Teacher leaders can potentially fit into various positions and meet the needs of any situation. Yet, a lack of content knowledge in specific subjects causes a void in content-specific instructional practices (Wenner & Campbell, 2017). Developing leadership content knowledge and pedagogical content knowledge in instructional leaders yields increased teacher effectiveness and improved student progress (Neumann et al., 2018). Science content-specific pedagogical knowledge is a prerequisite to finding adequate representations of subject matter content and selecting and sequencing ideas to transform subject matter structure into an instructional design (Shulman, 1987). Although leadership content knowledge is not a new concept, Fuentes and Jimerson (2020) state that few studies have explored the role leadership content knowledge plays in school leaders' efforts to function as instructional leaders. They also claim educational scholars know little about how instructional leadership efforts rely on or reflect on leadership content knowledge or how teachers respond to the perceived leadership content knowledge, or lack thereof, among leaders.

Fuentes and Jimerson (2020) analyzed the influences of leadership content knowledge on instructional leadership efforts and explored ways in which leadership content knowledge facilitates or, in its absence, hinders instructional leadership. By claiming school leaders contribute to instructional improvement, directly and indirectly, Fuentes and Jimerson (2020) applied an equity lens to the corpus of their work. They stated one of the primary ways school leaders influence quality teaching and student achievement is by functioning as instructional leaders. The core of being an instruction leader is teachers engaging in dialogue around issues of pedagogy; wrestling with what is being taught, when, and how; and excavating assumptions around how learning is measured (Fuentes & Jimerson, 2020).

Drawing on work related to leadership content knowledge from Stein and Nelson (2003), Fuentes and Jimerson (2020) began a fundamental assumption that necessary and appropriate dimensions of school leaders' work involve meaningful engagement in curriculum, instruction, and assessment while aligning with national standards.

Leadership content knowledge builds on Shulman's (2013) concept of pedagogical content knowledge. This study's theoretical framework used the construct of pedagogical content knowledge to bridge what leaders in the ideal would know about content-area instruction to be well-positioned to support and sustain teacher growth. Rather than expecting school leaders to have a comprehensive and encyclopedic knowledge of content and pedagogy, Stein and Nelson (2003) suggested all administrators have a solid mastery of at least one subject (and the learning and teaching of it). They also need to develop expertise in other subjects by *post-holing,* which conducts in-depth explorations of an important but bounded slice of the subject, how it is learned, and how it is taught. Leadership content knowledge is critical support that enables leaders to engage with teachers in rich instructional dialogue that would likely be diminished if leaders lacked leadership content knowledge or failed to draw upon leadership content knowledge in supervision acts (Fuentes & Jimerson, 2020).

Fuentes and Jimerson (2020) used a phenomenological approach in this study to understand teachers' perceptions of the support they receive from school leaders and school leaders' characterizations of their efforts to support teachers in errors of content and grade level match and mismatch. They used snowball sampling (Merriam & Tisdell, 2016) and interviewed participants with semi-structured protocols specific to teachers or school leaders. Analyses included initial coding that was further refined into broader thematic categories followed by the second coding cycle, which allowed Fuentes and Jimerson (2020) to conclude how instructional leadership unfolds and intersects with leadership content knowledge. The analyses revealed that instructional leaders should have a substantive dialogue about instruction and teacher growth and highlighted the following themes:

- Instructional leadership embraces a spectrum of roles. Leaders engage in multiple roles within their instructional leadership efforts, and there are times when each of the roles (monitor, cheerleader, broker, co-learner, and coach) does meet teacher needs.
- Intentionality and leadership content knowledge provide a pathway to enhanced instructional leadership. The instructional leader's role warrants acknowledging the leader's responsibility to purposefully and intentionally develop leadership content knowledge across content areas.

- Balancing efficiency and effectiveness of instructional leadership by using efficient routines, constructive and trusting relationships with teachers, and building instructional credibility should accompany the building of leadership content knowledge for it to be effective.

A theoretical framework using leadership content knowledge fit this study soundly and appropriately. It positioned instructional leadership front and center to view classroom practice changes regarding meaningful leadership content knowledge (Fuentes & Jimerson, 2020).

Successful implementation of reform efforts like NGSS requires attention to multiple education system levels and various stakeholders (NRC, 2012). For principals to understand science practices with NGSS in view, they need a vision that aligns with the science practices but does not require (or have time to obtain) the same level of expertise as their science teachers (McNeill et al., 2018). McNeill et al. (2018) stated school principals are responsible for leading sweeping instructional reforms. More importantly, they claimed that supervision spans the content areas, regardless of the principal's expertise, despite significant subject-specific differences in instruction. While little is known about principals' capacities to support teacher learning in science, teachers require support to successfully integrate science practices into instruction, which can come from ongoing professional education promoted by strong instructional leadership (McNeill et al., 2018).

Principals supervise teachers across subject areas (Sergiovanni et al., 2013), and one way they can enact instructional leadership is by observing in classrooms and providing feedback to teachers. McNeill et al. (2018) investigated principals' understandings of the science practices, which present a significant challenge for schools implementing NGSS. They targeted their study on one aspect of recent reform efforts because of the limitations in administrators' science backgrounds and the competing demands on their time. They focused specifically on the NGSS science practices because they play a key role in the reform efforts and are potentially a significant challenge for schools. Grouping the NGSS eight patterns aligned with science's overarching goal and highlighting more challenging practices are most often absent from K-12 instruction, sensemaking, and critiquing (McNeill et al., 2018). This grouping led the study's theoretical framework by focusing on teachers and the science practices and investigating principals' views and noticings for science instruction to understand better how science instruction aligns or does not align with science practices. They found that principals often described good science instruction as including investigating practices but rarely including sensemaking or critiquing practices, almost all principals described good science instruction as hands-on, though they had different meanings of what counted as hands-on, when principals observed videos, they focused on general pedagogy with few comments about the science practices, and their evaluations did not always align with the quality of the science practices.

The science education system's complexity derives from the multiple levels of control—classroom, school, district, state, and national—that impact decision-making and classroom instruction (NRC, 2012).

Principals' understandings of the discipline significantly impact their instructional leadership and supervision (Spillane & Hopkins, 2013; Stein & Nelson, 2003). Principals need substantial support to serve as science instructional leaders (McNeill et al., 2018).

While a principal's vision of science needs to align with the reform efforts, it does not necessitate the same level of expertise as the science teachers. Investigating, sensemaking, and critiquing could serve as a productive scaffold for principals' understandings of the science practices, thus serving as an entry point for principals to develop richer understandings of the science practices.

High school department chairs represent a critical resource for instructional leadership and teacher support (Peacock, 2014). With the publication of *A Framework for K-12 Science Education* (NRC, 2012) and the release of the NGSS (NGSS, 2021), the state and local contexts for science are shifting alongside the national standards movement in response to political and social pressures, economic realities, student needs, and science and education research findings. To provide science teachers with any hope of thriving in the complex environment and achieving the NRC's vision, Peacock (2014) claimed science education leaders should provide ongoing, targeted support. Unfortunately, existing literature provides a gap in science education instructional leadership. Consequently, Peacock (2014) proposed a conceptual model of science instructional leadership for high school department chairs and discussed the implications for researchers and practitioners.

Peacock (2014) demonstrated how chairs could effectively act as instructional leaders within their schools. His conceptual model included four interdependent leadership capabilities for science instructional leaders: science pedagogical content knowledge, negotiating context and solving problems, building a collegial learning environment, and advocating for science and science education. Peacock's (2014) literature review led to compiled lists of practices, qualities, skills, and dispositions that contributed to instructional leadership.

Peacock’s (2014) model of science instructional leadership intended to define the concept in a manner that provided a valuable point of departure for researchers and practitioners. Still, it did not account for the myriad contextual factors that shape school instructional leadership practices. Additional research is warranted to determine how science department chairs’ instructional leadership practice compares to Peacock’s model in this study.

All administrators play a crucial part in systemic change, given their role in teachers’ professional lives (Steele et al., 2015). However, administrators often focus on the form of an initiative rather than the substance and philosophy, making it challenging to provide teachers with critical support for meaningful change (Spillane & Hopkins, 2013). Administrative support is especially vital at the secondary level, and principals have essential roles in supporting teachers to effect systemic instructional change (Steele et al., 2015). To provide this support, principals need knowledge of a district’s systemic structures, the teachers they work with, and some fluency with the content teachers teach. A principal’s ability to participate in and promote teacher learning, particularly about content, significantly impacts student learning. Stein and Nelson (2003) added a scarcity of work related to what knowledge of school content principals might need. They claim this issue is particularly prominent at the secondary level, where the subject matter is more complicated than at the elementary level, and principals are less likely to have a multi-subject background.

Stein and Nelson (2003) used the construct of leadership content knowledge to describe the knowledge principals need to identify promising teaching, support its development both when it is and is not present, and set conditions for continuous improvement. By aiming to support systemic change at the classroom level, the school level, and the district level, Stein and Nelson (2003) suggested a *post-holing* approach, in which principals engage in an in-depth exploration of a slice of content from the perspective of the learner, the teacher, and the principal. Post-holing echoes two theories for supporting systemic change: effectively supporting teachers through meaningful student learning and focusing on student engagement by analyzing student work to support content knowledge development (Steele et al., 2015).

The post-holing approach worked well in this study because the constructs and frames supported an instructional change in mathematics broadly and led to essential leadership content knowledge changes, even in a challenging content area. The leadership content knowledge construct showed to be critical in effective instructional leadership and represented an effort to design professional development using the post-holing construct. By following Stein and Nelson (2003), Steele et al. (2015) developed multiple leadership content knowledge levels to set the stage for meaningful systemic change in how principals support the teaching and learning of algebra. Steele et al. (2015) suggested further research to investigate how changes in principals' understandings of effective teaching and learning in a content area influence their practice in teacher evaluation and instructional leadership.

The idea of instructional leadership through developing leader content knowledge and pedagogical content knowledge contributes to understanding science instructional leadership. Shulman (1987) and Stein and Nelson (2003) referred to applying content-specific knowledge as leadership content knowledge. From the leadership content knowledge perspective, Peacock and Melville (2018) claim instructional leaders should combine knowledge of the content area being taught, knowledge of how to teach it (i.e., pedagogical content knowledge), knowledge about teachers as adult learners, and knowledge and skills needed to build a learning community that draw on individual expertise to achieve common goals.

Summary

Science instructional leadership is increasingly critical and becoming more demanding and complicated with the growing complexity in educational contexts, especially with implementing new science reforms across the United States (Fuentes & Jimerson, 2020; Hairon, 2017; Hallinger et al., 2020; NGSS, 2021). Science is a content area where leaders often feel unconfident in their instructional practices, leading to a lack of support for classroom teachers (Hairon, 2017; Lochmiller & Cunningham, 2019; McNeill et al., 2018). The day-to-day demands and issues often interfere with instructional leaders' abilities to support their science teachers, frustrating both groups. Increased need to support improved teaching and classroom practice challenges instructional leaders to become more effective in their roles both within and outside the school system. Successful instructional leaders' roles are constantly changing, yet the position still requires promoting learning, engagement, and increased student achievement (Fuentes & Jimerson, 2020; McBrayer et al., 2020; Neumerski, 2012).

Science content-specific leadership also involves a relationship with pedagogical content knowledge. This unique relationship can potentially affect instructional leadership in the school system positively. Leadership is second only to classroom instruction among all school-related factors contributing to students' learning. Leadership content knowledge and pedagogical content knowledge development increase teacher effectiveness and student progress (Fuentes & Jimerson, 2020; Neumerski, 2012; Wenner & Campbell, 2017). In the era of the NGSS, instructional leadership requires a vision that aligns with science practices and attends to all stakeholders involved. Following Peacock's (2014) conceptual model, building out science instructional leadership contributes to building a collegial learning environment while advocating for science and science education. The relationship between science content knowledge and pedagogical content knowledge is further solidified with science leadership content knowledge and the need for negotiating content and solving problems (Hallinger, 2005; NGSS, 2021; Peacock, 2014). The use of the construct of leadership content knowledge and pedagogical content knowledge provides the tools needed to provide the necessary support to teachers and implement meaningful change (Peacock, 2014; Spillane & Hopkins, 2013; Steele et al., 2015; Stein & Nelson, 2003).

CHAPTER 3

METHODOLOGY

This qualitative case study aimed to better understand the relationship between effective leadership and leaders' content-specific knowledge and pedagogical knowledge. Based on findings from the literature, the population sample was drawn from high school principals, supervisors, and science educators for research through a social constructivist lens. Screening questionnaires, semi-structured face-face interviews, online data, investigative journalism, and non-numerical data were collected through different qualitative research methods demonstrating the ways instructional leaders impact effective classroom instruction based on the level of content-specific knowledge they possess and whether or not the leaders supported improvement in that professional area. The goal was to employ an overall inductive and comparative analysis strategy.

Research Questions

This study sought to build a theory and give a conceptual structure in answering the following research questions:

RQ1: What are science teachers' expectations of instructional leaders' pedagogical knowledge and scientific knowledge?

RQ2: In what ways do instructional leaders' content-specific pedagogical knowledge and content knowledge affect instructional leadership efficacy?

RQ3: How do leaders perceive their content and pedagogical knowledge and its effects on instructional leadership in science?

Methodology Selected

A qualitative study is appropriate when the research aims to explain a phenomenon by relying on the perception of a person's experience in a given situation (Stake, 1995). Because this study aimed to analyze instructional leaders' content-specific knowledge and pedagogy and its effect on effective classroom instruction, preparation, and practice, a qualitative approach was the most appropriate choice. The study was performed using the case study methodology. Stake (1995) defines the case study as a specific, complex, functioning thing in an integrated system. Therefore, using this case study was instrumental in accomplishing the need to understand content-specific knowledge and pedagogy in science classrooms.

The case study method follows the interpretivist paradigm approach known to understand human experience's subjective world of human experience (Kivunja & Kuyini, 2017). Every effort is made to understand the subject's viewpoint rather than the observer's perspective. Emphasis is placed on understanding the individual and their interpretations of the world around them. Hence, the fundamental tenet of the interpretivist paradigm is that reality is socially constructed. The conceptual framework describes the relationship between specific variables identified in the study. It also outlines the whole investigation's input, process, and output.

This in-depth investigation of a single event or person was exploratory and generated new ideas that other researchers can later test with other methods. This case study illustrated theories by comparing similarities and differences among other cases. This study was not sampling research but rather a particularization, not a generalization. The opportunity to learn was of primary importance and balance and variety (Stake, 1995).

This study was conducted using the social constructivist approach. Theoretically, constructivism is a social theory that encompasses realist insights and stems from several philosophies. Greater emphasis is placed on the logic of practice and practical knowledge rather than identity and norm compliance. Constructivism is a theory in education that recognizes the learners' understandings and knowledge based on their own experiences before entering school. It is associated with various philosophical positions, particularly in epistemology as well as ontology, politics, and ethics (Wadsworth, 1996). The term constructivism is derived from Piaget's reference to his views as constructivist and from Bruner's description of the discovery of learning as constructionist (Applefield et al., 2001).

Selection of Participants

The researcher used purposeful sampling to identify and select participants to gather rich information related to the phenomenon of interest (Stake, 1995; Yin, 2014). The high school selected for this study was a public high school that is currently rated "Met Standard" by the Texas Education Agency (TEA) and complies with all state statutory reporting and policy requirements (TEA, 2021). The school's 2021-2022 student enrollment was 1,530 at the time of data collection and offered dual credit opportunities, gifted and talented programs, fine arts, and bilingual/ESL support for students in its independent school district (TEA, 2021). The interview sample was drawn from a population of secondary principals, assistant principals, instructional coaches, grade-level supervisors, and science teachers who had a minimum of 5 years' experience in their respective positions. All participants were employed full-time and possessed a minimum of a bachelor's degree. In addition to education degrees, the target population included alternative career examples that led to the teaching profession, including but not limited to researchers, allied health professionals, physical scientists, life scientists, and social scientists.

Participants were recruited through the researcher's existing professional networks and represented different administration and science education levels that were particularly knowledgeable about or experienced with the phenomenon of interest. The pooled sample also confirmed the importance of availability and willingness to participate and communicate experiences and opinions in an articulate, expressive, and reflective manner (Palinkas et al., 2015). Henceforth, they offered data triangulation based on their unique experiences with secondary science classroom instructional leadership practices.

Data Collection

The participants were intentionally selected based on their role in science instruction and administration and served during the fall semester of the 2021-2022 school year. The researcher contacted ten science teachers and nine instructional leaders via electronic mail with a brief questionnaire about science instructional leadership at their high school. Participants were assured their responses were confidential, and their names and the content area would never be revealed if they agreed to participate in the study. All selected participants responded to the questionnaire, and 18 of the 19 agreed to schedule a more detailed one-on-one interview relating to science instructional leadership. Unfortunately, one instructional leader declined a follow-up interview.

Each participant then selected an alpha-numeric character to which his/her answers could be attributed, and the participant list with identifiable characters was kept separately from the interview data in the researcher's interview reflection journal. The researcher also kept other reactions and notes in the journal to record personal observations from the inception to the completion of the study to allow for reflexivity and positionality (Lincoln & Guba, 1985). See Table 1 for participant pseudonyms with backgrounds and observations.

Table 1

Participant Pseudonyms, Backgrounds, and Observations

Participant Pseudonyms	Backgrounds and Observations
T01	Teacher with master's degree; 40 years' experience; certified in composite sciences 6-12 and additional contents; very hands-on in the classroom; enjoys demonstrations and student projects; encourages instructional leader visits; looking forward to retirement
T02	Teacher with bachelor's degree; 26 years' experience; certified in composite sciences 6-12; very hands-on in the classroom; enjoys getting the students involved in applicable concepts to daily life; encourages instructional leader visits; looking forward to retirement
T03	Teacher with bachelor's degree; 5 years' experience; certified in life sciences 7-12; takes lead in the department; even though certified in life sciences, undergraduate work was extensive in physical sciences; teaches end-of-course (EOC) tested subject
T04	Teacher with doctorate degree; 12 years' experience; certified in composite sciences 6-12; undergraduate and graduate work was

Participant Pseudonyms	Backgrounds and Observations
	extensive in life sciences; Future Farmers of America (FFA) coach; not interested in moving into instructional leadership
T05	Teacher with master's degree; 5 years' experience; certified in life sciences 7-12; athletic coach
T06	Teacher with master's degree; 8 years' experience; certified in life sciences 7-12; University Interscholastic League (UIL) academic coach; teaches EOC-tested subject
T07	Teacher with master's degree; 32 years' experience; certified in composite sciences 6-12; technology savvy with his content and enjoys hands-on in the classroom; encourages instructional leader visits; not interested in moving into instructional leadership
T08	Teacher with bachelor's degree; 5.5 years' experience; certified in life sciences 7-12; athletic coach; teaches EOC-tested subject
T09	Teacher with bachelor's degree; 10 years' experience; certified in life sciences 7-12; teaches EOC-tested subject
T10	Teacher with master's degree; 5 years' experience; certified in composite sciences 6-12; extensive graduate work in life sciences
IL01	Instructional leader with master's degree; previous teacher and athletic coach; government and history background; great rapport with students
IL02	Instructional leader with master's degree; previous science teacher; life science background more than physical science background; technology savvy; science content knowledgeable for all grades K-12
IL04	Instructional leader with doctorate degree; previous teacher; extensive special education (SPED) background; enjoys visiting science classrooms on laboratory days
IL05	Instructional leader with master's degree; previous teacher; music background
IL06	Instructional leader with master's degree; previous teacher; history background; enjoys visiting science classrooms on laboratory days, especially dissections in life sciences; great rapport with students
IL07	Instructional leader with master's degree; previous science teacher; life and composite science background
IL08	Instructional leader with master's degree; previous health and physical education teacher and athletic coach; extensive SPED background

Participant Pseudonyms	Backgrounds and Observations
IL09	Instructional leader with master's degree; previous science teacher and athletic coach; extensive background in physical sciences

The reflective memos the researcher collected throughout the study were in constant and comparative analysis to help minimize bias and aid in objectivity. These memos reminded the researcher of thoughts or concerns related to the study during the interview process and the interpretation of relevant journal articles, the process quality, and reviews on emerging categories, themes, or codes.

The researcher conducted initial screening questionnaires via electronic mail to gain background information about instructional leaders' content-specific knowledge and pedagogical content knowledge. The questionnaires also served to gain participant permission to agree to more detailed semi-structured interviews relating to the depth of instructional leaders' science content knowledge and science pedagogical knowledge and how their depths of that knowledge support effective instructional leadership. Interviews were scheduled with the 18 favorable respondents and recorded using an audio recording device. See Appendix A for the interview protocol.

The semi-structured interviews began with a general introduction and personal background information to provide participants with a relaxed, comfortable environment. The researcher stated the interviews would only be audio recorded to ensure the accuracy of the information and that the participant's identity and campus identity would remain confidential. The beginning of the interview established commonality and frame of reference for the term *instructional leader* to include teacher mentors, teacher leaders, instructional coaches, grade level supervisors, assistant principals, principals, and superintendents.

The researcher proceeded with the interview questions after establishing the frame of reference. The researcher guided the interview with a specified outline; however, the researcher also allowed for unexpected responses, newly surfaced concepts, and additional self-reflective notes for emerging themes. The questions served as initial boundaries but did not limit the conversations to predetermined conclusions allowing the participants to respond to their own words. The researcher used follow-up questions during the interviews to clarify or expound on the participants' ideas to ensure the accuracy of the information.

Because qualitative study methods allow for discovering phenomena during the research process, two interview questions were added as new data emerged during the screening process. Stake (1995) says there is no particular moment when data gathering begins. Instead, qualitative research capitalizes on ordinary ways of getting acquainted with things. Added to normal looking and thinking, the qualitative researcher's experience is one of knowing what leads to significant understanding, recognizing good data sources, and consciously and unconsciously testing out the integrity of their eyes in the robustness of their interpretations. Upon critical examination during the screening process, the questions were added during the interview phase of the data collection. The researcher also added clarifying questions to a few subsequent interviews to further explore the topic of interest.

Merriam and Tisdell (2016) discuss the concept of saturation, where the researcher notices that continued data collection produces no new information or insights into the phenomenon being studied. The data's ongoing analysis produced categories, themes, and findings robust enough to cover what emerged in data collection. According to Merriam and Tisdell (2016), the best rule of thumb is that the data and emerging findings should feel saturated; that is, the researcher begins to see or hear the same things repeatedly, and no new information surfaces as data collection continues. The data collection ended in this study when saturation had been determined in the interview process.

Data Analysis

After each interview, the researcher transcribed the audio recordings into text and labeled each transcription with the previously assigned participant alphanumeric characters. Next, the researcher developed an initial coding list for the participants' answers, categorizing them for each research question. No new themes emerged from the initial coding list; therefore, the coding list remained unchanged throughout the study. However, some participants' comments provided further context for the research questions to easily retrieve the participants' data, further creating more all-inclusive codes. The researcher followed up by electronic mail to clarify the accuracy of the transcripted conversations with each participant. Participants then had opportunities to expand on or correct any previously provided information, and the transcribed interviews were sent to the interviewees for review only one time. While each interviewee had the right to strike any content, the researcher did not encourage the practice. The interviewee was also asked if they wanted to add anything upon reflection. Following review, no participants requested edits to the transcriptions.

The researcher used this process after each interview. The researcher then compared and refined the coding list with each subsequent interview, clustering similar ideas into more inclusive codes without altering the original codes exceedingly. New data were analyzed, reanalyzed at each coding phase, and compared to new data as a constant comparison so that connections were continually being made until the saturation was met. Some participants' transcripts revealed gaps in their thought processes, resulting in follow-up phone calls to address those gaps and confirm or negate the disconcerting ideas. The data collection and analysis did not occur wholly separate and sequential; however, listening, observing, coding, and categorizing proceeded in loops as data collection progressed. The researcher periodically recorded her brief reflections following each interview in her reflection journal to later use as the basis for her postulations.

After completing all 18 interviews, initial data coding revealed various descriptions for instructional leader knowledge levels, in-class teaching experience, self-perceptions, and leader efficacy on their campuses. Next, the researcher developed a list of coding phrases for the data from those main theme descriptions. From that point, follow-up conversations expanded upon and confirmed the data collected in the one-on-one participant interviews, and the comprehensive coding remained the same. Finally, data were condensed and sorted a second time and categorized accordingly.

The six male and eight female instructors were varied in professional backgrounds, years of teaching experience, education degree level, teaching content area, and certification status. The education levels represented were one holding a doctorate, eight with masters' degrees, and five with bachelors' degrees. Nine instructors had degrees in education, while the non-education degreed instructors received their post-secondary education in a science content area. All but two participants were certified by the state to teach in their content area.

The six male and five female instructional leaders varied in professional backgrounds, years of educational experience, and education degree level. No data were collected regarding previous teaching content or certification status for the instructional leaders. The education levels represented were two holding a doctorate and the remainder holding masters' degrees. Nine instructional leaders had degrees in education, while the non-education degreed instructors received their post-secondary education in other non-science content areas.

Trustworthiness

Lincoln and Guba (1985) state credibility, transferability, dependability, and confirmability are essential in establishing trustworthiness. The reliability and validity of qualitative research depend on what the researcher sees and hears. The researcher ensured credibility and transferability by verifying the participants had the experience to discuss the phenomenon the researcher sought to explore. The participant selection criteria helped accomplish this goal, and snippets from the interviews were used to illustrate the key terms for this study. Establishing confirmability corroborated no researcher bias, and the data told the interpretation in an unbiased way. Transcribing the participant interviews and coding them also helped ensure a deep understanding of the interview content and the participant intent.

The constant comparative analysis established systemic comparisons, and research demonstrated the link between the study and resulting theories. A worthy topic, rigorous and sincere research, transparent methods, resonating with various audiences, significant contributions, ethical considerations, and meaningful coherence provide credibility to the theory claimed. The researcher sought a quality that pointed to identifying critical elements and wringing plausible interpretations from them, something another person could pursue without being obsessed with finding the right or ultimate answer or correct version of the truth. The internal validity answered the question of how the research findings matched reality. The best-known strategy for this is triangulation, which was used from multiple data sources, comparing and cross-checking data collected through observations (Merriam & Tisdell, 2016). The researcher also used respondent validation by soliciting feedback on the preliminary findings from interviewed participants. These checks were the most critical way of ruling out the possibility of misinterpreting what participants said in their perspectives on what was going on and being an essential way of identifying researcher bias and misunderstanding what was observed.

Summary

This chapter aimed to propose an outline for the proposed research method to answer the research questions. A discussion of the procedure, study participants, data collection, and interview questions outlined how the study was conducted and who participated in the study. A social constructivist lens developed the case study theory on how instructional leaders either promoted or inhibited effective classroom instruction with their lack of pedagogical content knowledge in areas they are responsible for supervising. All study participants contributed to this theory by sharing their experiences in the high school science classroom and their perspectives on the importance of content-specific knowledge and its efficacy in the classroom.

CHAPTER 4

RESULTS

The problem at the center of this instrumental case study was the relationship between instructional leaders' science content knowledge and pedagogical content knowledge and its effects on instructional leadership efficacy in secondary science classrooms. This study aimed to learn more about instructional leaders' depths of science content knowledge and science pedagogical knowledge and how their depths of both pedagogical and content knowledge support effective instructional leadership. Chapter 4 presents the data collected for this study with selected faculty who either teach high school science courses or have leadership roles over the science educators on their campus.

This case study drew on data collected from teaching faculty and administrators at a public Texas high school in the southern United States. The sources for this data included screening questionnaires and semi-structured in-person interviews. The data also included information from an American Educator Panel report on perceptions of school leadership using a nationally representative sample of teachers and instructional leaders whether perceptions of school leadership practices vary by educator positions (Tosh & Doss, 2020).

The researcher collected data from screening questions, interviews, and follow-up interviews, then coded and placed data from the open-ended questions into initial categories using constant comparative analysis. The semi-structured interviews served as the next phase of data resulting in follow-up interviews with some participants with the intent to gather data with more depth on motivation to increase effective classroom instruction through content-specific pedagogy. This data triangulation revealed patterns that answered the interview questions, which echoed the three research questions for this case study.

Research Questions

This chapter includes a rich, thick description and interpretation of the findings related to the guiding research questions:

RQ1: What are science teachers' expectations of instructional leaders' science content and science pedagogical knowledge?

RQ2: In what ways do instructional leaders' content-specific pedagogical knowledge and content knowledge affect instructional leadership efficacy?

RQ3: How do leaders perceive their science content and science pedagogical knowledge and its effects on instructional leadership in science?

Based on responses from teacher and instructional leader participants, the results of this study produced four main themes. These themes encompass instructional leader science content knowledge and education, pedagogical content knowledge and experience, instructional leadership efficacy, and instructional leader self-perceptions.

The next portion of this chapter aligns these themes with the research questions above and corroborates in further detail based on the evidence.

Theme 1: Instructional Leader Science Content Knowledge and Education Teacher Results

All teacher participants agreed that it was important for instructional leaders to have some level of science content knowledge and post-secondary education for the science classes taught on their campus. The two concepts of this theme are interdependent, thus placing them in the same category. However, the analysis for each was separate. The first half of the theme analyzed science content knowledge, and there was a near consensus on the amount needed by participants. One teacher felt a background in all sciences being taught on campus was essential for instructional leaders, up to and including being state certified in those sciences.

> T04: It is important for our science leaders to have a background in all sciences that are being taught on their campus. What that looks like for me is a composite science certification. But, I know that does not happen because that is like the beast [certification exam] no one wants to tackle. So, it is very hard for me to go to my leader to ask questions when they do not understand my content.

Another teacher agreed with T04 on the need for increased levels of content knowledge.

> T08: I think they need a high level of content knowledge. I teach an EOC tested subject to students who have not had a normal school year since the sixth grade [due to a pandemic]. They are struggling. It is not feasible for every leader to have as much knowledge as the teachers. But their foundation should be solid enough

to walk into the classroom and know exactly what is happening at any given moment.

One teacher also acknowledged the need for certification for secondary science classes for instructional leaders to serve in their positions.

T07: Well, they need to be certified in the areas they supervise. It is silly not to. How can they help me in my class if they do not know what I do? If I need ideas on kinetic theory because it is over my students' heads, who can help with this? These leaders need to know content before walking into my classroom and giving advice.

One added component to science content knowledge was the importance of knowing the content standards taught. Participants T05, T06, and T09 felt the importance of understanding the content standards and the science content-associated language was needed to offer productive classroom assistance.

T06: Leaders need to be able to help us with our content areas, especially if we are an EOC tested subject. If they do not know the standards or content we teach, they cannot offer strategies to enhance our teaching. If I cannot go to them and have a conversation about that content, then they are of no help in that position.

Being well-versed in content standards must also include recognizing and understanding the science language associated with those standards.

T05: They [instructional leaders] need to be familiar with the verbiage used in each science class, or they are not going to know what is being taught in the classroom. They cannot be expected to know the full course load but at least be able to have conversations about it, especially during observations and classroom walk-throughs. I need to be able to go to my leaders and ask questions, and they know what I am talking about.

Language is one of the most important parts of any culture. It is the way by which people communicate with one another, build relationships, and create a sense of community. Participant T09 felt speaking the science language was vital to instructional leaders knowing the validity of what teachers were saying in their classrooms.

T09: When a leader does not know the terminology spoken even to be able to differentiate whether we are teaching the standards or not, we could just be throwing some stuff out there.

Finally, two participants had somewhat different ideas about the level of content knowledge needed for science instructional leaders. They believed leaders did not need to be content experts. Still, they felt leaders should know enough to determine whether students are being taught the body of knowledge, understanding, and skills they are expected to learn in the science curriculum. More specifically, the participants' views depended on the leaders' roles.

T01: Different leaders have different requirements. I think I said in the screening questions that I felt leaders needed to be well trained in content. But I think it depends on what they do at the school. For instance, all the assistant principals and principals conduct all the teacher evaluations at schools where I have taught. If they come to evaluate us, and they do not really know the subject I teach well, they may not understand some of what I do. But that does not mean they are not good leaders. They know I am teaching from the standards.

Participant T03 expounded on what T01 described for leader requirements and further added what he felt were realistic expectations for science instructional leaders on high school campuses.

> T03: All campuses are different. I think it depends on the role they fill. It is not realistic to think every leader on every campus has to be an expert in all sciences to lead that department. But I do believe that at least one leader on your team has content knowledge and/or expertise in at least one field of science. Otherwise, someone [science teacher] is going to be left out. For example, if no leaders on the campus have no experience in physics, how are they going to serve those teachers who teach that subject? Serve means in all ways, not just in name only. We, as teachers, need quality leadership and support to serve our students.

At this study site, where one instructional leader lacked in a particular content area, another was proficient in that same area. In addition to that phenomenon, the researcher's reflective journal included an entry stating the study site uses weekly professional learning communities with their science department team members to communicate and collaborate with their instructional leaders. Moreover, the following response from T10 demonstrated the collective perspective of all teacher participants regarding instructional leadership science content knowledge on their campus.

> T10: Although I have had some horrible instructional leaders in the past, I am thankful to be on the science team on which we have so many instructional leaders with varied educational backgrounds and high content knowledge levels. They collectively represent all courses taught on our campus and are quick to come to the aid of any science team member.

In so much as participant teachers believed instructional leaders needed background science content knowledge, the second, smaller half of this theme analyzed the level of post-secondary education teachers thought leaders needed to be effective in their roles and varied among participants. The levels ranged from taking one college science course at the bare minimum up to being a science major with a Bachelor of Science degree. Some participants did not specify the amount of education needed. However, enough responses on this question yielded inclusion in this theme.

Beginning at the bare minimum, T02 gave a synopsis on the range of education instructional leaders need in their position.

> T02: If the leaders are supposed to be actively helping the teacher, at the bare minimum, to do a mediocre job, they must have had at least one science course in college just to understand. Actually, it must be a science course with a lab that is the bare minimum for mediocre [leadership]. If they are really going to be extremely helpful, they probably ought to be a science major. Well, if they spent time teaching [before leadership], they would have had a lot of science in college.

T05 and T10 also believed a portion of leaders' post-secondary education should involve some science coursework before assuming a leadership position for a science department.

> T05: I think you [instructional leaders] need to have taken at least one college life science course and one physical science course, with labs, to appreciate the differences in sciences taught on the campus. It also equips them with that content knowledge I mentioned earlier. When you put those two together, you see a strong leader who understands what I do daily in my classroom. Does he know

> everything? No. But he has the background and the content to support me as a teacher where someone without both cannot.

Participant T10 concurred with T05 and added some perspective on teachers who graduated with education degrees as opposed to ones who completed alternate paths.

> T10: Instructional leaders will have a hard time supervising any teachers in a high school science department without any formal education in some sort of science courses. Even in education majors, undergrads take methods courses for specific content, like science methods or math methods. So at least they get some formal science education per se, even if they are an education-only major. I did an alt cert program for my master's and still took methods courses even though I was a science major as an undergrad. It is beneficial for leaders to have this, too, I think. It gives them a more in-depth perspective on content-related classroom experiences. As a teacher, that is important to me.

Instructional Leader Results

Moving from the teachers' perspectives to the instructional leaders' perspectives, the instructional leader participants agreed that it was vital for them to have some level of science content knowledge and post-secondary education for the science classes taught on their campus. Again, the two concepts within this theme are interdependent and are placed together in the same category. However, unlike the teachers' perspectives, the two concepts will be combined in analysis for this section as they could not be separated and intelligible.

The level of content knowledge needed varied among participants, much like the teacher participants, as did the necessary level of post-secondary education. Four of the eight participants claimed proficiency in at least one science content area taught on their campus. They defined proficiency as having a high competency or skill in a particular content. That skill may be from their education, but it may partly be from their experience in the field, as discussed later in Theme 2.

> IL01: Instructional leaders need to have a thorough knowledge of the content standards being taught and how best to deliver the content for learners to retain. It is such an advantage to take science courses at the college level before assuming any leadership role over teachers in that department. Even if it is just one course, it is helpful to learn the language and behavior of a science classroom. At least we have some prior knowledge to fall back on as we go in and out of classrooms for visits or formal observations. Do I think we need a full-fledged science degree? Not really. We are all not content experts in every area we supervise. Our teachers would beat us out every time.

Participant IL02 together with IL01 acknowledged the need for proficiency but added the college level as necessary.

> IL02: Your [instructional leader] content level needs to be at a proficient college level.

Participant IL04's stated the reason she felt the science content level needed to be high was due to the increased rigor of science coursework.

> IL04: For science, the level of science content needs to be high. Science is rigorous, and if the leader is not at a high proficiency in that content, they do not understand language, terminology, or any concepts being taught.

Finally, one instructional leader explained the need for science content proficiency for instructional leaders to fill in any educational gaps they might have.

> IL06: There does not necessarily have to be a high level [science content knowledge] but needs to be proficient. Science content is difficult for those who did not study science as undergraduates. At the very least, they need training and professional development to fill in the gaps so they can support their teachers.

Other participants highlighted the need for high levels of content knowledge unrelated to their education levels, even though it was interesting to note that the instructional leader participants in this study each had a minimum of one master's degree. In addition, one participant had a doctorate, as indicated by the researcher's reflective journal.

> IL05: Content knowledge for any content area requires a high level of proficiency. No way I like to walk into a classroom and not know something about what is being taught. I want to engage and join when I have time. I cannot do that if I don't even understand what is said. So that also goes back to the standards. Knowing or having a working knowledge of them definitely benefits me walking into a room. And I like to talk to the kids when I'm in there, not just lurking from the back corner watching. So, I need that knowledge to interact with them. And on top of that, how can I help my teachers when they come to me with a problem regarding their content if I don't know any? That's kind of embarrassing.

Participant IL08 also felt the increased level of content knowledge benefitted her and her science teachers, which she draws on from her previous experience.

IL08: I think a high level of content knowledge is needed for science instruction. I am thankful to have my science background to coach my teachers when they need help. Otherwise, I feel useless in my role.

Participant IL09 agreed with most of the other participants citing a need for higher science content knowledge levels.

IL09: A high level of content knowledge is best. Sometimes it is higher or lower than pedagogy, but the good part about that is you can always keep learning and becoming better.

For an additional note to this theme, the researcher's interview reflection journal notes added to the proficiency proclamation citing six of the eight instructional leader participants had previously taught in high school science classrooms before transitioning into leaders. They, in fact, did have a high competency or skill in their content area. Despite not having expertise in a science content area, the remaining two participants felt confident in their abilities to lead in their roles with a familiarity with the science content on their campus. In addition, they knew they had an entire instructional leader team to fall back on if needed.

IL07: Teamwork makes the dream work. I am an expert in history and English, not science. When I walk through a science classroom for observation, I may not know everything they talk about. But I know education, and I know pedagogy. I can understand the process but not all the details. I do not believe that makes me a less effective leader. Our team of instructional leaders relies on one another for their areas of expertise if

> needed. If I do not know the answer, I will find someone who does. We want all of our teachers to be successful and feel supported on our campus.

On one final note, the instructional leader participants concurred with the teacher participants that communication and collaboration were vital to successfully leading their science teachers. In addition to the weekly professional learning communities with teachers from each science discipline, the instructional leaders also cultivate communication intentionally through their own team meetings, leading to fewer instructional difficulties at the classroom level. Fewer difficulties on the classroom level led to fewer difficulties at the department level leading up to the campus level. Science content knowledge was the foundation of that communication and collaboration.

Theme 2: Instructional Leader Pedagogical Content Knowledge and Experience

Teacher Results

Not surprisingly, it has become clear that both pedagogical content knowledge and subject matter knowledge are crucial to good science teaching and student understanding. Pedagogical content knowledge takes experience and organizes it as a basis for helping students to understand specific concepts (National Association for Research in Science Teaching [NARST], 1997). This combination is applicative to instructional leaders and follows Shulman's (1987) original model to be more consistent with a constructivist perspective on teaching and learning. In this study, all teacher participants agreed that it was important for instructional leaders to have a high level of science pedagogical content knowledge in addition to previous teaching experience in a science classroom, particularly one with a lab section, before entering a supervisory role.

The two concepts of this theme are synergetic. So, for this reason, the analysis for both was combined.

The data revealed a near harmonious level of pedagogy and experience suggested for instructional leaders. The teacher participants supported the claim that all instructional leaders should have spent considerable time teaching in a high school science classroom before advancing into their leadership roles. Although the researcher did not collect specific data on the amount of teaching time suggested by the teachers, she did have entries in her interview reflection journal pointing to approximately 5 years of teaching experience to grasp what was needed. Also, participants almost exclusively equated pedagogical content knowledge and experience level together in their responses. Beginning with T01 and moving numerically through the participants, each teacher shared his/her thoughts on the amount needed for instructional leaders as a whole, not necessarily the ones on his/her campus.

> T01: I think they [instructional leaders] should have taught in a high school science classroom for a good while. If they haven't taught in a science class, they don't really know what the chaos might look like on a given day. We have demos or activities going and need to move furniture. Or we might need to wad up balls of paper and throw them at a target, teaching accuracy and precision. So, they [instructional leaders] might be looking through the window walking through and see paper flying across the room, kind of like a kindergarten class. But an experienced leader who has taught science knows that it is what it should look like. Science classrooms are just different from other subjects.

A follow-up interview with T01 added more in-depth information to his previous response.

> T01: We have several leaders. They obviously don't all have backgrounds in science. That is not feasible. They all have their strengths in certain areas. Leaders know from experience in walking through the campus what science classrooms look like. Can they come in and teach the class? Probably not most of them. A few could, yes. They previously taught chemistry and physics in their past. Even the ones without that teaching science experience have the rest of their leadership team to fall back on if they have an area of weakness. They keep adding to their experience each time they walk into the classroom.

Participant T02 explained the need for science pedagogy by highlighting the dangers that can often be found in science classrooms and laboratories.

> T02: They ought to hear some of the scary stories of when science goes wrong, and students do not follow directions. This is where the experience of teaching in a lab portion of a class comes in. If they [instructional leaders] don't understand how dangerous chemistry is, they don't appreciate the need for following directions and how critically important it is. The pedagogy part goes with experience because the way to teach science a lot of times is through first-hand knowledge by teaching yourself.

Adding to T02, participant T03 also discussed the behaviors found in science classrooms and how they differ from others.

> T03: Well, if they haven't taught in a science classroom, how does that work? How can they know what a lab or science activity looks like if they haven't taught

a high school class? Those classes look very different from any other class on campus. For example, most labs and activities have to be done as partners or in small groups. It looks a little chaotic. But trust me, it's an organized, chaotic environment. Leaders who expect all their ducks to always be in a row and sit at their desks will not understand what is happening. Teaching science is just not like others. So, if a leader just has a name but no science teaching experience or pedagogical knowledge, they cannot offer support.

Participant T04 highlighted information on how science classrooms are not traditional classroom settings.

T04: I think it's important that they [instructional leaders] have been in the classroom. If they don't spend enough time in the classroom, they really don't understand what it's like in the trenches, day in and day out. I feel like a science classroom is different than most. There is a lot going on. We don't only have content that we have to teach in terms of lecture, but we also have content that is hands-on in the lab portion. Most leaders are not used to organized chaos because they're used to having the single-file line rows and a lecture-type atmosphere.

Participant T05 added further to what T04 described by stating that science often goes outside the four walls of the classroom.

T05: Science is different than, say, math or English. We are hands-on with all kinds of stuff, digging our hands in. If leaders don't know what science looks like, they won't understand and cannot offer helpful feedback. Sometimes, we are not even in our classrooms. We may be outside doing field investigations, or like physics, and be outside shooting bottle rockets. It's almost like science is a verb.

Participant T06 stated she enjoyed having instructional leaders come into her classroom, especially the ones who have previous science teaching experience.

> T06: They [instructional leaders] need to know this class is wild. Just kidding. If they haven't taught science previous to moving into a leadership role, they will not understand the scope of learning for all the science classes. The leaders who have previously taught science love to come to our classrooms during demonstrations and labs. I think they miss being in the classroom sometimes. They will jump right in and talk to the kids and ask questions. If they did not have that science knowledge background, they would not be able to do that. I like for them [instructional leaders] to come in.

Participants T07 and T08 expressed similar views on instructional leaders' knowledge of pedagogy.

> T07: Leaders need to know what it's like to teach science. We use our hands to learn, not just our minds. If you have not taught science, you do not understand.
>
> Then, participant T08 clarified the meaning of pedagogy.
>
> T08: They [instructional leaders] need to know we are more than textbook learning. So you refer that to pedagogy. They need to know *how* to teach, not just the content.

Participant T09 added some depth to this theme by discussing the pedagogical content knowledge along the lines of teaching science as it referred to observation scores.

> T09: When a leader doesn't know how to teach science, we sometimes score less on formal observations because those leaders do not know what a science classroom looks like. Science classrooms are very different than others. Having

> that pedagogy knowing how to teach is just as important as having the content knowledge to actually teach it. Many of our leaders taught for several years before they ever moved into a leadership position. Our scores should not be affected by someone who has no science knowledge.

Finally, T03 and T05 were the only participants who did add some general ideas regarding the extent of experience with needed pedagogical content knowledge.

> T03: It's hard to know exactly how much or how many years of experience somebody needs because we are all different. I think teachers master their content in around five years or so. That gives them a good foundation. Now do leaders need that much? That is subjective at best. It varies. Many people, in general, are afraid of high school classes because they don't understand them.

Participant T05 only differed from T03 in the number of years' experience needed for proficiency.

> T05: At the very minimal, leaders need to have taught in high school science classrooms themselves for a number of years. Actually, I think for high school science, you need to have at least taught high school science with labs for at least two years, if not more. We have several leaders who are very proficient in leading science teachers. Some have taught science for several years before transitioning into administration. We have a wealth of pedagogical content knowledge and experience to depend on when we need it. Unfortunately, all schools do not have that luxury.

Participant T08 supported beliefs of T03 and T05.

> T08: I am pretty sure that they [instructional leaders] taught multiple years before moving to administration. So, it's not like in some other places. Most leaders at this school fall into the higher level of content knowledge and pedagogy as well as experience.

All teacher participants felt that a high school science classroom is different from most other classrooms because instructors should teach content in a lecture portion. Still, they also should teach hands-on content in a laboratory or activity portion. Both parts are often synchronous and may appear chaotic to an instructional leader lacking that science pedagogical knowledge. Forty percent of high school science classroom time should be spent in the lab (TEA, 2021). Therefore, if instructional leaders have not spent adequate time in science classrooms or laboratories, they cannot effectively observe or assist instructors in those environments.

Instructional Leader Results

Shifting to the instructional leaders' perspectives for this theme, the participants had similar ideas to their science content knowledge responses but with the added experience to connect the two parts of the theme. As summed up by IL02, "Your pedagogical content knowledge needs to be experience-based." Participants IL06 and IL07 agreed with IL02 in the following responses.

> IL06: It is extremely beneficial to have that pedagogy from first-hand experience in order to offer assistance to the teachers in times of need. Leaders can learn the skill over time by visiting classrooms, but to me, that does not seem to be as

> effective. Most leaders teach in the classroom for a while before assuming a leadership role. Teaching in a science classroom is a whole new level.

Participant IL07 attributes his leadership success to his previous teaching experience.

> IL07: I taught high school science for several years before transitioning into a leadership role. I definitely would not be good at my job if I had not.

To add to the views from IL06 on the science classroom, three other participants also described similar aspects about those classrooms, including time spent in laboratory sections.

> IL04: Students are up and everywhere. Science classes are broken up in a way that about 40% of their time is required to be spent using labs or activities to reinforce learning. Someone with a low level of science pedagogy might see that as utter disarray. For me, if I walk into one of my teachers' science classes, and everyone is just sitting at a desk, I might have questions. I know from experience that is not the norm for a whole class period.

Participant IL07 built onto IL04's response further emphasizing the difference in science classroom culture.

> IL07: There are so many facets to science education. At times, it can be overwhelming. You have to teach content and labs. That is like two separate classes during the same time period. Learning doesn't happen in a tidy white, straight line anymore. We look for opportunities to engage in scientific thinking, not just memorize the history of science. They look at diseases and catastrophic

> events happening around them and can apply their knowledge long after they leave school. They don't just learn science. They do science.

Agreeing with IL04 and IL07, participant IL09 stated instructional leaders without experience in science classrooms are unaware of the atmosphere.

> IL09: If you haven't spent any time in a science class, it resembles disorder and mayhem as students move from station to station in the lab or move furniture to make room for a physics project. Even if you take a step back and know what you're looking at, it just turns into orderly mayhem. However, everyone in the class knows what they are doing and where they are supposed to be and gets the job done when it is running smoothly and correctly. Unfortunately, inexperienced leaders are not used to that environment.

Participants IL01 and IL05 rounded out the remainder of the responses encompassing all aspects of Theme 2.

> IL01: Pedagogical content knowledge and knowing how to deliver content to students is both a science and an art. Most of that pedagogical knowledge comes from in-class teaching. You can study it in books or videos or workshops, but until you step foot in a classroom in a teaching position, you truly can't grasp how to teach a subject, especially science. When I was still in the classroom back in the day, I had a principal come in to do my observation one time. He had no clue about anything related to science. He was just trying to check the boxes on his rubric. I thought to myself, "This guy has no idea what I'm saying, and I can just be throwing words out there to impress him. He wouldn't know the difference."

Finally, participant IL05 mentioned how the NGSS implementation changed the direction of learning and what administrators now see in the classrooms.

> IL05: Pedagogy for any content area requires a high level of proficiency. Some of that is gained on the job in the classroom, then later in administration through observing what teachers are doing in their classrooms. But if you don't know *how* to teach science, you cannot be effective. Their classrooms are not the same as others. When they adopted the new NGSS standards, you could really see the difference in how kids learn versus what they know. Inquiry-based and project-based learning have changed the strategies since I have been in the classroom.

Pedagogical content knowledge is a craft learned over time by teachers and instructional leaders. Shulman (1987) first developed the idea, and it integrates subject expertise and skilled teaching of a particular subject. He stated teachers should keep specific methods in mind when preparing to teach a subject. This approach is relevant for instructional leaders as it focuses on understanding how knowledge is related to the quality of teaching performance. The more experience instructional leaders have in the classroom; the more pedagogical content knowledge they have. Moreover, they are more well-equipped to lead their science teachers.

Theme 3: Instructional Leadership Efficacy

Teacher Results

Several ideas surfaced when teacher participants responded to how science content knowledge and pedagogical content knowledge significantly affect instructional leadership effectiveness. McCormick (2001) pointed out that every major review of the leadership literature lists self-confidence as an essential characteristic for effective leadership. Teachers tend to go to their instructional leaders most of the time when they have problems looking for resolutions. However, science content knowledge and pedagogical content knowledge affect instructional leaders' abilities to offer assistance effectively. Three participants began with somewhat negative scenarios in their responses.

> T01: Some leaders are just in their positions just to have a position. I am just speaking in general, not at this school. I call them ladder climbers. They are not interested in the purpose of education, which is the teaching and receiving of knowledge. They are interested in being called leaders, not student outcomes or teacher initiatives. They spend as little time as necessary to get the minimum requirements needed to get promoted to a leader and continue working their way up. That is not an effective leader.

Participant T02 also felt instructional leaders who just claim titles are not effective in their leadership roles.

> T02: I think if they [instructional leaders] haven't had any [classroom] experience, they're probably pretty ineffective. It bothers me that people can move up the ladder with only two or three years of teaching experience. I think there should be a minimum of five years of teaching in the classroom. And I think whatever level you're going to be a counselor or principal at, you need to have taught at that level. An example of that would be switching from an elementary principal to a high school principal. In the past couple of years, I know they [school systems] are trying with these bonuses to keep good teachers in the classroom and pay them well, so they don't climb the ladder just for a paycheck.

> Teaching is seen as a stepping stone to becoming a principal, especially for men. They want to climb the ladder of success. Even some women need that pay to go up because they are single moms trying to support the whole family.

Participant T04 also described the path some instructional leaders take without ever understanding what happens in a science classroom.

> T04: We have educators in every school system that just try to climb the proverbial ladder. They teach a minimal number of years, then they get certified in administration. They serve as an assistant principal for the minimum number of years and move into being a curriculum specialist or getting the superintendent certification, and bam. They are leading a whole district without being in the trenches to truly understand what it is like day in and day in a science classroom.

Moving towards the more positive responses, this participant group frequently mentioned (43 times) that their classroom successes had been directly related to effective instructional leaders who motivated them. Albeit through different means, they still felt their leaders were effective in their roles and described as follows.

> T01: When I need help, I go to my supervisor. They are there to help us, right? If I struggle with something on my lesson plan, or I need ideas for a hard topic to teach my students, I need support. I think they can point me in the right direction or give me the resources I need. If they have that science background in the classroom with content areas of their teachers, they can confidently support us teachers, especially those with more rigorous content. They can provide physical, emotional, and material support. To me, that makes an effective leader.

Participant T03 praised the instructional leaders on his campus, recognizing a team mentality being the reason for efficacy.

> T03: At our school, we have a host of instructional leaders all the way up the ladder with many years of teaching experience in science and are a wealth of knowledge. We have leaders in positions who have taught every core subject on this campus before moving to administrative roles. I can bounce ideas off the ones who know my content. The overall goal is for our students to succeed. One of us is not better than the other. We are a team.

Participant T04 described how leadership efficacy led to her own success as well as her students' successes.

> T04: It's really important they [instructional leaders] have that science background to help give me ideas on how to teach or resources on how to teach. Because I think at the end of the day, if my leader helps me succeed, then I'm able to help my students succeed and grow.

Participant T05 equated efficacy with equipment and knowledge.

> T05: Knowledge affects everything. You cannot be effective in any role if you are not equipped adequately, right? It is common sense. The more you know, the better you can serve. There is no such thing as too much scientific knowledge.

Participant T06 also discussed changing strategies and unconventional resources might lead to increased leadership efficacy.

> T06: To be effective, you have to be able to offer the teachers what they need in their content as well as classroom strategies to teach it. I think it [knowledge] affects it a lot. Most teachers, except novice teachers, have a handle on what they

are teaching. But standards change. Students change. Strategies then have to change. And sometimes we are just plum out of ideas. So, a good science leader will sit down and brainstorm some ways to address an issue. They also pull in some other leaders on the campus if needed. On occasion, they have been known to reach out to other schools in the county or even to the local university. To me, that is effective.

Participant T07 compared leadership efficacy with content knowledge and classroom culture.

T07: They [instructional leaders] can be good leaders if they know the material and how to be in a science classroom. Science is hard sometimes. Good leaders rise to the challenge.

Participant T08 also compared sufficient content knowledge with leading teachers effectively.

T08: It [content knowledge] affects leaders' abilities tremendously. If they do not have the adequate content knowledge and have no idea how to teach the concepts, then they cannot effectively lead any teacher. If they are not confident in their abilities, then we are at a loss.

Lastly, participant T09 showed a preference for instructional leaders having more content knowledge than pedagogical content knowledge.

T09: If they [instructional leaders] don't have the content or know how to teach concepts, they're not able to help the science teachers at all. They go hand in hand. I might prefer my leader to have more content knowledge than the actual pedagogy. I can always ask a coworker or a co-teacher for ideas about the implementation or some ways to actually teach. But, if my leader doesn't know the content, then it is very hard for us to even have an intelligent conversation.

Instructional Leader Results

From the instructional leaders' viewpoints, all participants claimed a strong sense of pride in leader efficacy in their screening questions. Specifically, the participants claimed they possessed high levels of content knowledge and pedagogical content knowledge in multiple content areas. However, their science content knowledge might not be as strong as in other content areas. Participants also credited their campus instructional leadership teams for supporting one another by combining their expertise in their respective disciplines to reach a higher level of efficacy across the board.

> IL09: We, as a department, attend professional development for training opportunities so we can support our teachers. This training helps us strengthen our content knowledge and ascertain research-based instructional strategies. I find this extremely helpful for myself because my science background is not as strong as some of our other leaders here. Leaders should already have that pedagogical knowledge from their own classroom experiences before moving into administration. We must embody continuous improvement and learning alongside our team and independently. As educators, we must all consistently model the lifelong concept of learning. That is what makes us highly effective. In a nutshell: bad leader equals bad learning. Effective leader equals positive classroom experience.

To support IL09 on the efficacy of instructional leaders, not just on their team but all leaders in general, several participants described how effective science instructional leadership affects classroom teaching and learning through content knowledge and pedagogy.

> IL01: Effective instructional leadership greatly affects classroom teaching and learning through aiding teachers in what best to teach, best practices for divulging the information, and constantly using data to drive classroom instruction. We use common assessment district data in our weekly professional learning community meetings to drive that instruction and find ways to help our teachers reach all students. It is such a positive learning culture, and especially for me as a facilitator of those meetings, I love to see our content teachers collaborating in those meetings. I can honestly say that the teachers are the ones who make me effective, not the other way around. I couldn't be what I am without what they do in the classroom. That makes me happy.

Participant IL02 maintained his abilities directly affect his teachers' abilities, which in turn affect the students' abilities, thus placing the responsibility for leadership efficacy on himself.

> IL02: I believe effective leaders help create effective teachers and students because if a teacher is not comfortable going to leadership for advice, then teacher growth is more difficult, which affects student learning. So, if I don't have that knowledge or understand how to teach in that science classroom, my teachers will not bother coming to me. They will doubt my abilities to lead them. So, for me to be the most effective at what I do, I have to continually hone my skills and knowledge. I want to support my teachers in every way I can. And if I don't know

how to help them, I will find somebody who can, and we will figure it out together.

Participant IL05 attested to her teachers being the best at what they do, and they in turn motivated her to do her job well. Combined with content knowledge and pedagogy, she has the qualities of effectiveness.

IL05: If you have a bad leader, you know teachers can't teach, and students aren't learning. This is not the norm, but it happens. Effective leaders naturally promote good classroom teaching and great student learning. They have the knowledge and the pedagogy you're talking about to lead a science classroom. Now, can I go in and teach all their lessons? Most definitely not. But I know when I am walking through those science classrooms, I understand the standards and the content. I know what the culture of that room looks like. I could certainly join in and assist. But the teachers are the real MVPs. I mean, they give me the desire to continue learning and adding to my own knowledge. It is a great dynamic, and I love my coaching position.

Some participants also connected instructional leadership effectiveness to their abilities to provide resources their teachers need, and this was achieved through that content knowledge and pedagogical knowledge.

IL04: Effective leadership begins at the level for which the leader feels confident in their leadership abilities. The more confident they are in their role, the more they have to offer their teachers. When you are proficient in a content area such as science, you are more likely to go above and beyond to help your teachers succeed. Science, and even math, are two areas that intimidate some leaders if

> they don't have that background knowledge or experience. This is because those subjects are so content-specific and application-based. It's not just memory work. Leaders can't fake their way through those classes.

Participant IL06 highlighted the problems for fair teacher evaluations from instructional leaders lacking efficacy due to decreased content knowledge and science classroom experience.

> IL06: Administrators can't be in their jobs for money. They have to want to help their teachers be the best they can be so their students have the brightest future possible. Leaders can't be effective if they don't have experience-based knowledge to extend to the teachers. They also can't objectively evaluate a teacher in that classroom. Years ago, my principal came in to do one of my formal observations. He had only previously been a K-8 principal before moving to high school. He had no content knowledge of any high school sciences on our campus besides what he learned in high school himself 25 years prior. So, he walked into my chemistry class and told me that he knew everything about chemistry since he knew the periodic table. I immediately knew one of two things were about to happen: either he would check off all his boxes, so we both looked good, or his scores would have no true reflection on my ability to teach chemistry because he had zero knowledge of what I was saying, and my scores would be low. Neither scenario reflects an effective leader.

Finally, two participants rounded out the responses with general overviews encompassing effective instructional leaders.

> IL07: To be effective, instructional leaders have to fulfill their roles to the fullest to see a return on productive classroom teaching and learning. A leader's job is to lead. They need to provide all resources needed to produce the best learning environment for their school. I often put math and science together in one category because math is such an integral part of most sciences. Effective leaders can't support those teachers without that math or science content knowledge or the know-how to teach those subjects. Most of the know-how comes from previous teaching experience of our own, or it can come through years of being a leader spending a lot of time in those classrooms. But that content has to be learned. We do go through trainings and workshops every year for specific content. But what I would really like to see on a campus leadership team is for at least one leader to be highly proficient in each of the sciences. That would be amazing.

According to participant IL08, leadership efficacy stems from experience and content knowledge.

> IL08: I would like to say effectiveness breeds greatness to one's well-being. I like to live by that. So, I take my experience, my know-how, and my resources and give it all to teachers. We have so many great teachers, and many times they make my job easy. I love spending time in their classrooms. I love the labs and activities and seeing students engaged. But if I can't be the most effective I can be, my teachers can't be their best. In my opinion, high school science is one of the most difficult subjects to teach. So, as a leader, it is up to me to give them every tool I can to succeed.

The researcher included some additional notes from her interview reflection journal during this interview phase. Most of the instructional leader participants mentioned at least one characteristic they believed defined an effective instruction leader. These traits included but were not limited to: being a continuous learner, being effective working with adult learners, being an effective communicator, being collaborative, being knowledgeable of content and pedagogy, being knowledgeable of assessment and data, and providing helpful feedback to their instructors. The data support the research of Fuentes and Jimerson (2020) on instructional leadership. They assert it is a primary task of school leaders, but the work is complicated when leaders and teachers do not share content area or grade level expertise. Despite the different working contexts and various professional backgrounds, all participants, teachers, and instructional leaders alluded to that concept.

Finally, seven of the eight participants felt more confident in their leadership abilities because their levels of science content knowledge and teaching concepts gave them higher senses of self-efficacy. Therefore, they felt their leading capabilities were effective at least 90% of the time. Unfortunately, one participant did not elaborate on this question to include any additional information on this topic.

Theme 4: Instructional Leader Self-Perceptions

Teacher Results

Leading from instructional leader efficacy into self-perception closed out the semi-structured interviews. Both groups of participants had a plethora of views on this last question. Beginning with the teacher participants, they quickly answered this question without hesitation. Several thought it was finally their turn to “roast” their leaders. However, once the conversations began, the researcher noticed a change in participants' demeanors as they changed thought processes about their instructional leader perceptions. Deep thought and careful consideration led to honest answers that surprised them. There were two significant distinctions in these descriptions. First, some participants felt instructional leaders were open about how their science content and pedagogical knowledge affected their leadership roles. Alternatively, some participants felt like their roles over-boosted their confidence because of the titles they held. Beginning with the former distinction, T01, T03, and T05-T09 describe the characteristics of a good leader and their self-perceptions based on their science content knowledge and pedagogical content knowledge.

> T01: Great leaders are open with their level of knowledge. They know they don't know everything. So, they are honest. On a campus as large as this and with as many different courses we teach, it would be almost impossible to be a master of all the sciences. They know their limitations. But effective leaders work as a team for the better good of their faculty and students.

Participant T03 believed experience equals positive self-perceptions in relation to content knowledge.

> T03: I think leaders perceive their knowledge based on what experiences they have. Effective leadership affects teaching and learning, so they need to equip teachers with all the supplies they need and the appropriate curriculum. Those who offer this to their teachers are unsung heroes. Many are afraid to teach science or come into science classrooms. They find it somewhat intimidating. But effective leaders take all the tools in their toolbelts and supply teachers with all

they have. That includes their own knowledge and ways of teaching from previous teaching. As a teacher, you can tell who has taught in the classroom and who has not.

Participant T05 claimed open leaders are good leaders in regard to knowledge and pedagogy.

T05: If they are good leaders, they are open to perceptions. They already know what their content background is. Most here on this campus take pride in their knowledge and pedagogy. They worked a long time to get where they are. But they will stop and ask how they may help teachers and make things easier for them where they can.

Participant T06 believed honest perceptions and experience were directly related to content knowledge and pedagogical content knowledge.

T06: Most leaders are honest about their abilities. They have so many eyes on them, and kids can see right through a fake. But seriously, honest perceptions are believing in their abilities to the extent of their science knowledge and how to teach it. They are in their positions to help, not hinder. They use the experience they have to fulfill their duties. Some do it well, and others not so much.

Participant T07 related instructional leader confidence with increased content knowledge and experience.

T07: They [instructional leaders] look at their knowledge level, and they know if they can effectively lead a science class like mine or yours. They are hard subjects for a lot of people. The ones with experience in those areas are confident they can

> lead us well. And we like for them to. They are better leaders because they have high-level knowledge and know-how to teach science.

Participant T08 also claimed honest perceptions and experience were directly related to content knowledge and pedagogical content knowledge.

> T08: If they [instructional leaders] are honest with themselves, the great leaders are good with those self-perceptions. They know if they are confident in their abilities, and if they are, they can lead their teachers or team well.

Participant T09 also maintained honest perceptions and experience were directly related to content knowledge and pedagogical content knowledge, adding efficacy as an offshoot.

> T09: I believe that instructional leaders have pretty honest perceptions of their content knowledge and how to teach science. They know they cannot effectively lead if they cannot even discuss or have conversations about anything that pertains to content. They also know their level of knowledge and their level of studying. They know how long they've taught and what classes they've taught that could help them in this leadership role. The really great leaders actually strive to be the best at their role so they can help teachers help their students.

In the latter distinction, two participants felt instructional leaders had false senses of efficacy because of the title, not solely because of how their science content and pedagogical knowledge affected their leadership roles.

> T02: It has been said for a long time by administration that a good teacher can teach anything. Others have the attitude that if they're a good teacher, they can teach anything [subject]. I think these people getting these jobs without having the

> science background believe since they were good teachers previously, then they can help you. I think it colors their perception of how effective they are. I think they are over-confident because if they felt like they couldn't do the job [as instructional leader], they probably wouldn't have tried out for it.

Participant T04 described what he thought a good leader should be.

> T04: I think the good ones [instructional leaders] are okay with self-perceptions. They do not know it all. Personally, I have a life science background, so I am uncomfortable helping teach physical sciences or giving pointers. But I will go look something up and try to find out. Most leaders fall into the category of "I'm a leader." I need to be strong and not let them know my weakness. The leaders on my campus are the total opposite of that. They will look you in the face and tell you they have no idea, but they know somebody who does. That is a great leader.

The remaining participant in this group (T10) expressed no opinion on this topic and declined to comment.

Instructional Leader Results

The instructional leader participant group quickly shared their self-perceptions because they were proud of their careers' accomplishments and successes thus far. Sherman and MacDonald (2008) found that a good instructional leader will encourage the critical study of pedagogy and curriculum and encourage teachers to be self-reflective. All group participants assented to this same philosophy in their leadership roles. For example, instructional leaders IL02, IL04-IL06, and IL08 discussed what self-perceptions looked like from their point of view.

> IL02: Effective leaders naturally have that self-confidence in their abilities. If they are effective and are seeing the desired results, they feel pretty effective. There are days when they don’t feel that way, obviously. School days can get crazy, and we get pulled in a hundred different directions. But at the end of the day, we are confident in our knowledge and experience to lead our science teachers. One of our roles as leaders is establishing and maintaining a focus on learning in school through continued and routine engagement. Combining all of those things with the knowledge and experience we had before becoming a leader helps us have a positive self-perception.

Participant IL04 compared self-perceptions to teachers’ perceptions of their instructional leaders and claimed the two directly correlate.

> IL04: I said earlier that effective leaders begin at a level where they feel confident in their abilities. The same applies here with self-perceptions, I think. We can certainly have positive self-perceptions when our teachers feel the same way about us as we feel about ourselves. Confidence can be seen on the outside in the way we carry ourselves and conduct ourselves in the classroom. However, when teachers’ perceptions do not line up with ours, it causes a diminishing effect on leadership effectiveness. That has adverse outcomes that we try to avoid. So, to sum that up, I would say positive breeds positive.

According to Participant IL05, confidence builds positive perceptions, which in turn builds trust. That trust leads to success and increased self-esteem for instructional leaders.

IL05: Referring to science instructional leaders makes me think specifically of curricular and instructional activities. This includes knowing the science performance standards and how they are taught. We have that role on top of discipline and other managerial duties. While some may argue one task is more important than the other, the curriculum and how it's taught is high on my list. I take the role very seriously and take pride in my work. As leaders, I think we are confident when we have the knowledge base and experience from our own backgrounds. That confidence allows me to trust that I can accomplish my goal, and my teachers can accomplish theirs. It is a snowball effect. Confidence builds trust. Trust builds self-perception. Self-perception builds success. Success increases self-esteem.

Participant IL06 linked self-perception to effectiveness and self-confidence.

IL06: I feel like self-perception is the central value to effectiveness. Having self-confidence is like the biggest motivator to achievement in our lives. We have to constantly compare our goals with what we are trying to achieve. Then, we try to project that same drive onto our teachers. Science teachers have such an active learning environment, and we leaders need to be able to support their content and culture. When we can do that, we have a great self-perception. What does that look like? That looks like I know what I'm doing and putting my own skills and content knowledge to work. I can't imagine trying to do this job without an extensive background in science.

Participant IL08 mentioned having increased levels of content knowledge and pedagogy were responsible for positive self-perceptions.

> IL08: When you say self-perception, I feel like I am judging myself. It also makes me think of how well I do my job. I usually have a pretty decent self-esteem. Most education leaders probably do as well; else, they wouldn't be in their positions. I believe what we do with the information between that perception and putting plans into action is the most important. Looking at the whole theme of this research you're doing, and by what you're saying, science instructional leaders need to have a positive self-perception. And the way they get that (well, hopefully, they already have it) is by having a high level of scientific knowledge and a high level of pedagogy. With all the experience and knowledge from those sciences classes, who wouldn't have a great self-esteem and feel like we could walk into any classroom confidently? But that's just my opinion.

Two of the eight instructional leader participants attested to lower self-perception initially in their science leadership roles because they felt somewhat deficient in their science content knowledge. However, once they began their new leadership positions, they had a confidence boost after realizing they had an entire support team to help them gain valuable experience.

> IL01: When I first transitioned into admin, I was nervous and excited at the same time. When I found out we [instructional leaders] had to do multiple walk-throughs [observations] in the school year, my first thought was, what am I going to do about science and math? I'm a history and English kind of guy. I mean, I've had many science courses. But to me, that is not the same as teaching science or math. My beliefs in myself were not very high, even though my coworkers believed in me. But I quickly realized that they were not going to throw me to the

> wolves. Instead, they mentored and supported me and helped me get where I am. What a blessing that has been. Now, my self-perception is pretty, and I know how to use my knowledge and experience to help my team and our teachers. Personal and professional growth is a wonderful thing.

Finally, participant IL07 brought the human aspect into the self-perceptions, claiming humans make mistakes, and attitudes are crucial to positivity and effectiveness.

> IL07: Our own self-expectations can have a negative impact on self-perception in regard to our performance as leaders. We want to be the best and do the best. Unfortunately, our best doesn't always shine through. We are human. Am I qualified for my position? Absolutely. Do I make mistakes? Absolutely. Self-perception is more of an attitude toward yourself. So, if you believe in yourself and know you are effective in your job, you can help your teachers meet those performance standards. Then, you can both have positive self-perceptions.

Summary

The answers to the three research questions provide a framework for the relationship between instructional leaders' science content knowledge and pedagogical content knowledge and its effects on instructional leadership efficacies in secondary science classrooms. In addition, these data agree with the perceptions of school leadership related to the implications of leadership effectiveness published by the American Educator Panels (Tosh & Doss, 2020). The factors affecting the efficacies of science instructional leadership are the relationships between science content knowledge, pedagogical content knowledge, education, experience, and self-perception. In addition, teachers and instructional leaders shared some perspectives on supports and hindrances affecting the relationships and what that looked like at the study site. Collectively, the data demonstrated the aforementioned factors do affect instructional leadership practices in high school science classrooms.

CHAPTER 5

DISCUSSION

This single case study aimed to determine if there was a relationship between instructional leaders' science content knowledge and pedagogical content knowledge and the effects it has on instructional leadership efficacy in secondary science. Chapter 5 discusses the research findings and situates the current study findings within the context of existing research, recommendations for leadership practices, implications for future research, and concluding remarks.

Findings

According to teachers and instructional leaders, the level of content-specific knowledge and pedagogical content knowledge influences leadership efficacy. The findings of the present study support science teachers' expectations that instructional leaders need higher levels of science content knowledge and pedagogical content knowledge to serve in their leadership roles. This is consistent with existing research that instructional leaders need knowledge and fluency with the content teachers teach to provide professional and classroom support. Lochmiller and Cunningham (2019) confirm that support is vital at the secondary level and is seen more in challenging subjects like science from leaders who lack content area expertise and educational backgrounds. These findings also align with the existing research from Stein and Nelson (2003), who claim to apply subject matter knowledge is needed to understand science instructional leadership. They concluded that from the leadership content knowledge perspective, an instructional leader should combine knowledge of the subject matter taught with knowledge of how to teach that subject matter (i.e., pedagogical content knowledge).

The present study acknowledges the need for instructional leaders at the secondary classroom level to possess increased science-specific content knowledge. Science content knowledge is critical support that enables instructional leaders to engage with teachers in rich instructional dialogue that would likely be diminished if leaders lacked content knowledge or failed to draw upon content knowledge in supervisory duties (Fuentes & Jimerson, 2020; McNeill et al., 2018; Shulman, 1987; Wenner & Campbell, 2017). One of the significant findings of this study is that the science content knowledge instructional leaders need comes from a couple of different sources. The first source of knowledge is from the leaders' own post-secondary education coursework. The other is from knowledge gained on the job, either through prior instructional experiences or supervisory acts. The present study also found that one instructional leader on the campus might lack expertise in a particular content area. On the other hand, another was likely proficient in that same area, thus leading to collective background knowledge.

The present study also finds the need for instructional leaders to possess increased pedagogical content knowledge at the secondary classroom level. Science content-specific pedagogical knowledge goes beyond subject matter knowledge. It is domain-specific teaching connecting knowledge of the subject matter taught and how to teach it (Hausfather, 2001; Shulman, 1987). This study notably relates pedagogical content knowledge to instructional leaders' previous classroom teaching experiences as a prerequisite before transitioning into leadership roles. This research also highlights the need for some classroom teaching experience, including science classes that include lab sections. The study's results confirm what existing research explains as the need for enhanced understanding of the cultural norms associated with science instruction. Several current studies describe a phenomenon where instructional leaders cannot engage or identify connections between practice and assess the richness of concepts without knowledge of pedagogy (Fuentes & Jimerson, 2020; Lochmiller & Cunningham, 2019; Stein & Nelson, 2003). The researchers equate this ability with instructional leaders' own prior instructional experiences, and it is necessary to offer the level of support needed for understanding science instruction. Instructional leaders who maintain science content knowledge and pedagogical science content knowledge can apply their experiences and skills as leaders in the diverse ways needed in secondary science classrooms.

The second finding of the present study supports the idea that science content knowledge and pedagogical science content knowledge affect instructional leadership efficacy. Existing research investigates effective instructional leadership practices and improved student outcomes, particularly in more challenging subjects like science. Science scholars agree that instructional leadership for high-quality instructional experiences requires significant pedagogical and content area understanding to be effective (Jackson et al., 2015; Lochmiller & Cunningham, 2019; McBrayer et al., 2020).

The present study confirms how effective science instructional leadership positively affects classroom teaching and learning through content knowledge and pedagogy. Instructional leaders who are honest with their levels of expertise and experience are more effective because they use all their resources to support their teachers by helping them increase their self-efficacies with science instruction, which yields a collective efficacy. The results also affirm that collective efficacy is possible with campus-wide instructional leadership teams supporting one another. This, in turn, fosters an intellectual, supportive, and trusting relationship with the teachers. Existing research confirms this finding through instructional leaders who engage in self-reflection to understand their practices better and identify strengths and areas of improvement to contribute to collective efficacy (McBrayer et al., 2020; Versland & Erickson, 2017). Many instructional leaders continue to increase their science content knowledge and pedagogical content knowledge through professional development, professional learning communities, and ongoing post-secondary education.

The present study also reveals how science instructional leadership negatively affects classroom teaching and learning through a lack of content knowledge and pedagogy. This study calls attention to instructional leaders who move up the educational hierarchy for a position in name only. Albeit for increased salary or position of power, those leaders offer no scientific content knowledge nor any levels of pedagogy to teachers or other instructional leadership team members. This contributing factor to decreased efficacy is not seen in existing research to much extent. However, ongoing research does highlight the limitations in instructional leaders' backgrounds and competing demands on their time while acknowledging they should work in consultation with other school staff to improve science instruction (Fuentes & Jimerson, 2020; Hairon, 2017; Lochmiller & Cunningham, 2019; Neumerski, 2012). Even though instructional leaders hold formal titles within the school system, this does not excuse them from knowing what good instruction entails nor how to engage in content area instruction with intention (Stein & Nelson, 2003).

The last finding of the present study focuses on instructional leaders' perceptions of their knowledge of science concepts and teaching science and how it affects their leadership. Existing research suggests good instructional leaders will encourage the critical study of pedagogy and curriculum and encourage teachers to be reflective (Bandura, 1997; Sherman & MacDonald, 2008). Furthermore, the present study's findings share the same point of view, adding that effective leaders have self-confidence in their abilities. Self-confidence leads to positive self-perceptions as most instructional leaders are proud of their career accomplishments and successes. The present study confirms instructional leaders work hard to get to a high professional level, and their confidence promotes efficacy. They honestly reflect on their knowledge and expertise and are transparent with their teachers and other faculty. McBrayer et al. (2020) agree that school leaders are aware of their impacts through instructional leadership practices and are engaged in self-reflection better to understand their instructional leadership practices. Other existing research is consistent with the American Educator Panel's previous findings that principals and other instructional leaders have highly positive self-perceptions of their own leadership practices (Tosh & Doss, 2020). While teachers consistently rate their leaders positively, there are significant gaps between their perceptions.

On the contrary, the present study also points out that some instructional leaders fall into the category of false confidence in their leadership roles based on their titles and not on the science content knowledge or pedagogical content knowledge. Their self-perceptions are false positives and have a decreased efficacy, which teachers and other leaders are quick to notice. Existing research demonstrates that teachers tend to rate instructional leaders lower on important leadership practices than the leaders rate themselves. Tosh and Doss (2020) claim numerous studies in human resources and organizational management fields reveal that leader self-perception is in agreement with what subordinates perceive is directly related to leadership effectiveness. The degree to which leaders rate themselves more highly than subordinates correlates with diminished organizational outcomes, including reduced subordinate job satisfaction and productivity. Specific to education, negative teacher perception of school leadership correlates with teacher burnout and reduced teacher collaboration (Hallinger, 2005). Versland and Erickson (2017) conclude that using teachers' perspectives as a lens provides significant insight into instructional leadership practices.

Recommendations for Leadership Practice

This study provided valuable information regarding instructional leadership practices of school leaders and their science content knowledge, pedagogical content knowledge, self-efficacy, and self-perceptions. Current and existing research demonstrates that instructional leaders cannot know everything about teaching in specific content areas but suggests instructional leaders can work to bridge the divide. Furthermore, closing the content gap can improve leadership efficacy and self-perceptions relating to content knowledge, thus strengthening collaborative instructional leadership practices for overall instructional improvement.

Instructional leaders at the secondary level may consider this information for reflection on practice and future planning of professional learning for overall school improvement. For example, acquiring or utilizing current content area experts as mentors or supervisors and moving away from deferred leader responsibility can sharpen effective instructional leadership. Also, purposefully and intentionally developing a content knowledge foundation across all content areas over time can broaden the gateway to a diverse instructional leader pool enabling leaders to accommodate all teachers' needs. This aligns with the findings of this study, demonstrating a need for instructional leaders to provide useful feedback and support to secondary science teachers through content and pedagogical knowledge.

Instructional leaders may also consider these findings as they reflect on their supervision abilities and evaluations of their teachers. Increased self-efficacy and self-perceptions are positive predictors of effective instructional leadership when leaders are confident and effective in their abilities. A leader's ability to be transparent on strengths and limitations in his/her instructional content expertise can be a segue into coaching, mentoring, and co-teaching with increased instructional leadership capacity while developing a firm knowledge foundation. School districts may investigate implementing this type of distributed leadership model as a collaborative effort to combine instructional resources and increase leadership efficacy. Therefore, implications exist for future actions aligned to instructional leadership practices and leadership self-efficacy.

Implications for Further Research

Based on the findings and limitations of the current study, I recommend the following future research using both qualitative and quantitative methods: a multi-site qualitative analysis encompassing multiple schools to broaden the perspectives from both teachers and instructional leaders, a multi-site qualitative analysis involving rural school districts who may be underserved, and a quantitative or mixed-methods study providing numerical data that looks into which leadership practices are most related to science teachers' perceptions of school-level leadership.

Existing literature offers sound qualitative research on science instructional leadership efficacy. However, expanding the analysis across multiple sites to include a more significant number of participants would produce a more detailed look into science content knowledge and pedagogical practices beyond one district. A study of this magnitude could provide needed information for instructional leaders to enhance science education, training, and professional development for the leaders and teachers on their campuses. It could also go beyond the scope of science content to reach across multiple disciplines. In fact, Stein and Nelson (2003) suggested all administrators have solid mastery of at least one subject and the learning and teaching of it. In addition, since instructional leaders embrace a spectrum of roles, researching multiple sites could build instructional credibility and enact a full range of roles to meet teachers' individual needs.

While much of the current study contained information from one large public high school, it would be beneficial to analyze an often underserved and underrepresented population in rural school districts. Yow et al. (2018) researched the complexities of content-based teacher leadership in 10 rural schools; however, teacher leadership in rural contexts is still needed and constantly evolving. Focusing on science content and pedagogical knowledge could provide a specific focus on high-quality instructional learning and leading.

One topic that emerged in the current study warranting further research is a distributive leadership model on school campuses. As principals and other instructional leaders consider the effectiveness of traditional roles, they are beginning to look at transitioning into distributive instructional leadership, actively facilitating and supporting the instructional leadership of others. Using a mixed-method or quantitative study, researchers will be able to generate quantitative and qualitative data allowing the researcher greater certainty in inferences. In addition, by combining the two types of data in a single study, the contextualized insights from the science content and pedagogical content knowledge will benefit the generalizable insights of the quantitative data. Instructional leaders can use that data to measure growth, set goals, and monitor the effectiveness of the distributive leadership model.

Conclusion

The findings of this study indicate that science content knowledge and pedagogical content knowledge increase instructional leader efficacy and self-perceptions. The results also suggest that teachers expect heightened levels of both types of knowledge from the instructional leaders on their campus. Science educational leadership lays out specific challenges and goals due to the complexity of the subject matter at the secondary level. Effective instructional leaders need a vision that aligns with the ever-changing science standard reform and transfer their knowledge, skills, and expertise to the teaching and learning of science content. These findings only provide a narrow view through a broad content and pedagogy best practices window.

While these findings do give a generalized idea of the desired expectations of science instructional leaders, more research is needed for school leaders to implement the necessary initiatives and how to best support their teachers through content-specific knowledge. Certainly, collaboration and communication can help facilitate those initiatives. However, further research would help establish a supportive organization for learning and maintaining a science culture. Through self-reflective processes and additional data, instructional leaders can improve overall performance by clarifying roles and objectives and meeting instructional goals.

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APPENDIX A

INTERVIEW PROTOCOL

Semi-Structured Interview Questions

Me: I am studying the effects of science instructional leadership in secondary science classrooms. I am researching both science content knowledge as well as pedagogical content knowledge that instructional leaders have. Instructional leaders include teacher mentors, teacher leaders, instructional coaches, grade-level supervisors, and principals.

1. <u>Introduce yourself and include your professional education experience.</u>

   I am in my fourth year of teaching chemistry. Education is my second career. I previously practiced as a medical technologist for 23 years before acquiring a master's degree in teaching. This research will help me complete my Doctor of Education degree requirements. Thank you for your willingness to speak with me.

RQ1: What are science teachers' expectations of instructional leaders' pedagogical knowledge and scientific knowledge?

2. What science content do leaders need to know for their position?
3. What do leaders need to know about *teaching* science?
4. How do instructional leaders in *this* school stand relative to what you just described as being necessary?

RQ2: In what ways do instructional leaders' content-specific pedagogical knowledge and content knowledge affect instructional leadership efficacy?

5. After describing how much science content and teaching concepts leaders need, how does that affect their ability to be instructional leaders in science?

RQ3: How do leaders perceive their content and pedagogical knowledge *and* its effects on instructional leadership in science?

6. How do you think instructional leaders *perceive* their knowledge of science concepts and teaching science and its effects on their leadership in science classrooms?
7. If you could change one thing about your school's current science content and pedagogical knowledge, what would it be and why?

APPENDIX B

HUMAN USE EXEMPTION LETTER

LOUISIANA TECH
UNIVERSITY.

Office of Sponsored Projects

EXEMPTION MEMORANDUM

TO: Ms. Mary Ann Chapman and Dr. Bryan McCoy

FROM: Dr. Richard Kordal, Director of Intellectual Properties RTK
rkordal@latech.edu

SUBJECT: HUMAN USE COMMITTEE REVIEW

DATE: August 11, 2021

TITLE: "Science Instructional Leadership Knowledge: A Case Study"

NUMBER: HUC 22-015

According to the Code of Federal Regulations Title 45 Part 46, your research protocol is determined to be exempt from full review under the following exemption category(s): 46.104 (a)(d)(1)(2)(i)(ii).

a) Unless otherwise required by law or by department or agency heads, research activities in which the only involvement of human subjects will be in one or more of the categories in paragraph (d) of this section are exempt from the requirements of this policy, except that such activities must comply with the requirements of this section and as specified in each category.

(d) Except as described in paragraph (a) of this section, the following categories of human subjects research are exempt from this policy:

(1) Research, conducted in established or commonly accepted educational settings, that specifically involves normal educational practices that are not likely to adversely impact students' opportunity to learn required educational content or the assessment of educators who provide instruction. This includes most research on regular and special education instructional strategies, and research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

(2) Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording) if at least one of the following criteria is met:

(i) The information obtained is recorded by the investigator in such a manner that the identity of the human subjects cannot readily be ascertained, directly or through identifiers linked to the subjects;

(ii) Any disclosure of the human subjects' responses outside the research would not reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, educational advancement, or reputation.

NOTE:

Following the 2021 Code of Federal Regulations, I recommend that HUC 22-015 be exempted from full review. There are no treatments offered or administered. The research includes no physical contact with the participants. Pseudonyms will be used for participant names and for school names. Subject areas are not identified in the study.

Thank you,
Richard Shrubb

Thank you for submitting your Human Use Proposal to Louisiana Tech's Institutional Review Board.