UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

AN EXPLORATION OF TEACHER AUTONOMY IN RELATION TO ELEMENTARY TEACHERS' SCIENCE INSTRUCTIONAL PRACTICE

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

Degree of

DOCTOR OF PHILOSOPHY

By

JANIS L. SLATER
Norman, Oklahoma
2017

Downloaded from SHAREOK. Persistent Handle URL: https://hdl.handle.net/11244/50802

AN EXPLORATION OF TEACHER AUTONOMY IN RELATION TO ELEMENTARY TEACHERS' SCIENCE INSTRUCTIONAL PRACTICE

A DISSERTATION APPROVED FOR THE
DEPARTMENT OF EDUCATIONAL PSYCHOLOGY

BY

_____
Dr. Ji Hong, Chair

_____
Dr. Timothy Laubach

_____
Dr. Jean Cate

_____
Dr. Xun Ge

_____
Dr. Barbara Greene

© Copyright by JANIS L. SLATER 2017
All Rights Reserved.

Acknowledgements

I would like to thank my 'village' for their help and support on this amazing journey. Thanks to my doctoral committee for bringing me to this place through wise counsel and excellent instruction. Special thanks to my committee chair, Dr. Ji Hong, who has supported and encouraged me, even when external factors provided barriers to my self-determined motivation. I would also like to acknowledge Dr. Ray Miller, who was my original committee chair and is now retired. He introduced me to the joy and value of self-determination theory, and the rest is history.

I would also like to express gratitude to my K20 Center family for their patience, support, and authentic learning context for a graduate degree. My science education colleagues have encouraged and supported me through this process. I especially want to thank my friend and elementary teaching sage, Pat Turner, for her help and thoughtfulness. I could not have done this without her. My sincere appreciation goes to Drs. Linda Atkinson and Jean Cate, who have been my mentors and friends throughout my educational career. I owe them a huge debt of gratitude.

Most importantly, I thank my two remarkable children, Grant and Rebecca. Their unwavering belief in my ability to attain this goal and their unconditional love have sustained me and allowed me to succeed in this endeavor.

Table of Contents

Page

Acknowledgements ……..iv

List of Tables ……..……..….xii

List of Figures …….……..xiii

Abstract ……..…xiv

Chapter 1: Need and Purpose for the Study …..…….……..1

Introduction ……....1

Problem Statement ……1

Need for the Study …… .5

Reason for the Study ……7

Purpose of the Study …….....11

Chapter 2: Literature Review and Research Questions ……..... 13

Introduction ……...13

Motivation Research and Self-determination Theory……14

Origins of Self-determination Theory……14

Needs-driven Theories ……...14

Achievement Goal Theories……16

Self-determination Theory……...19

Cognitive Evaluation Theory …….…….20

SDT and Goal-directed Behavior ……21

Organismic Integration Theory (OIT) ……22

Science Education Literature Relating Teacher Beliefs and Practice ……28

Page

Relationship Between Science Teacher Beliefs and Practice ……29

Elementary Teacher Efficacy Beliefs for Science Teaching ……..31

Constructivist Beliefs About the Nature of Science and Science Learning …34

Constructivism and Student-centered Learning ……..34

Constructivist Teaching in Science ……36

Research on Beliefs about the Nature of Science ……...39

Autonomous Motivation ……42

Summary of Study Rationale with Research Questions……..50

Chapter 3: Methodology ……55

Research Design ……55

Quantitative Design ……61

Participants ……61

Participant Recruitment ……..61

IRB and Participant Confidentiality ……63

Participant Description ……63

Quantitative Data Sources ……...66

Survey Instrument ……...66

Instrument Construction ……..67

Demographic Items ……68

Teaching Frequency Items ……..68

Instructional Method Items ……69

Quantitative Data Analysis ……70

Page

Demographic Data ……..70

Teaching Frequency Data ……...70

Instructional Method Data ……..72

Quantitative Data used for Qualitative Participant Selection..72

Qualitative Design ……..73

Participants ……..73

Qualitative Data Sources ……75

Interviews ……75

Interview Protocol ……..76

General Teacher Information ……76

Teaching Practice ……76

Autonomous Motivation for Teaching ……77

Autonomy Support for Science Teaching ……...78

Teacher Orientation to Autonomy Support ……79

Other Qualitative Data ……81

Qualitative Data Analysis ……...82

Triangulation ……...85

Chapter 4: Findings ……87

Introduction ……87

Results of Quantitative Analysis and Participant Selection ……87

Research Question 1: Percentage of Time Teaching Science …….87

Grouping for Interview Participant Selection ……89

Page

Results of the Qualitative Analysis ……91

Introduction ……91

Final Grouping for Analysis ……...91

Definition and Use of Autonomous Motivation as a Lens ……93

Themes ……94

Research Question 2: Autonomy and CPSIT Relationship ……95

Theme: Valuing of Science ……96

Results ……96

Connections to SDT ……..100

Theme: Efficacy for Science ……103

Results……..….104

Connections to SDT ……...106

Theme: Perception of Student Ability ……...106

Results ……107

Connections to SDT ……...110

Theme: Attitude Toward Effort Required for Science ……...112

Results ……113

Connections to SDT ……...116

Theme: External Factors Affecting Science Instruction ……117

Results ……118

Schedules ……...118

Page

New Science Standards ……...……. 121

Mandated State Testing …….123

Curricula and Materials ……..124

Connections to SDT ……...……130

Theme: Support for Science Instruction ……..……..132

Results ……..……..133

Collegial Support …….……..134

Administrative Support …….136

Teacher Learning ……..140

Parental Support ……141

Connections to SDT …….…….142

Summary: Autonomy and CPSIT …….143

Research Question 3: SCL and CPSIT Relationship ……146

Theme: Endorsement of Student-centered Learning …….146

Results ……148

Use of Structures for SCL ……..149

Attitude Toward Science Learning ……153

Integration of Science ……156

Summary: SCL and CPSIT Relationship ……..157

Conclusion …….159

Chapter 5: Discussion and Implications ……...161

Introduction ……161

Page

Discussion of Findings ……...161

Quantitative Findings ……161

Beliefs and Practice Disconnect. ……163

Satisfaction of Psychological Needs in SDT ……166

Need for Relatedness ……166

Need for Competence ……167

Need for Autonomy ……...169

Faith - Introjected Regulation and Frustration ……...169

Addie, Diane, Ellen, and Gayle - External Regulation ……..170

Brooke, Hannah, and Iris - Introjected Regulation ……171

OIT and the Importance of Context in Belief Systems ……..173

External Factors as Barriers and Support ……...174

OIT Continuum Example from the Data ……175

Gayle - External Regulation ……...176

Carol - Introjected Regulation ……177

Kelly - Introjected-Identified Regulation ……...178

Jenna - Identified-Integrated Regulation ……179

Autonomous motivation and the OIT continuum ……..180

SDT as a Lens for Examining Science Teaching Beliefs and Practice ……..183

Implications for Practice ……187

Limitations ……189

Page

Directions for Future Research ……..……190

References ……..…….192

Appendices ……..……220

Appendix A - Embedded Belief System Model ……220

Appendix B - Survey Items ……221

Appendix C - Interview Protocol ……...……224

Appendix D - Autonomous Motivation for Teaching Subscales ……...……228

Appendix E - Autonomy Supportive Behavior Items ……229

Appendix F - Features of Autonomy Support ……230

List of Tables

Page

Table 3.1 - Teacher Distribution by District Size ……64

Table 3.2 - Grade Level Distribution of Study Teachers ……65

Table 3.3 - Teaching Experience of Study Teachers ……...65

Table 3.4 - Profile Data from Interview Participants ……...74

Table 4.1 - CPSIT Frequencies for Survey Participants ……..88

Table 4.2 - CPSIT Frequencies for Teachers Providing Interview Permission ……...88

Table 4.3 - Initial Grouping for Participant Interviews ……90

Table 4.4 - CPSIT and Profile Data from Interview Participants ……93

Table 4.5 - OIT Levels of Intrinsic Regulation ……94

Table 4.6 - Study Themes ……95

Table 4.7 - Time Schedules for Science Instruction ……..119

Table 5.1 - Levels of Perception for Study Associated Themes ……168

List of Figures

Page

Figure 2.1 - A Taxonomy of Human Motivation (Ryan & Deci, 2000) ……..23

Figure 2.2 - Beliefs versus Practice Model - Science Ed. Literature ……...51

Figure 2.3 - Beliefs and Practice Model - SDT Perspective ……52

Figure 3.1 - Participant Selection Model - Qualitative Emphasis ……57

Figure 5.1 - Integrated Beliefs Model (Jones & Leagon, 2014) ……165

Figure 5.2 - Beliefs and Practice Connections from Data - SDT ……...184

Abstract

This mixed methods study uses a participant selection model with a qualitative emphasis (Creswell & Plano-Clark, 2007) to examine the science teaching practices of elementary teachers in self-contained classrooms. Their choices regarding amount of time and teaching methodology are explored in relation to their perceptions of instructional and curricular autonomy within their teaching context. The study focuses on reform teaching methods such as those outlined in *A Framework for K-12 Science Education* (NRC, 2011) as the desired standard of practice for science instruction. The *Framework* emphasizes the importance of the role of elementary science education in providing a foundation for scientific literacy and proficiency, which has also been incorporated into the recently released *Next Generation Science Standards* (2013). Even with this national imperative, statistics show that significantly less time is spent in elementary schools on science instruction than on other core subjects (Banilower et al., 2013). It has become imperative to find ways to support and encourage teachers to devote sufficient time to science teaching and learning.

Studies in science education examining the relationship between teacher beliefs about science and science learning and what they do in their classroom have yielded mixed results. Teacher efficacy and nature of science beliefs are not consistently shown to match elementary teachers' enacted classroom practice (Jones & Leagon, 2014). These discrepancies show that the belief constructs behind teachers' instructional decisions, rather than being linear and predictable, are complex, interrelated, and situated in context. This has made it difficult to delineate specific

ways to help teachers implement reform-based science teaching practices (Davis, Petish, & Smithey, 2006; Russell & Martin, 2014).

Another approach to studying the disconnect between beliefs and practice could be to explore teacher motivation for science instruction through a motivational framework that considers context within the belief system. This study frames the issue from a motivational approach using Self-determination Theory (Ryan & Deci, 2000). Self-determination Theory (SDT) is concerned with looking at the decisions people make based on the perception that their psychological needs for autonomy, competence, and relatedness have been met. The study examines teacher perceptions of autonomy in relation to their instructional choices about science teaching.

Findings show that contextual factors considered through the needs-based perspective of SDT can either support or serve as barriers to teacher autonomy for acting on beliefs they have formed through teacher education and experience. Identification of autonomy support structures has the potential to inform professional development and teacher education to find ways to encourage elementary science instruction at a time when its importance has been elevated by the *Framework* and the *NGSS.*

Chapter 1: Need and Purpose for the Study

Introduction

This study examines the current science teaching practices of elementary teachers in self-contained classrooms in Oklahoma schools. Their choices regarding amount of time and teaching methodology are explored in relation to their perceptions of instructional and curricular autonomy within their teaching context. The study focuses on reform teaching methods such as those outlined in the *National Science Education Standards* (NSES) (National Research Council, 1996) and *A Framework for K-12 Science Education* (NRC, 2011) as the desired standard of practice for science instruction. These instructional methodologies are recommended to increase the quality of K-12 education. Chapter 1 describes in detail the need and purpose for this study.

Problem Statement

There has been increased concern over the past few decades that the United States is not preparing enough students and teachers in the areas of science, technology, engineering, and mathematics (STEM) to meet the growing need for STEM jobs and careers. The *Science and Engineering Indicators* (2014) from the National Science Board show that, despite slowly increasing scores since 1990, more than half of all U.S. elementary and secondary school students failed to reach proficiency in math and science on the 2011 National Assessment of Educational Progress (NAEP). An international assessment of 15-year-old students in 34 countries (Fleischman, Hopstock, Pelczar, & Shelley, 2010) found that the United States ranked 25th in math literacy and 17th in science literacy. To maintain its status as a world

leader and innovator in science and engineering, it is important for the United States to raise its standing in STEM education in comparison to that of other nations. STEM analysts agree that the cultivation of STEM skills is necessary for jobs across multiple sectors of the U.S. economy. It is also important for all students to have access to quality STEM education at all levels to address the current lack of racial/ethnic and gender diversity in the STEM workforce (National Science Board, 2015).

The National Research Council (NRC) publication *Taking Science to School* (2007) advocates support for scientific literacy through a strong science foundation in grades K-8 that will increase student achievement in secondary education. This emphasis stems from recent research findings on the ability of children to learn science at a very early age and the increased understanding of learning progressions as important pathways for the conceptual understanding of core science concepts (Corcoran, Mosher, & Rogat, 2009). With this new understanding of the critical need for incrementally developed core ideas in science for grades K-8 (NRC, 2007), it is more important than ever to look closely at current science practice and pedagogy in the primary (K-6) grades. The publication of *A Framework for K-12 Science Education* (NRC, 2011) further conveys the importance of the role of elementary science education in providing a foundation for scientific literacy and proficiency, which has also been incorporated into the recently released *Next Generation Science Standards* (2013). It is important for preservice education programs to ensure that elementary teachers are prepared for and committed to the kind of science instruction that research has shown to be effective in increasing scientific literacy and conceptual understanding.

Even with this national imperative, statistics show that significantly less time is spent in elementary schools on science instruction than on other core subjects. In a recent national survey of science and mathematics teachers (Banilower et al., 2013), 80% of self-contained elementary teachers reported that their students receive science instruction only a few days a week or during only some weeks of the year. The same survey showed that self-contained K-3 elementary teachers report spending only an average of 19 minutes per day on science instruction compared to 54 minutes on mathematics and 89 minutes on reading/language arts. Teachers in grades 4-6 report an average of 24 minutes per day on science instruction compared to 61 minutes on mathematics and 83 minutes on reading/language arts. *High Hopes – Few Opportunities*, a comprehensive research report on the status of science education in California schools (Dorph, Shields, Tiffany-Morales, Hartry, & McCaffrey, 2011), concludes that elementary students are receiving less science instruction than is generally recommended and that most of the instruction provided falls short on the emerging national consensus that quality science instruction should provide active, student-initiated opportunities to engage in the practices of science for deeper conceptual understanding. Data also show that 77% of elementary teachers say they are confident in their ability to teach mathematics, compared to only 39% who are confident in their ability to teach science (National Science Board, 2014). Many other studies bear out the fact that elementary teachers do not utilize reform-based pedagogy in their day to day classroom practice (Marshall, Horton, Igo, & Switzer, 2009; Wee, Shepardson, Fast, & Harbor, 2007), despite strong support for the use of inquiry-based

pedagogy from the science education community over the last 20 years (AAAS, 1993; NRC, 1996; NRC, 2011; NSTA, 2004).

Inquiry learning is a major element of the NSES (1996) and, as a result, guidelines were created specifying abilities students must possess to do inquiry. Inquiry instruction as advocated in the NSES has been shown to increase active thinking and engagement in students which, in turn, increases conceptual understanding (Minner, Levy, & Century, 2010; Wilson, Taylor, Kowalski, & Carlson, 2010). Until recently, science standards, including those in Oklahoma, originated from the NSES and included inquiry instruction and scientific processes either as discrete standards or as a means to develop content understanding. Although these standards were in effect for more than 10 years, research studies and science education publications continued to refer to the standards for inquiry as "reform-based." One reason for this might be that there is little evidence in the literature that teachers use curricular and pedagogical strategies that reflect the NSES consistently (Bybee, McCrae, & Laurie, 2009; Wee et al., 2007).

With the publication of *A Framework for K-12 Science Education* (2011) a new era of reform was ushered in. Building on research lessons learned and the foundation created by the NSES, the *Framework* publication advocates for the complete integration of scientific practices and overarching scientific ideas with relevant content in the disciplines of science. Additionally, it suggests a way to sequence these ideas in learning progressions from K-12. This work resulted in the eventual creation of the Next Generation Science Standards (NGSS, 2013), which

have been adopted by 18 states and adapted by numerous others. Oklahoma is one of the states using the NGSS as a major resource for their standards.

The Oklahoma Academic Standards for Science (new science standards) support the approach to science learning from the NGSS advocating integration of scientific practices, disciplinary crosscutting concepts, and disciplinary core ideas, which is referred to as 3-dimensional teaching and learning (Moulding, Bybee, & Paulsen, 2015). This integrative strategy encompasses inquiry, but also includes other aspects of scientific practice such as constructing explanations and using models to build and refine scientific knowledge. This modification in the new reform agenda is intended to more clearly define the process of scientific inquiry and to include other processes and activities employed by scientists in their endeavors. Currently there is little or no research on the use of 3-dimensional learning in the classroom. However, Trygstad, Smith, Banilower, and Nelson (2013) report that elementary schools are currently unprepared for teaching with the new standards because of lack of science-focused professional development and curriculum support.

Need for the Study

Due to indications that elementary students are not receiving sufficient science instruction, it has become imperative to find ways to support and encourage teachers to devote sufficient time to science teaching and learning. A common strategy for examining implementation of reform-based science teaching methodologies has been to study the relationship between teachers' underlying cognitive beliefs about inquiry pedagogy and/or the nature of science and their resulting classroom practice. It is assumed that an understanding of these beliefs could inform strategies for supporting

desired teaching behaviors or changing those that have been shown to be less effective. Although many studies show that, generally, teacher beliefs have a significant effect on classroom practice (Jones & Carter, 2007), there are conflicting results in the literature regarding the match between teachers' beliefs and how they translate to teaching practices. This has made it difficult to delineate specific ways to help teachers implement reform-based science teaching practices (Davis, Petish, & Smithey, 2006; Russell & Martin, 2014). Some studies have shown that, even though many teachers believe that students should be provided with hands-on, inquiry-type learning, they often default to more traditional methods of teaching such as textbook or lecture (Cady & Rearden, 2007). Other studies have determined that teachers' beliefs and their pedagogical practice are closely related (Roehrig & Kruse, 2005). Some science education researchers have proposed more complex models that include other factors, such as attitudes, knowledge, and environmental constraints, that might further explicate the conflicting results (e.g. Jones & Carter, 2007; Samuelowicz & Bain, 2001). So far, none of these models have been shown to provide a full explanatory picture, while others are still emerging (Hutner & Markman, 2017).

Another approach to studying the disconnect between beliefs and practices could be to explore teacher motivation for science instruction through a motivational framework that considers context within the belief system. This study frames the issue from a motivational approach using Self-determination Theory (Ryan & Deci, 2000a). Self-determination Theory (SDT) is concerned with looking at the decisions people make based on the perception that their psychological needs for autonomy, competence, and relatedness have been met. In particular, this study examines teacher

perceptions of autonomy in relation to their instructional choices about science teaching because choice is closely related to autonomy from the SDT perspective. SDT provides a novel way of examining this relationship which could lead to new insights and increased understanding of how the science education community can encourage the enculturation of reform-based teaching into elementary schools.

Reason for the Study

A variety of explanations have been suggested for the current status of reform efforts in science education. Accountability emphasis on reading and mathematics is often cited by teachers and administrators as a reason for the lack of science instruction (Marx & Harris, 2006). This is consistent with earlier findings of Duschl and Wright (1989), who determined that accountability pressures and prescribed curriculum are among the most important contextual factors influencing decisions made by teachers about what and how to teach. However, current science education research has shown that teacher belief factors contribute to teacher instructional decisions involving science learning in a much more significant way than was previously thought (Windschitl, 2002). Numerous studies have examined factors such as efficacy for science teaching (Joseph, 2010), beliefs about the nature of science (Lederman, 1999), epistemological learning beliefs (Samuelowicz & Bain, 2001), and content and pedagogical knowledge in relation to teacher practice (van Driel, Beijaard, & Verloop, 2001), with most of these studies targeting preservice teachers and secondary science teachers. Studies with practicing elementary teachers are less frequent, especially with teachers in the early primary grades (K-3) and generalist teachers (grades 4-6) who teach all content subjects in self-contained classrooms

(Appleton, 2007). The results from existing studies have not yet been able to provide a clear, organized representation of the factors motivating teachers to utilize reform-based strategies in the classroom as indicated by seemingly inconsistent findings from study to study (Fang, 1996; Mansour, 2009). While some studies show that teachers endorsing constructivist beliefs about science learning and the nature of science are able to translate these beliefs into science lessons using scientific process and inquiry (Crawford, 2007; Hubbard & Abell, 2005; Windschitl, 2002), others show that teachers expressing similar beliefs about instructional pedagogy vary widely in actual classroom practice (Lederman, 1999; Marshall et al., 2009; Trumbull et al., 2006). These discrepancies show that the belief constructs behind teachers' instructional decisions, rather than being linear and predictable, are complex, interrelated, and situated in context.

A potential way to examine this complex set of interrelated beliefs within a context burdened with external mandates and pressures is through a motivational lens such as SDT that takes these external conditions into account along with teacher beliefs. SDT proposes a set of innate psychological needs (competence, relatedness, and autonomy) that are necessary for growth and well-being. When environmental conditions supporting these needs are met, individuals are said to be self-determined and are moved to act on desired goals. When environmental conditions interfere with the satisfaction of these needs, individuals are less-self determined (Deci & Ryan, 2000). SDT distinguishes between two broad types of motivation based on the goals (reasons) that move people to action and refers to these as intrinsic and extrinsic motivation (Ryan & Deci, 2000a). Intrinsic motivation represents the desire to do

something because it is inherently interesting or enjoyable, while extrinsic motivation represents actions that are carried out because of the expectation of some type of reward or outcome.

Intrinsic motivation represents the most self-determined behavior and is considered important in education because it reflects the ideal vision of life-long learning that allows individuals to succeed on their own volition. Practically speaking, however, intrinsically motivated behavior is not the norm because the world is a complex place, creating situations that do not necessarily support fully self-determined behaviors (Deci & Ryan, 2000; Ryan & Deci, 2000). This leaves extrinsic motivation, which has sometimes been portrayed as undesirable because it represents externally controlled behavior and a lack of internal volition. It has also been shown that external rewards undermine intrinsic motivation and lead to short-lived educational outcomes (Deci, Koestner, & Ryan, 2001). Since so much human behavior is context dependent and often relies on external motivators that do not necessarily involve negative outcomes, SDT proposes a continuum of external motivation with *regulatory styles* that range from total external regulation to more internal types of regulation. This continuum, a sub-theory of SDT known as Organismic Integration Theory (OIT), provides a way to explore social contextual factors that cultivate behaviors leading to desired educational outcomes which increasingly reflect a more intrinsically motivated orientation (Deci, Vallerand, Pelletier, & Ryan, 1991). This continuum reflects the perceived autonomy (in opposition to perceived external control) of an individual in his/her actions and encompasses beliefs and expectations related to these actions. Thinking of science teaching as a desired goal using this perspective, it is ideally

desirable for teachers to be more intrinsically motivated to teach science (Lepper, 1988) and teach it in a way that lines up with research-based recommendations on student learning. In actual elementary school contexts, this tends to be unrealistic due to many contextual factors such as curricular mandates, accountability pressures, and school organization vision priorities (Dorph et al., 2011) that run counter to conditions supporting intrinsic motivation and may get in the way of teachers' more idealistic beliefs about science learning (Tschannen-Moran, Woolfolk Hoy, & Hoy, 1998). An examination of how contextual factors integrate with teacher beliefs regarding science teaching and their own competency as represented in the OIT autonomy continuum could prove be a more comprehensive way to view teacher practice.

This study utilizes OIT as its primary lens while keeping in mind perceived needs for competence, autonomy, and relatedness as being necessarily related to complete a picture of self-determined behavior. While these three basic psychological needs constitute separate constructs in SDT, the perception that all these needs are being met is a necessary condition for individuals to grow and thrive in their endeavors (Sheldon & Hilpert, 2012). Competence has been shown to be a requirement for autonomous motivation according to the theory, so both of these factors are given primary consideration in the study. The autonomy component of the model is foregrounded because contextual factors are a primary driver of autonomy perceptions and these are the aspects that have been problematic in beliefs/practice models in science education.

Few studies have been done in science education using frameworks described in motivation literature to guide the examination of teacher beliefs and practices.

Fewer still have been done using SDT or any of its related sub-theories. This study seeks to fill this gap in the existing literature on science teacher beliefs and practice and to examine a novel approach for interpreting existing (and sometimes conflicting results) found in this literature.

Purpose of the Study

The ultimate goal of this study is to inform teacher education and professional development practice for science teaching and learning. Professional development is most effective when implemented as a contextual activity (Wei, Darling-Hammond, Andree, Richardson, & Orphanis, 2009). The purpose for utilizing SDT to study the problem is to seek a framework that will consider both the beliefs teachers hold with regard to science and the external factors influencing those beliefs in order to identify support structures that will contribute to successful professional learning. It also provides another approach for examining preservice teachers' beliefs to help them translate new knowledge and pedagogy learning into their eventual teaching practice. Often teachers leave preservice programs with new ideas and understanding about science teaching, only to find barriers and lack of support for the transition to the classroom (Hutner & Markman, 2016). It is important to understand how these beliefs can be sustained and enacted in context.

The following chapters describe a study examining the connection between teacher beliefs and practice from an autonomy perspective using the SDT framework. The intent is to further explicate inconsistencies in science education literature between teachers' efficacy and pedagogy beliefs and their enacted teaching practice. In Chapter 2, relevant literature from motivation related to SDT and previous findings

from science education literature on the connection between teacher efficacy and pedagogy beliefs are presented as a rationale for the research questions in this study. Chapter 3 provides an explanation and rationale of the methodology for the study. Results of the study are presented in Chapter 4 and a discussion of the results and their implications are provided in Chapter 5.

Chapter 2: Literature Review and Research Questions

Introduction

Motivation is broadly defined as "processes that give behavior its energy and direction" (Reeve, 2008, p. 8). These processes have been variously identified by researchers as needs, cognitions, emotions, or reactions to environmental events. Recent motivational theories have focused on a set of processes related to beliefs and perceptions which are cognitive in nature. These theories seek to explain how individuals' cognitive appraisals, based on perceptions regarding such things as efficacy, autonomy, or instrumentality, affect the goals for which they strive (Pintrich, 2012; Weiner, 1990). The research focuses on specific types of goals or on the reasons individuals pursue these goals.

Some of the literature on science teaching also focuses on beliefs but seldom utilizes motivation as an explicit framework; and it rarely refers to any of the current theories of motivation that incorporate multiple belief constructs such as perceived control, instrumentality, attribution, or needs satisfaction. Instead, most studies that mention motivation refer to it as a unitary factor associated with instructional decision making (e. g. motivation to teach inquiry science). It seems to be implicit in many studies that beliefs about self-efficacy, pedagogy, or epistemology are related to motivation but few papers in science education directly address individual motivation theories as a framework for understanding belief systems.

This chapter presents relevant conceptual and empirical findings from educational psychology literature related to motivation and from science education literature on the relationship between beliefs and practice. The first section provides a

look at the motivation literature pertaining to individual choice from a Self-determination theory (SDT) perspective. Motivation is discussed first in general terms to show the origins and foundations of SDT. A broad description of SDT is then provided, followed by a detailed description of Organismic Integration Theory (OIT), including rationales for the use of the SDT framework in this study. The next section provides connections between SDT and the extrinsic motivation patterns from OIT to relevant science education literature on the relationship between teacher beliefs and practice, focusing on efficacy beliefs and beliefs about the nature of science as either a body of knowledge or a method/way of knowing about the natural world (Lederman, 2007). The third section discusses the limited findings on autonomous motivation for teaching and how it has the potential to provide a novel way of exploring teacher beliefs and perceptions in relation to their instructional practice. In the final section the research questions are presented along with key points from the literature review supporting the formulation of the research questions.

Motivation Research and Self-determination Theory

Origins of Self-determination Theory

Needs-driven theories. Early research on motivation has its roots in behaviorism, proposing that human physiological needs produce drive states (motivational states) that impel humans to certain actions (behaviors) (Hull, 1943; Spence, 1958). Such theories, however, do not account for human behaviors that do not directly fulfill physiological needs (e.g. inquisitive or playful activities). Maslow (1943) proposed a theoretical needs hierarchy that also includes innate psychological and social needs (security, belonging, esteem, and self-actualization) in addition to

basic physiological needs. The inclusion of these internal needs provides further explanation for additional aspects of human behavior beyond those that meet basic needs for survival. Although aspects of Maslow's model have come into question and subsequent research has failed to provide clear support for the proposed needs hierarchy itself (Wahba & Bridwell, 1976), the proposed psychological and social needs have been utilized extensively in business, workplace, and educational settings (e.g. Sadri & Bowen, 2011). Maslow's needs, along with those advocated by others such as competence (White, 1959); personal causation (deCharms, 1968); and existence, relatedness, and growth (Alderfer, 1969) form the basis for a more recent theory of needs-driven motivation known as Self-Determination Theory (Deci & Ryan, 1985).

SDT identifies three broad categories of innate psychological needs as being necessary for ongoing psychological growth, well-being, and integrity. These needs are identified as competence, autonomy, and relatedness. The need for competence represents an individual's fundamental inclination to feel effective in interacting with the environment (Deci & Ryan, 2000; White, 1959). The need for autonomy characterizes an individual's desire for psychological freedom and volition when carrying out an activity (deCharms, 1968; Deci & Ryan, 2000). In SDT, perceived autonomy is contrasted to the perception of external control over one's behavior. The need for relatedness is defined as an individual's inborn desire to feel connected to others and to develop supportive and caring relationships (Alderfer, 1969; Baumeister & Leary, 1995; Deci & Ryan, 2000). The extent to which an individual perceives that these three needs are being met produces motivational states which result in various

behaviors and outcomes (Reeve, 2012). The needs fulfillment approach to motivation looks at the way people pursue and attain various goals based on their perception of whether or not these needs have been met (Deci & Ryan, 2000). The more individuals perceive that these needs are being met, the more they are said to be self-determined in their behavior according to SDT.

Achievement goal theories. To a large extent, recent research in motivation has been focused on the underlying cognitive motivational processes involved in the pursuit of specific learning or achievement goals rather than primarily considering the aspects of need fulfillment. This approach to motivation examines the ways in which beliefs, values, expectancies, and goals are translated into action (Eccles & Wigfield, 2002). Beliefs, values, expectancies, and goals are cognitive in nature and represent the enduring ways in which people think about and approach what they do in their lives (Reeve, 2008). SDT reflects elements of these theories because it examines motivation by categorizing reasons why people act on goals that can be either instrinsic or extrinsic (Ryan and Deci, 2000a).

The bulk of contemporary research on motivation in the field of education has concentrated on what is known as 'achievement behavior' (Atkinson & Feather, 1966; Maehr & Sjogren, 1971; Maehr, 1984). Achievement behavior is directed toward developing or demonstrating ability on tasks for which people believe that their competence affects an outcome (Nicholls, 1984). The most salient type of achievement behavior in educational settings is student learning behavior, so this has logically been the major target of educational research on motivation. Achievement motivation occurs when people strive to maintain or increase their capabilities in

activities for which they believe their success or failure will be evaluated against some standard of excellence (Atkinson & Feather, 1966). In the case of K-12 student education, the activity is learning and the standard is usually one of the many assessments of student achievement employed in the school context.

There is no single theory that dominates the current literature in this area. Rather there are multiple mini-theories that attempt to explain various cognitive beliefs that motivate behaviors. These theories include attribution theory (Weiner, 1986), expectancy-value theory (Eccles & Wigfield, 2002), and goal orientation theory (Ames, 1992; Dweck, 1986; Maehr, 1984; Nicholls, 1984). The theories tie behaviors to various beliefs that people hold about their efficacy, their ability, or the expected outcomes of specific actions. This is particularly pertinent to educational settings since student learning in organized educational systems has specific outcomes both within and outside of the system that are judged against both formal (objective) and informal (subjective) criteria. Elements of each of these three achievement goal theories can be identified in various aspects of SDT. Goal orientation theory, in particular, has been associated with SDT (Pintrich, 2000). The different goal orientations in this theory correspond in many ways to the OIT descriptions of various types of external motivation, further illustrating the comprehensive nature of SDT as a way of looking at teacher autonomy perceptions of science teaching and learning.

While much is known about student achievement motivation, considerably less effort has been directed toward teacher motivation. This may be because achievement looks different for students than it does for teachers. Since student achievement is a primary goal for teachers, student success is undeniably intertwined with teachers'

professional goals, although student success may not be the best proxy for teacher success because factors other than teacher practice also contribute to student achievement. When looking at motivation for teaching practices in a specific content area such as science, consideration of more than just student outcomes becomes necessary to gain an understanding of what teachers do and how they do it (Kocabas, 2009). It is difficult to fully define what constitutes an achievement goal for teachers. Butler (2014) recently described four types of goals for teachers that align to intrinsic motivation and some of the levels of extrinsic motivation delineated in OIT. These include mastery of professional skills; goals for demonstrating teaching ability, goals for avoiding demonstration of poor teaching skills, and goals for avoidance of teaching in order to minimize effort. These constructs are somewhat aligned to intrinsic motivation and some of the levels of extrinsic motivation delineated in OIT.

As a comprehensive theory that merges achievement goal and needs theories, SDT could provide a way to examine the effects of multiple teacher beliefs on their practice as it occurs in context, thus providing a more comprehensive motivational picture currently missing from beliefs versus practice literature in science education (Czerniak & Lumpe, 1996; Samuelowicz & Bain, 2001). This includes looking not only at efficacy, outcome, and epistemological beliefs, but also at how teachers' perception of the amount of control they have over the context in which they function allows them to achieve the student outcomes they desire (Ajzen, 1991; Jones & Carter, 2007; Wenner, 2001). SDT offers this type of comprehensive motivational framework and, in the case of teaching, provides a method for focusing on ways in which teacher choices and behaviors are regulated, both internally and externally. The next section

describes SDT and its related sub-theory, OIT, to establish an understanding of the framework that forms the lens for this study.

Self-determination Theory

Self-Determination Theory, as described by Ryan and Deci (2000), provides a broad framework for the study of motivation and how people are moved to action. It includes a focus on the ways in which social and cultural factors facilitate or weaken people's desire to attempt a task or activity. According to SDT, conditions that support the basic human psychological needs of autonomy, competence, and relatedness provide the most optimal form of motivation to approach and complete tasks (Vansteenkiste & Ryan, 2013). These basic needs are innate rather than being acquired through social interaction (Deci & Ryan, 2000). Deci and Ryan assert that innate psychological needs are necessary for "ongoing psychological growth, integrity, and well-being" (p. 229). Human tendency is to pursue goals that satisfy these basic psychological needs. An understanding of this pursuit makes it possible to recognize social factors that favor high-quality performance and growth in individuals (Ryan & Deci, 2000). This makes the framework useful for looking at teacher practice because it may provide an opportunity to use needs satisfaction in a practical way to identify necessary conditions for encouraging desired educational behaviors such as research-based science teaching methods.

Motivational states generated by psychological and social needs are driven by underlying attitudes and goals that, in turn, result in specific actions and behaviors. In the most basic sense these states are commonly categorized as being either intrinsic or extrinsic. Intrinsic motivation represents a desire to do something because it is

innately interesting or gratifying, while extrinsic motivation represents a desire to doing something because it leads to a distinguishable or anticipated outcome (Ryan & Deci, 2000a). While people are naturally inclined to seek out intrinsically motivating activities, it has been shown that these inclinations require supportive conditions or they can easily be disrupted by non-supportive or interfering factors occurring in many contexts (Ryan & Deci, 2000). A sub-theory of SDT known as cognitive evaluation theory (CET) was introduced by Deci and Ryan (1985) to identify conditions that enhance or undermine intrinsic motivation.

Cognitive evaluation theory. CET is focused on the competence and autonomy aspects of SDT and specifies factors that enhance or undermine intrinsic motivation. The theory argues that interpersonal types of rewards such as meaningful feedback, optimal challenge, and positive communication enhance feelings of competence and contribute to intrinsic motivation (Deci & Ryan, 1987). CET also maintains that tangible extrinsic rewards (money, grades, food, etc.) can undermine intrinsic motivation. This has been shown to apply especially when the reward is perceived as a way of controlling an individual's behavior (Deci, Koestner, & Ryan, 2001). This relates directly to the perception of control versus autonomy and indicates that the two psychological needs (competence and autonomy) are interrelated.

CET contends that "feelings of competence will not enhance intrinsic motivation unless they are accompanied by a sense of autonomy" (Ryan & Deci, 2000a, p. 58). This indicates the importance of autonomy-supportive conditions as a necessary element of more intrinsic types of motivation (Deci, Vallerand, Pelletier, & Ryan, 1991; Haggar & Chatzisarantis, 2011). It also elevates the importance of

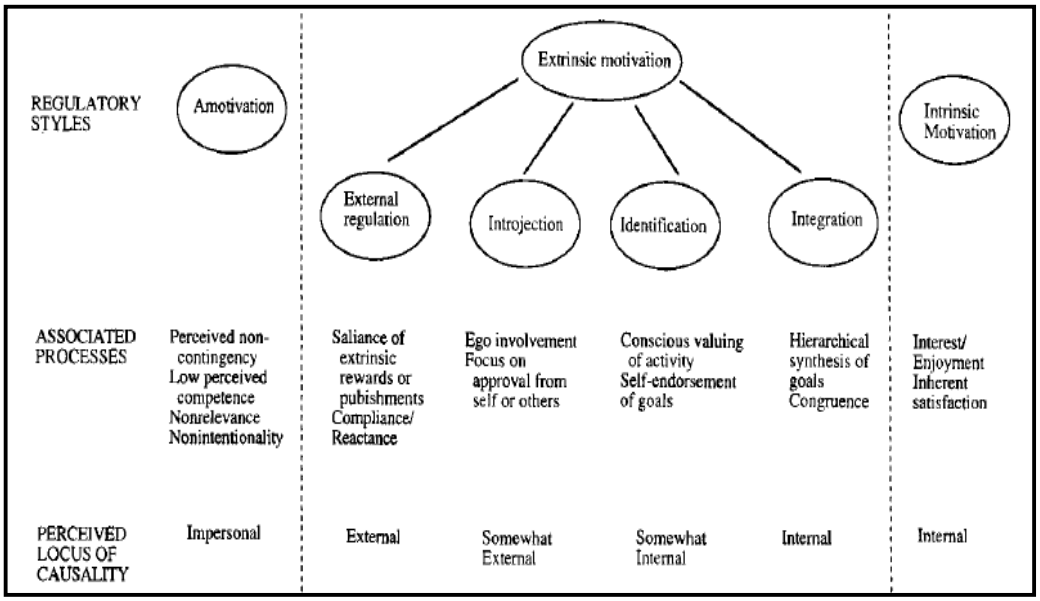
meeting perceived autonomy needs in situations, such as school settings, where there are many external factors that might be viewed as controlling.

SDT and goal-directed behavior. According to SDT, people who experience intrinsic motivation are doing so because they are pursuing goal-directed activities that they perceive as meeting their psychological needs. This constitutes self-determined behavior. Furthermore, intrinsic motivation is activity-dependent and differs within the same individual from activity to activity and goal to goal. Studies have shown that mastery learning goals are associated with intrinsic motivation (Cordova & Lepper, 1994; Deci & Ryan, 1985; Heyman & Dweck, 1992) and that when people are intrinsically motivated toward a learning activity their conceptual understanding increases (Benware & Deci, 1984; Elliot & Haracjiewicz, 1996; Ryan & Deci, 2000a; Young, 2005). Mastery goals are considered a desired characteristic for students in educational settings because when students hold these goals they focus on mastering and developing skills, making improvement, and acquiring new knowledge (Ames, 1992). This is in contrast with students holding performance goals, who are focused on demonstrating their ability to others and receiving rewards such as good grades. The beliefs held by an individual about a particular activity constitute the motivational orientation toward that activity (Ryan & Deci 2000a). An example might be an elementary teacher who loves to read. This teacher could be intrinsically motivated to teach reading because of her personal feelings about reading. However, if the same teacher hates mathematics, she might not be intrinsically motivated to teach it. Despite the lack of intrinsic motivation for mathematics teaching, it is unlikely that this teacher will forego teaching mathematics since it is part of her job.

In this case, it might be important to identify certain factors that might support a more intrinsic stance toward math teaching such as interpersonal rewards or raising awareness of its perceived value for students. Another SDT sub-theory known as organismic integration theory (OIT) provides a description of possible extrinsic motivation patterns that might apply when pure intrinsic motivation is not possible.

Organismic Integration Theory (OIT). Studies of intrinsic motivation often operationalize it as "free choice" (Deci, 1971; Ryan & Deci, 2000a). When people engage in a behavior through their own volition rather than to receive some sort of extrinsic reward or avoid some sort of punishment, they are said to be intrinsically motivated. A reward or punishment would consist of something tangible (i.e. money, physical isolation) or something more cognitively affective in nature (i.e. praise, criticism). Thus, intrinsically motivated behavior is said to be autonomous because it occurs without any form of external control. Extrinsic motivation, on the other hand, results from the expectation of some sort of reward or the attempt to avoid some sort of undesirable consequence. It is said to be externally controlled and, therefore, less autonomous. The degree of autonomy is related to the amount and type of external control (Ryan & Deci, 2000). Rather than being a unitary construct, SDT proposes that extrinsic motivation is a differentiated construct, with different types of extrinsic motivation associated with different degrees of autonomy on a continuum (Reeve, 2012). This taxonomy is the basis of OIT and is pictured in (*Figure 2.1)*.

Figure 2.1 – A Taxonomy of Human Motivation (Ryan & Deci, 2000)



OIT provides a motivation continuum from "amotivation" to intrinsic motivation that details different levels of extrinsic motivation as they fall between these two extremes. In this continuum, different types of extrinsic motivation are referred to as behavioral "regulations" and these regulations (reasons) are incrementally more autonomous as they move toward the intrinsic end of the scale (Ryan & Deci, 2000a). This implies that the more an individual personally endorses the value and significance of a behavior within a specific context such as learning or teaching, the more likely they are to perceive a sense of autonomy for that particular behavior (Reeve, 2012).

Ryan and Deci (2000a) define behavior regulation in the motivation taxonomy continuum in terms of perceived locus of causality and the extent to which the instrumental value of specific behaviors is internalized. Together these two ideas characterize the innate need for autonomy described in SDT. The construct of

perceived locus of causality (PLOC) was originally introduced by Heider (1958) as a social construct showing how we explain the behavior of others. His idea was that we explain behavior based on whether it is intentional or unintentional. He sees intentional behavior as coming from within, referring to this as personal causation, and unintentional behavior as coming from external sources, referring to this as impersonal causation. This differs slightly from Rotter's (1954) idea of locus of control, which refers to a personality trait indicating whether individuals feel they have control over their lives (internal) or they feel that outcomes in their lives are beyond their control (external). Later, deCharms (1968) extended and refined the idea of PLOC to describe the intentional behavior of personal causation in different situations as having two distinct levels, an internal PLOC or an external PLOC. Individuals with an internal PLOC see themselves as the originators of their own behavior and those with an external PLOC see themselves as "pawns" responding to outside forces beyond their control. In a series of studies examining elementary school students' orientation toward classwork, Ryan and Connell (1989) demonstrate that rather than having two distinct levels, the internal-external PLOC dichotomy is more of a "gradient of autonomy" from the perception of high control to the perception of little control (high autonomy). They identified four distinct groups from this study, which became the basis for the continuum of extrinsic motivation known as OIT. When incorporated with the idea that voluntary behaviors from the lower end of the spectrum to the higher end become more and more internalized with the individuals' own beliefs and values (Ryan & Deci, 2000), the result becomes four levels of extrinsic regulation that fall between amotivated behavior and intrinsically motivated behavior (*Figure 2.1*).

At the lower end of the regulation continuum is amotivation. The behavior of an amotivated person lacks intentionality and results from the absence of value placed on a behavior by an individual as well as a perceived lack of other factors that constitute self-determined behavior such as competence and autonomy. At the upper end of the continuum is intrinsic motivation. When individuals are intrinsically motivated they participate in an activity or behavior because it is inherently satisfying to them. They choose the activity freely and are not motivated to participate by any type of external reward.

Between these two anchors lies the extrinsic motivation continuum set forth in OIT. As the motivation types move from amotivation at one end to intrinsic motivation at the other, behavior regulation changes from external control to the perception of free-choice autonomy. These regulations are perceived by the individual and serve as sources or reasons for intended action (Roth, Assor, Kanat-Maymon, & Kaplan, 2007). The type of extrinsic motivation with the least autonomy (highest external control) is *external regulation*. Individuals perceiving external regulation engage in behaviors in order to obtain a discrete reward/outcome or to avoid some sort of punishing consequence. Their personal value for the behavior is low and engagement in the behavior is a result of an external PLOC. They believe that outside forces affect their ability to succeed and that the rewards they receive in a particular situation are mostly outside of their control (deCharms, 1968; Rotter, 1966). Their behavior is simply a reaction to the contingencies with which they are presented.

At the next level is *introjected regulation*. This type of external motivation is slightly more autonomous than external regulation, but still exhibits an external

PLOC. Rather than being totally external, perceived control shifts inward, in that individuals engage in specific behaviors to avoid guilt or anxiety which they perceive to be coming from external sources. They are seeking approval or, at the very least, seeking to avoid feeling guilt or shame as seen through the eyes of others. The locus of causality is, therefore, still external but the emphasis has shifted toward ego protection rather than mere compliance (Ryan & Deci, 2001a).

The next regulation level, more autonomous than the previous, is *identified regulation*. At this level, the individual identifies with the importance or value of the activity, although it may not be directly related to their most highly regarded goals and values. This level has been shown to be associated with more free choice than the previous two motivational regulations (Ryan, Rigby, & King, 1993). Self-endorsement of the activity or behavior as having value, especially to some future goal or outcome, moves this regulation more toward an internal PLOC.

The highest level of extrinsic motivation is *integrated regulation*. It moves beyond identified regulation because the individual assimilates the motivational processes into their overall self-concept rather than simply focusing the motivation in a specific area for which they have future goals. This is the most autonomous type of extrinsic motivation. It represents an internal PLOC because these individuals believe that the rewards they receive are determined by their actions and that they can control what happens to them through their own choices (deCharms, 1968; Rotter, 1966). While integrated regulation results in self-determined behavior, it does not quite reach the same level as pure intrinsic motivation. The behavior is carried out for its perceived instrumental extrinsic value regarding an outcome that is outside of the

behavior itself, even though it is executed through free choice (Ryan & Deci, 2000a). This is in slight contrast to intrinsically motivated behavior, in which individuals engage for the pure enjoyment and satisfaction it gives them, regardless of any type of separable outcome.

Elementary teachers in self-contained classrooms may have some choices about when and how they teach science. This brings intrinsic and extrinsic motivation into consideration as factors driving their decision-making process. Due to various required structures imposed on a typical elementary school day, it is unlikely that most elementary teachers make these decisions based solely on their love for science and science teaching. The extrinsic regulation continuum could provide a logical way to think about these choices. Decisions made about science instruction are influenced by curricular mandates, accountability expectations, and teaching norms, all of which are generally factors external to teachers' beliefs and sense of self. Very little research has been done in the area of autonomous regulation for teaching (Roth et al., 2007) and almost none can be found in the area of science teaching in elementary schools. However, research on educational reform models emphasizing basic psychological needs satisfaction using SDT shows that the internalization of the value of these factors into the individual belief systems of teachers influences their willingness to implement reform-type methods (Deci, 2009). It has been shown that elementary teachers often avoid teaching science (Appleton, 2007) and that the time spent on science instruction in elementary schools is less than that of other core subjects (Banilower et al., 2013). Examining teacher motives for the amount and type of science instruction in which they engage through the lens of the extrinsic motivation

continuum may serve to broaden the current research picture of teacher decision-making beyond the basic beliefs versus practice dichotomy that is prevalent in science education literature (Fang, 1996; Mansour, 2009; Marshall, et al., 2007; Wallace & Kang, 2004).

In the next section, science education literature relating beliefs to teacher practice will be presented to draw attention to some areas where conflicting results exist that might be understood in a different way through an examination of teacher autonomy. The two beliefs areas that will be discussed are efficacy and the nature of science.

Science Education Literature Relating Teacher Beliefs and Practice

A significant portion of the beliefs and practice literature in science education is focused on two areas: efficacy beliefs about science teaching and teacher beliefs about science and science learning. The latter are generally discussed in the literature in terms of teacher beliefs about the nature of science, specifically whether teachers consider science to be a body of knowledge or a process that provides a way of knowing about the natural world and how that is reflected in their teaching (Lederman, 2007). While there is a considerable amount of literature in these two areas, it is acknowledged that these beliefs remain poorly understood (Jones & Leagon, 2012). In this section, science education literature related to teacher beliefs and practice will be reviewed. First, efforts to create conceptual models that represent the relationship between these and other beliefs to the practice of teaching science are described. Next, efficacy beliefs and beliefs about the nature of science are discussed in more

detail, particularly in regard to their relationship to teacher practice. Possible connections to SDT are discussed in each section.

Relationship Between Science Teacher Beliefs and Practice

It is widely acknowledged that the beliefs held by teachers have a powerful effect on their instructional practice. Beliefs influence perceptions and judgment which, in turn, shape teaching decisions in the classroom (Nespor, 1987; Pajares, 1992). Keys and Bryan (2001) assert that the complex web of teacher beliefs influences every aspect of science instruction from knowledge acquisition to instructional and assessment choices. Although there is general agreement on the importance of beliefs in teaching science, there is less agreement and relatively little understanding of how belief systems function together to inform teacher practice (Crawford, 2007; Fang, 1996; Jones & Carter, 2007).

In early studies, it was assumed that there is linear, predictive value between teacher attitudes or beliefs and classroom practice. Numerous studies with conflicting or ambiguous results show this assumption to be simplistic at best (Cronin-Jones, 1991; Mansour, 2009; Trumbull, et al., 2006; Wallace & Kang, 2004). Rather, as Pajares (1992) described, there seems to be a system of connected yet distinct beliefs that function together in context to influence teacher behavior.

Research synthesis publications (Roehrig & Kruse, 2005; Tschannen-Moran & Hoy, 2001) and mixed methods studies (Ramey-Gassert, Shroyer, & Staver, 1996) have resulted in representation models to explain the role of teacher beliefs in classroom practice. These models seek to explain the organization of science teaching beliefs within the overall belief structure and to show how these function as a

perceptual filter for teacher behavior. While it is often acknowledged that teacher beliefs contribute to teacher motivation for instructional practice, many of the proposed models identify 'motivation' as a separate construct within the model (Davis, Petish, & Smithey, 2006; Jones & Carter, 2007; Samuelowicz & Bain, 1992; Song, Hannafin, & Hill, 2007; Wee et al., 2007) as opposed to looking at the set of beliefs in the model as elements of a motivational framework in the way that SDT does.

A model proposed by Jones and Carter (2007) based on a research synthesis of science teacher beliefs and practices provides an example of the types of models described in science education beliefs literature. This model describes the belief system as an interconnected collection of beliefs, attitudes, and contextual conditions (efficacy, social norms, environmental constraints, epistemologies about science and science teaching, attitudes toward instruction and implementation, science content and pedagogical knowledge, and teacher motivation). It proposes that the belief system serves as a perceptual filter for environmental responses that lead to instructional practice. In this model, motivation is listed as being a separate element of the belief system. A diagram of this model can be found in *Appendix A*. The assumption in the model is that beliefs and attitudes are separate constructs, with the characterization of beliefs as cognitive and attitudes as affective. The model also assumes that beliefs influence attitudes, which in turn influence the level of "motivation" and, ultimately, teacher practice. The beliefs are proposed to occur at different "relative strengths" and influence attitudes based on these levels.

Another model, proposed by Samuelowicz and Bain (2001) from a case study of 39 science education professors at 3 universities, elicited nine belief dimensions (desired learning outcomes, expected use of knowledge, responsibility for organizing knowledge, nature of knowledge, existing student conceptions, teacher-student interaction, control of content, professional development, and interest and motivation). These models consider the sociocultural context of the school and school system, something missing from many studies examining teacher beliefs and practice. Both models also, notably, include teacher motivation as a single dimension of the model that is influenced by both context and teacher beliefs. Neither of the models suggest-the possibility that many of the beliefs, belief dimensions, or attitudes included as separate constructs in the model could, when considered together, constitute a single motivational framework with its own explanatory value. Although not studied in this way previously, it is possible that some of these dimensions and cognitive beliefs could be considered within the framework of the needs for competence, autonomy, and relatedness that constitute SDT. This fresh lens might provide a unifying explanation, illuminate new descriptive dimensions, or both.

Elementary Teacher Efficacy Beliefs for Science Teaching

Self-efficacy is the belief in one's ability to succeed. It is closely related to social learning theory in that we learn from observing others and, in so doing, we derive beliefs about our own efficacy through what we see as success and failure in others (Bandura, 1977). It also relates to the competence need from SDT, since self-efficacy beliefs affect individuals' understanding of their ability to attain various outcomes which, in turn, affect their perceptions of whether they have effectively

enacted specific behaviors. This creates the necessary conditions for meeting the need for competence. Studies show that efficacy plays an important role in classroom instruction (Tschannen-Moran et al., 1998) in areas such as: effort and persistence (Allinder, 1994; Gibson & Dembo, 1984); teaching commitment (Coladarci, 1992; Evans & Trimble, 1986); and valuing of teaching practices associated with mastery learning (Guskey, 1988). In these studies, higher levels of teacher efficacy are associated with teachers' willingness to remain in the teaching profession, persist with students, and work with students in groups rather than whole-class lecture.

Since most elementary teachers have relatively little exposure to rigorous science content during their preservice education, it stands to reason that their efficacy for science content and science instruction might be lower than that of their secondary counterparts. This has proven to be the case according to numerous studies. Preservice elementary teachers have been shown to have lower efficacy for science than other content areas (Buss, 2010; Wenner, 1995). Studies involving classroom teachers show that, in general, elementary teacher efficacy for science content and pedagogy is low (Palmer, 2011; Ramey-Gassert, et al., 1996). Experience and professional development have been demonstrated to increase efficacy (Esach, 2003), although results in this area indicate that not all professional development interventions are equally successful (Bryan & Abell, 1999; Choi & Ramsey, 2010; Gess-Newsom, Southerland, Johnston, & Woodbury, 2003; Roehrig & Kruse, 2010; Ross & Bruce, 2007; Wee et al., 2007). In a study by Hoy and Spero (2005), it was also shown that efficacy for science learning and instruction actually dropped between preservice education and the first few years of teaching. This was attributed to lack of

support from school administration and peers, indicating that efficacy can be affected by contextual factors.

Elementary teachers often exhibit avoidance behaviors for science teaching due to low efficacy (Appleton, 2007; Tilgner, 1990). Lack of appropriate teacher preparation presumably plays a role in the decrease in efficacy and consequent attempts to avoid science instruction (Hubbard & Abell, 2005; King, Shumow, & Leitz, 2001; Roth, 2014). This aligns with self-efficacy theory (Bandura, 1977) and achievement goal theory, which assert that people with high self-efficacy approach tasks as problems to be mastered and that people with low self-efficacy often try to avoid tasks that they see as difficult or out of their area of comfort. It could also be considered from an SDT autonomy perspective because mastery is a characteristic of self-regulated behavior associated with intrinsic motivation (Ryan & Deci, 2000) and avoidance behaviors fall into the area of introjected regulation in which people seek to avoid negative evaluation from external sources.

Science education literature shows that efficacy is clearly an important consideration for elementary science teaching. Most studies have focused on personal teaching efficacy and outcome expectation as it relates to science pedagogy (Ross & Bruce, 2010; Tschannen-Moran & Hoy, 2001). Few studies have focused directly on elementary teacher efficacy for science content. However, the relationship between the number of college science content courses taken by preservice teachers and their efficacy for science pedagogy has been studied. Many of these studies have found a positive relationship between the number of science courses taken by preservice teachers and their efficacy for science pedagogy (Joseph, 2010; Knaggs & Sondergeld,

2015). Other studies have shown a relationship between gains in science conceptual understanding and science teaching efficacy (Knaggs & Sondergeld, 2015; Menon & Sadler, 2016). This indicates an interaction between science content knowledge and efficacy for science pedagogy but this relationship has not yet been fully explored or agreed upon.

While the focus of this study is not on teacher efficacy, it is important to note that, in SDT terms, the need for people to experience competence in order to be more intrinsically motivated relates directly to their sense of efficacy (Deci & Ryan, 2000). This, in turn, is related to individuals' ability to experience autonomy. Although competence and autonomy are separate concepts within SDT, both are necessary for individuals to be self-determined in their behavior (Deci & Ryan, 2000). Competence is important for motivation to action but it is not sufficient for self-regulated behavior and must be paired with a sense of autonomy for intrinsic motivation to occur (Deci, et al., 1991; Niemiec & Ryan, 2009). The examination of teacher autonomy in this study, thus, necessarily includes exploration of teacher efficacy because it is a necessary condition for autonomy in SDT.

Constructivist Beliefs about the Nature of Science and Science Teaching

Constructivism and student-centered learning. Constructivism is an epistemological doctrine maintaining that social reality and human learning are constructed in different ways by different individuals based on their prior knowledge and experience (Gall, Gall, & Borg, 2007). It is generally accepted that the epistemology termed as constructivism has its roots in the work of Dewey (1933), Piaget (1936), and Vygotsky (1978). This has been translated into classroom practice

in multiple ways, which have sometimes been termed as "student-centered learning." The learning environments associated with student-centered learning have been demonstrated to share several commonalities (Land & Hannafin, 2000). These commonalities include: learning activities that focus on cognitive processes rather than products of learning; continuously evolving knowledge; students assuming responsibility for their own learning; learning support through multiple representations and activities; and learning that is embedded in relevant contexts and personal experiences. This contrasts with traditional, teacher-centered learning, which reflects a more positivist stance, holding the view that social reality and knowledge are objective, verifiable realities which are similar for all individuals. Teacher-centered learning presumes that: learning activities focus on products rather than cognitive processes of learning; knowledge is stable and finite; the teacher is responsible for delivering knowledge to students; methodologies and strategies are prescribed by the teacher; and learning occurs through indirect experiences such as reading text or listening to a lecture. In these contrasting environments students are (respectively) either active or passive learners.

Current research on cognition and instruction indicates that constructivist approaches to teaching and learning line up with what research has shown about how people learn most effectively (Bransford, Brown, & Cocking, 2000). Despite these findings, teacher-centered instruction is still the most commonly used mode of delivery in schools (Cuban, 2009). Inquiry instruction is widely considered to be a constructivist approach because of its emphasis on the investigation of authentic questions by students using scientific practices and methods. Methodologies such as

inquiry are often termed reform-based strategies because they are in opposition to more traditional teacher-centered strategies based on the positivist tradition.

Student-centered and teacher-centered approaches to learning can also be linked to views on the nature of science as either a method/way of knowing about the natural world or a body of knowledge (Land & Hannafin, 2000; Lederman, 2007) respectively. Constructivism (student-centered approach) lines up with the view that science is a set of processes that allow us to learn about the natural world and that as we interact with the natural world using these processes, our knowledge is refined. The use of a process-based approach such as inquiry, which integrates scientific practices and core content, addresses this aspect of the nature of science in context (NGSS, 2013a). Positivism (teacher-centered approach) aligns with the view of learning as a verifiable body of knowledge attained through teaching strategies such as reading and lecturing, which provide access to definitions, ideas, and core concepts that reflect current understandings of science. The processes related to the acquisition of those understandings are peripheral rather than integral, as in found in inquiry learning (NRC, 2007).

Constructivist teaching in science. Inquiry instruction, as advocated by the National Science Education Standards (NSES) (National Research Council, 1996), is broadly defined as the "diverse ways in which scientists study the natural world and propose explanations based on evidence derived from their work" (p. 23). One of the issues with the NSES has been that an "operational definition" is not specifically provided for inquiry and it is left up to some interpretation by the reader (Anderson, 2002). This ambiguity results not only in problems with translation into practice for

teachers, but also in problems for creating a common understanding of inquiry practice for researchers and the participants in the studies they conduct. It may contribute to some of the conflicting research results in the literature related to the assessment of teacher practice in numerous studies that utilize inquiry as an outcome (Speer, 2005). While it has been expected that teachers who hold constructivist beliefs about the nature of science will utilize inquiry instruction in their classroom, this has not been a consistent finding in studies related to nature of science (Crawford, 2007; Lederman, 1999). Whatever the inconsistencies in the literature about nature of science and inquiry implementation, it has become increasingly clear that teachers are finding the implementation of inquiry practices more challenging than has been previously acknowledged by the reform community (Windschitl, 2002).

A Conceptual Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (NRC, 2011), which supersedes NSES as a guide for the development of science education standards, describes inquiry and the scientific process using a set of "scientific practices." The goal of delineating scientific practices was to provide a more specific characterization of scientific inquiry and to more comprehensively describe what it means to "do" science. These eight practices have been incorporated into the Next Generation Science Standards (NGSS, 2013) which have been considered in most states for full or partial adoption. These standards were the main resource used to create the new science standards for the state of Oklahoma. Briefly, the practices are: 1) asking questions; 2) developing and using models; 3) planning and carrying out investigations; 4) analyzing and interpreting data; 5) using mathematics, information technology, and computational thinking; 6)

constructing explanations; 7) engaging in argument from evidence; and 8) obtaining, evaluating, and communicating information. The *Framework* recommends that students engage in these practices as the means to deepen their understanding of core concepts in the areas of life, earth, and physical science (NRC, 2011). Additionally, the *Framework* committee recommends the integration of a set of crosscutting concepts that tie scientific ideas together across disciplines. The crosscutting concepts are: 1) patterns; 2) cause and effect; 3) scale, proportion, and quantity; 4) systems and system models; 5) energy and matter; 6) structure and function; and 7) stability and change.

While still lacking some instructional and pedagogical specificity, this framework may provide a clearer way to operationalize constructivist science teaching practice for teachers and researchers looking at classroom procedures and outcomes. This could prove particularly useful for elucidating connections between beliefs and practice, which have been inconsistent in the existing literature to date (Anderson, 2002; Klahr & Li, 2005; Minner, Levy, & Century, 2010).

The integration of scientific practices, crosscutting concepts, and disciplinary core ideas in science instruction and assessment aligns with the constructivist paradigm because it is a way of teaching that allows students to construct scientific knowledge through active engagement in the processes of science (NRC, 2011). This pedagogical approach has been termed as "3-dimensional learning" because it integrates practices, crosscutting concepts, and core content (Moulding, Bybee, & Paulsen, 2015). It represents a shift from previous descriptions and definitions of inquiry as used in the NSES to a more comprehensive view of the endeavor of science.

It also necessitates a pedagogical shift that is unfamiliar to most teachers. Three-dimensional teaching and learning comprise the core of the next wave of science education reform (NGSS, 2013). As a result, elementary teachers are now expected to incorporate this new way of teaching into their classroom practice. This has become one of the external factors associated with the practice of science teaching in K-5 schools that has the potential to affect the relationship between teacher beliefs and practice.

Research on beliefs about the nature of science and instructional practice. A significant body of research exists that examines teacher beliefs about the nature of science and its relationship to instructional practice, particularly regarding the use of inquiry methods in the classroom. In this research, nature of science and scientific inquiry are sometimes conflated, although they are not the same thing. Scientific inquiry refers to the process of science, while nature of science signifies a way of knowing about the natural world through science and its processes (Lederman, 2007). This has resulted in some conflicting research results regarding the relationship between what teachers believe about science and the pedagogy they use to teach it.

Understandings about the nature of science are considered essential to scientific literacy (AAAS, 1993; NRC, 1996; NRC, 2007). Some controversy exists as to what is meant by the construct known as nature of science, but in general it refers to the epistemological foundations of the activities of science and the characteristics of its resulting knowledge (Lederman, 2007). The construct consists of factors such as: the distinction between observation and inference; the distinction between scientific laws and theories; the subjectivity (or theory-laden) nature of scientific knowledge; its

immersion in culture; and its tentative nature based on evolving understand of new evidence. While the nature of science construct obviously extends beyond the basic idea of opposing beliefs about science as a collection of facts versus a process for knowing about science, this dichotomy has been evoked in studies examining nature of science beliefs in relation to the practice of inquiry (Davis, Petish, & Smithey, 2006; Hubbard & Abell, 2005; Pollak, 1993). Logic would dictate that teachers who hold a process view of nature of science would endorse and/or practice inquiry instruction in the classroom while teachers with a view of science as a search for truth would favor a more didactic approach. Studies have not consistently borne this out. This may be due to the previously mentioned issues with defining the practice of inquiry in the classroom (Byers & Fitzgerald, 2002; Mansour, 2009; Speer, 2005) and the use of a broad definition for the nature of science (Lederman, 2014). Some studies have concluded that inquiry instruction alone is not sufficient to address all aspects of the nature of science (Adb-El-Kahlick & Lederman, 2000). Many studies cite additional beliefs and contextual factors as explanations for inconsistent findings (Brickhouse, 1990; Hodson, 1993; Hubbard & Abell, 2005; Lederman, 1999). This is illustrated by the following study examples.

A study of 5 inservice secondary teachers during their internship (Crawford, 2007) found that beliefs about teaching and views of science were closely related to the interns' intention and attempts to utilize inquiry teaching methods. It was acknowledged, however, that supports and constraints from school culture as well as mentor beliefs and attitudes influenced the approaches utilized by these teacher interns. In a multiple-case study (Lederman, 1999), the teaching practices of five

biology teachers from diverse backgrounds, selected because of their similar views of nature of science, were examined using interviews, classroom observations, student interviews, lesson plans, and the Views of the Nature of Science (VNOS) survey. All five teachers scored similarly in their views of the nature of science in line with the current reform vision but varied widely in their classroom practice. Factors that emerged as contributing to the varying decisions about instruction included experience, intentions, perception of students' needs and characteristics, and a desire for student success. The teachers' perception of their subject matter expertise was also shown to factor into their instructional decisions. Connections to teachers' similar nature of science beliefs were not found in any of the data related to their instructional decisions. Similar results were found by Shim, Young, and Paolucci (2010) in a quantitative study showing that inservice teachers' nature of science beliefs were not correlated to their curriculum preferences.

These representative studies indicate that the decision to utilize inquiry is related to a complex system of beliefs and contributing factors rather than an isolated belief about the nature of science. Although this may be due to unclear definition and use of nature of science and inquiry variables in the studies, the complexity and interrelation of the variables must be taken into consideration as well (Speer, 2005). Since science education research shows that teachers' efficacy and nature of science beliefs do not always translate into corresponding practice patterns because of other contributing factors, the OIT continuum provides a way to examine these beliefs and how they influence instructional practice decisions in a way that considers contextual factors that may influence teachers' enactment of these beliefs. Perceived autonomy

as influenced by external controls experienced by teachers has the potential to add explanatory value to the findings in these areas.

Autonomous Motivation

While the beliefs literature from science education paints a broad picture showing that teacher practice is undeniably associated with beliefs, it is also clear that numerous other factors contribute to the practices teachers enact in their classrooms. These factors have been studied broadly but without attention to the specific supporting or interfering roles they play within models of belief systems that have been studied. Among those mentioned in explanatory models are specific contextual factors associated with instructional support and what is often termed as overall teacher motivation. Often these are simply referred to as "other" factors because they cannot be necessarily categorized as beliefs, although they may influence the belief system (Mansour, 2009; Marshall, et al., 2009; Roehrig & Kruse, 2010; Waters-Adams, 2006). Since these contextual factors are generally external to the teacher, there is an unexplored possibility that these might affect teachers' perception of autonomy because they may directly relate to locus of causality. A classic example of this is accountability pressure, which is both external to the individual and controlling. Autonomy perceptions could explicate the role of the "other" factors often mentioned in science education literature in a way that has not been previously explored in these systems.

In general, the term "teacher autonomy" evokes a notion of the freedom teachers have (or lack) to make choices about how, what, and when they will teach their students to ensure that prescribed learning standards are met. It includes views of

teacher professionalism, personal beliefs and values, and mandated administrative control (Parker, 2015; Pearson & Moomaw, 2005). It has also sparked considerable public debate about how teachers should balance professional obligation and responsibility with their personal views and beliefs in a climate of accountability (Carey, 2008; Culbert, 2011; Hawthorn, 1986). Much of the early literature on teacher autonomy focuses on teacher professionalism, job satisfaction, and administrative control (Crawford, 2001; Ingersoll, 2003; Wilches, 2007). Early empirical studies of teacher autonomy show two types of teacher autonomy, "general" and "curricular" (Pearson & Hall, 1993; Pearson & Moomaw, 2005). General autonomy is related to classroom standards of conduct, teaching method, creativity, and assessment, while curricular autonomy encompasses instructional content, planning, and sequence. These studies, generated in an era of accountability emphasis, have focused largely on the professionalism aspect of teacher autonomy and rarely consider autonomy from a motivational standpoint by focusing on perceptions of autonomy rather than contextual evidence that autonomy exists. From a motivational perspective, the important consideration for teacher autonomy is teacher perception regarding the degree of autonomy they have in their role as teachers and, in turn, how that perception affects what they do in the classroom (Deci, 2009). This may or may not be related to the actual amount of freedom that is afforded to them within the system.

In terms of SDT, three main qualities exemplify autonomy: locus of causality, volition, and choice (Deci & Ryan, 1987). Locus of causality relates to the perception of individuals' personal endorsement of their own behavior. Volition refers to how free or unforced people feel when participating in an activity. Choice refers to

individuals' perceptions that they are genuinely choosing their own actions. These overlapping qualities are influenced by the extent to which individuals feel that external factors either thwart or reinforce their personal values and goals. The perceptions people hold regarding these qualities have been termed "autonomous motivation" (Koestner, Otis, Powers, Pelletier, & Gagnon, 2008; Roth et al., 2007) and are related to the perception of autonomy versus control that is found in the OIT continuum. This is slightly different than what people generally think of as autonomy because it involves perception rather than objective reality. Autonomous motivation has been shown to be related to several positive and desirable educational outcomes in the case of students (Black & Deci, 2000; Reeve, Deci, & Ryan, 2004), including persistence, decreased anxiety levels, and increased interest in approaching learning tasks. Few existing studies examine teacher autonomy from an SDT perspective and none specifically address science teaching.

On the other hand, there is a substantial body of literature advocating teacher autonomy support for students as a way to increase student engagement. Autonomy support signifies ways in which behaviors or conditions support individuals' sense of autonomous motivation. The types of conditions and behaviors that provide autonomy support for students have been defined at length in the motivation literature. Student engagement represents active involvement in the learning process on the part of the student (Reeve, 2008), an important aspect of student-centered learning. Teachers who provide autonomy support for students to engage in inquiry-type activities say and do things in the course of instruction that increase student perceptions of their own autonomy which, in turn, helps them engage more actively in learning (Assor, Kaplan,

& Roth, 2002). Autonomy support goes beyond offering students simple choices about their learning. It involves affording an environment in which students are encouraged and allowed to be creative, offering students opportunities for higher levels of cognitive engagement in relevant tasks, and providing positive feedback about competence (Stefanou, Perencevich, DiCinto, & Turner, 2004). When students receive support in the form of organizational autonomy for comfort and security; procedural autonomy for initiating engagement in learning tasks; and cognitive autonomy for engaging in deep-level thinking, they tend more toward an intrinsic goal orientation, which results in higher engagement and positive student outcomes (Reeve, Jang, Carrell, Barch, & Jeon, 2004). Since autonomy support from teachers has been shown to produce higher levels of student autonomous motivation and learning engagement, it is possible that teachers with higher levels of autonomous motivation could exhibit teaching behaviors that reflect an endorsement or even internalization of the value of science instruction and/or inquiry methods which utilize autonomy supportive strategies with students.

While we know what autonomy support looks like for students, this has yet to be defined for teachers. Studies with adults from work settings show that autonomy supportive behaviors in the workplace include providing meaningful rationale for doing a task, acknowledging peoples' feelings about a task, emphasizing choice over control, and providing needed information for performing a task (Deci et al., 1991; Gagne & Deci, 2005). Many research studies from science education talk about support for science teaching and conclude that administrative and peer support are needed for the successful implementation of reform strategies such as inquiry (Abd-

El-Khalick, 2005; Duschl & Wright, 1989; Marx & Harris, 2006; Morrison, Raab, & Ingram, 2009). Although the support needs are stated in terms of such things as professional development, scheduling structures, equipment, and communities of practice, another way of looking at these structures might be as autonomy support for teaching inquiry in the classroom.

Since the reform of science teaching is a current priority in science education, autonomy support for teachers implementing inquiry or 3-dimensional learning may prove to be an instrumental force helping to drive reform. When teachers receive administrative support for the implementation of reform strategies, their sense of autonomy increases and they are willing to try strategies they might not normally attempt and persist in their use (Davis & Wilson, 2000). Teachers do not necessarily want complete autonomy in what they do, nor do they want to be left completely alone in their teaching practice. They need to be supported and validated as they implement new strategies. Teachers indicate that when principals provide support by allowing them to work together to try new instructional strategies or provide constructive feedback during implementation, they feel more valued as professionals and experience a greater sense of autonomy (Gabriel, Day, & Allington, 2011). Administrative support for teacher collaboration, instructional experimentation, and creativity may prove to be a way to operationalize autonomy support for teachers.

In one of the few existing studies on teacher autonomy perceptions, Roth et al. (2007) suggest that autonomous motivation can be divided into two separate constructs in the case of teachers. The first, termed *autonomous motivation for teaching*, relates to teacher perceptions of their reasons for engaging in teaching.

These reasons fall along the OIT continuum and reflect teacher perception of control versus autonomy as well as the associated regulatory processes related to perceived locus of causality. When teachers engage in their job purely for the pay check, they exhibit an external regulation style with an external locus of causality indicating perceived external control. When their reason for teaching is because they believe that student-centered teaching helps students succeed, their style is more associated with an internal locus of causality, providing the perception of autonomy (Niemiec & Ryan, 2009). The other teacher autonomy construct, termed *orientation to autonomy and autonomy support*, reflects the autonomy supportive teaching practices used and endorsed by teachers that have been associated with desirable student outcomes (Black & Deci, 2000; Hardré & Reeve, 2003; Reeve, Deci, & Ryan, 2004). These include providing students choices about their learning, rationales for the relevance of learning topics, and positive feedback about competence (Stefanou et al., 2004). These practices reflect the constructivist perspective of learning and teaching.

Although the literature is limited on autonomous motivation for teaching, a number of studies of adults in various workplaces, including schools, have utilized the OIT autonomy continuum to conceptualize motivation for workplace engagement. It has been shown consistently and reliably that the degree to which the behavior of individuals is self-determined is reflected in the regulation and locus of causality patterns represented in the OIT continuum (Fernet, 2012; Gagné et al., 2010; Guay, Vallerand, & Blanchard, 2000; Stephan, Boiché, & LeScanff, 2010). These studies demonstrate that autonomous regulation styles reflecting an internal locus of causality result in positive outcomes such as higher levels of job satisfaction, task persistence,

and endorsement of reform or change strategies. Conversely, in situations where individuals perceive that their behavior is externally controlled, less self-determined outcomes such as procrastination, anxiety, and poor work or study habits have been demonstrated (Vansteenkiste, Sierens, Soenens, Luyckx, & Lens, 2009).

Although autonomous motivation for teaching and orientation to autonomy support are presumed to be separate constructs, two recent studies have shown that they may also be connected in some way. A study conducted with teachers and students (Pelletier, Seguin-Levesque, & Legault, 2002) found a positive relationship between teachers' perceived sense of self-determination and their self-reported endorsement of autonomy support for students. In a related study, Roth et al. (2007) demonstrated a connection between teachers' perceived autonomy and their self-reported use of controlling versus autonomy supportive behavior in the classroom. Teachers with higher perceived autonomy reported using more autonomy supportive strategies with their students and teachers who perceived themselves as being subjected to external control reported the use of more controlling strategies with their students (Deci et al., 1991). Further exploration of this connection might provide insight into the strategies teachers choose for science instruction. Science teaching provides a useful context for examining these factors because of the close relationship between autonomy support and the student-centered nature of inquiry-type instruction.

One area of research where autonomy versus control has received some exploration is the effect of high-stakes testing (HST) on teacher practice. By its nature, HST is a controlling form of motivation because it focuses on rewards and punishments regarding outcomes based on a specific set of learning standards (Ryan &

Sapp, 2005). While producing the desired outcome of increased test scores, negative effects include narrowing of curriculum (Au, 2007) and increased dropout rate (Shriberg & Shriberg, 2006). These negative effects occur because the external regulation in a high-stakes environment fosters performance rather than learning goals in both teachers and students. This type of regulation has a direct effect on the self-determined behavior of teachers and runs contrary to the student-centered environment promoted by most educational reform agendas, including science education reform. In order for these reforms to occur, teachers and administrators must internalize the value of reform strategies such as inquiry learning (Deci, 2009). This internalization results in more perceived autonomy for teachers but runs contrary to the controlling form of motivation found with high-stakes testing. The high-stakes environment is part of the overall context in which elementary science teachers make instructional decisions and is often given as a reason for the lack of science instruction they provide their students (Marx & Harris, 2006). This indicates that teacher perception of control versus autonomy will likely contribute significantly to their instructional decision-making in science when examined in-depth from an SDT perspective.

Foregrounding autonomous motivation and orientation to autonomy support through the motivational lens of SDT has the potential to reveal further understandings about elementary teacher instructional practice in science. It may shed light on conflicting findings from science education research regarding the relationship between teacher beliefs and practice. An exploration of teacher perceptions of autonomy may show how external factors outside the beliefs system itself affect teacher motivation to teach science in ways recommended by the science education

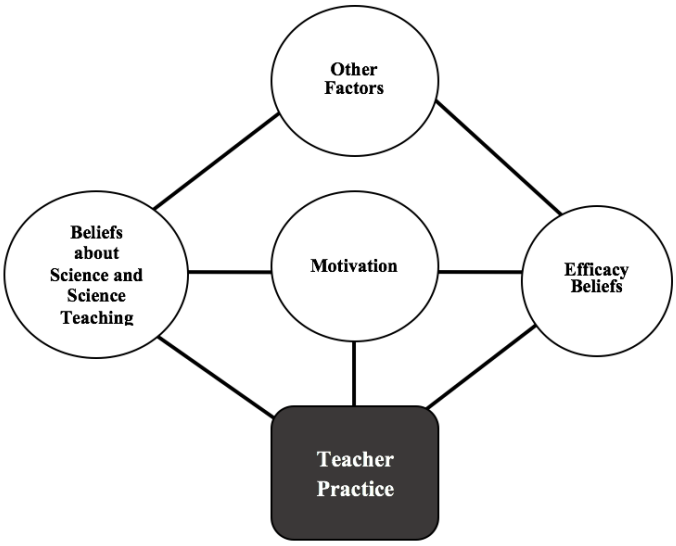
community and current understandings of how students learn. The final section in this chapter briefly summarizes the study rationale that has been presented in the literature review and presents the proposed research questions for the study.

Summary of Study Rationale with Research Questions

The existing literature in science education clearly shows that teacher beliefs play a role in the instructional practice of elementary teachers. In general, it has been demonstrated that a high sense of self-efficacy for science teaching and a belief that students learn best when they are actively involved in learning by doing science results in higher quality teaching of science to young learners. However, there are many aspects of elementary teacher practice that do not directly hold to this general pattern. External factors such as support for science teaching, administrative mandates, and differences in student abilities and home support have effects on teacher practice that do not fit meaningfully into models that primarily consider systems of connected or unconnected teacher beliefs. Some studies group these issues together as "other factors" because they may contain constructs outside the psychological realm of teacher beliefs. Other publications have separated the factors into various constructs to form more complex explanatory models. In any case, these models present motivation as a separate unitary construct within the model (e. g. motivation for teaching) rather than considering that many of the beliefs or belief dimensions within the model might be part of a larger motivational framework. *Figure 2.2* shows a simplified representation of connections between beliefs and practice discussed in this chapter that have been previously established in science education literature. Rather than being part of the motivation construct, the external factors are separate and

considered as something extra that contributes to beliefs. Motivation is usually considered a separate construct within these models.

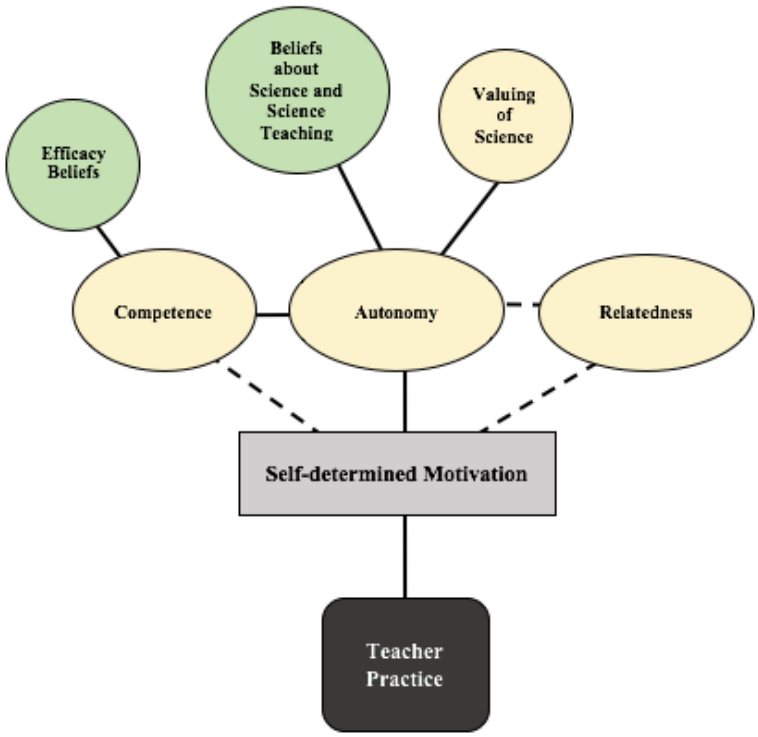
Figure 2.2 – Beliefs versus Practice Model - Science Ed. Literature Perspective



Another way to approach the problem of determining how teachers' beliefs affect their practice is to utilize a framework that focuses on reasons why teachers do or do not act on their stated beliefs. From an SDT perspective, the external factors are incorporated into the concept of autonomous motivation through the OIT continuum. These factors influence teacher perceptions of autonomy (or control) which, in turn, influence how they enact their beliefs. The SDT model also acknowledges the contribution of competence factors (efficacy beliefs) as a condition of autonomous motivation. The SDT motivational framework explains interactions of internal and external factors to explain teacher behavior, rather than viewing them as a collection of related factors that interact in various ways that may be too complex to be predictable for practical consideration.

Figure 2.3 is a simple representation of the proposed connections explored or discussed in this study and possible connections between them as identified in the literature review.

Figure 2.3 – Beliefs and Practice Model - SDT Perspective



The diagram shows that efficacy beliefs relate to competence perceptions and that competence is necessary for autonomy. According to SDT, competence is one of the psychological needs necessary for self-determined motivation. Autonomy is influenced by the degree to which an activity (science teaching) is valued and the beliefs about teaching and science as a discipline that reflect those values. The beliefs may relate to instrumentality of science, beliefs about student ability, or beliefs about constructivist versus traditional teaching strategies. Relatedness is the other psychological need identified in SDT as being necessary for self-determined motivation and has been shown to be important for teaching in general because of the

connections that teachers make with their students and their desire to do what is best for them (Deci & Ryan, 2002). Because of the importance of contextual factors and their role in autonomy, it was decided to focus on teacher autonomous motivation in this study within the science teaching context. The model (Figure 2.3) depicts connections explored in the study as solid lines and those not directly explored in the study as dotted lines. Concept bubbles related to motivation literature are shaded in yellow and those related to science education literature are shaded in green.

Although the SDT framework has never been used to explore teacher practice in science, the literature review in this chapter has described numerous possible connections that could exist between the SDT autonomy continuum in motivation literature and the beliefs versus practice framework in science education literature. The main emphasis of the study will be on finding out if an understanding of teacher autonomy can provide insight into the external factors that do not always fit into existing science education models of the relationship between beliefs and practice. These factors could include administrative support, student characteristics, environmental constraints, and social norms (Jones & Carter, 2007). This study is exploratory because, to my knowledge, these connections have never been studied in this way. The value of the study will be found in possible explanations that can be generated regarding external contextual factors that might relate to teacher practice which could be addressed through professional development or administrative support to improve or change teacher practice. The study may also find other connections that generate interesting questions for further study.

Since a significant issue in elementary science education is the relatively low amount of time spent on science instruction (Appleton, 2007; Banilower et al., 2013), it was determined that this would be a good way to group teachers to look for differences in perceived autonomy. An assumption was made that, when teachers have choices about the length of instruction, those who have high efficacy and autonomy perception related to science might choose to spend more time teaching it and those with lower efficacy and autonomy might teach science less. If time teaching science is not the choice of the teacher, it could also be considered a controlling external factor which also relates to teacher autonomy,

Based on the literature presented in this chapter and the need to examine teacher practice through a novel theoretical lens, I conducted an exploratory mixed methods study that utilized quantitative data to select teachers who teach science at different levels of frequency to intensively examine their autonomy perceptions through the collection of qualitative data. The research questions that will guide this study are:

- *What percentage of time do elementary teachers in self-contained classrooms report devoting to science instruction? (Quantitative Question)*
- *Does elementary teachers' autonomous motivation for science teaching differ depending on the time they devote to science instruction? If so, how and why? (Qualitative Question)*
- *Does elementary teachers' endorsement of student-centered learning for science differ depending on the time they devote to science instruction? If so, how and why? (Qualitative Question)*

Chapter 3: Methodology

Research Design

The principal epistemological framework for this study is pragmatism, which has roots in constructivism and has been popularized in education by the work of John Dewey (1933). This stance, referred to by Dewey as "instrumentalism," holds that a proposition is valid if it has practical significance for those utilizing it and that its meaning is found in how it is used and accepted rather than some absolute truth that guides the proposition. Pragmatism is widely considered to be the founding epistemological stance for mixed methods studies (Tashakkori & Teddlie, 1998). A mixed methods approach is utilized in this study to gain practical knowledge through the collection of diverse types of data that provide the best understanding of the research problem (Creswell, 2003) and indicate how the findings might find application in practice. Mixed methods research is defined as an "intellectual and practical synthesis based on qualitative and quantitative research" (Johnson, Onweugbuzie, & Turner, 2007, p. 129). The methodology utilizes both quantitative and qualitative data together to bridge the positivist assumptions of quantitative research and the constructivist assumptions of qualitative research. Rather than attempting to determine some type of objective reality as in the quantitative tradition or seek multiple context-based realities as in the qualitative tradition, a mixed methods approach utilizes both data types to best address diverse types of research questions (Johnson & Onweugbuzie, 2004). The functional approach of mixed methods research constitutes a separate research paradigm that draws on the strengths and minimizes the weaknesses of each of the other two approaches (Johnson et al., 2007).

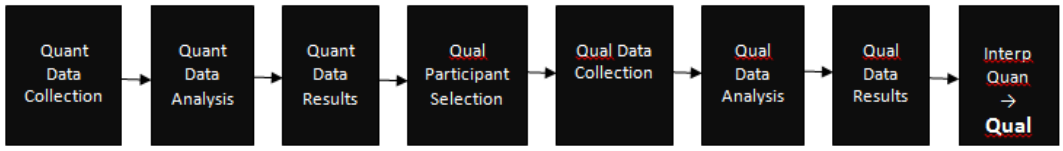
The utilization of both types of data to address problems that result in questions that cannot reasonably be answered by quantitative or qualitative methods alone characterizes a practical approach to research in the pragmatist tradition. As held by Dewey's (1933) instrumentalist perspective, the practical significance of utilizing a mixed methods approach to answer a research question makes the meaning that is generated from it justifiable.

The research questions in this study address possible relationships between the instructional practice of teachers and their perceptions of autonomy. Identifying patterns of instructional practice is necessary in order to explore connections between these patterns and the autonomy perceptions of teachers exhibiting them. One way to identify patterns of teacher practice from a participant pool is through survey data that elicit numbers reflecting different frequency and methodology practices regarding science instruction. However, there are currently no validated instruments available to assess teacher autonomous motivation. For this reason, a qualitative approach was needed to explore specific autonomy aspects of elementary science teaching in relation to their instructional time. A mixed methods approach was indicated since both qualitative and quantitative methodologies were the best options for exploring the two main aspects of the research questions. A practical advantage to the mixed methods strategy is that a survey can be used to identify instructional patterns of a relatively large number of teachers, which can then be sampled to find a smaller number of teachers with a variety of patterns represented to ensure maximum representation for further analysis without having conduct large numbers of interviews. Once instructional patterns are identified from the quantitative data, qualitative data

regarding the teachers' autonomy perceptions can be collected to explore whether relationships exist between perceptions and practice.

The qualitative data are needed to explore teachers' autonomy perceptions in-depth. Roth et al. (2007) developed a questionnaire to qualitatively assess teacher levels of autonomous motivation on the OIT continuum. This questionnaire was reviewed and was determined to be too generalized for the topic of this study. A specific interview protocol directed toward science teaching was required to tie SDT constructs to the beliefs literature in science education. Since no such protocol exists, the (Roth et al., 2007) questionnaire was used as a resource for a researcher-generated protocol for this study. A mixed methods approach employing a sequential participant selection design with a strong qualitative emphasis was chosen to guide this study because of the need for an efficient grouping strategy and the exploratory nature of the teacher autonomy data collection (see *Figure 3.1*).

Figure 3.1 - Participant Selection Model – Qualitative Emphasis (Creswell & Plano-Clark, 2007)



The participant selection model is a sequential mixed methods strategy in which quantitative data are collected and analyzed first to select a specific set of study participants. After the initial phase, qualitative data are collected from the selected participants in a second phase of the study. These data are analyzed and interpreted in light of the selection criteria used in the first phase. In the participant selection model the main emphasis is on the qualitative data and its interpretation (Creswell & Plano-

Clark, 2007). Although this design is generally considered to be explanatory in nature because the data are interpreted with regard to specific groupings created in the first phase of the study, the present study is more exploratory in nature. There are no expected differences between groups of teachers who spend different amounts of time on science instruction in relation to their autonomy perceptions because there is not enough literature in the area of autonomous motivation for science teaching to warrant any expected associations between practice and autonomy perceptions. The goal of the study is simply to look for patterns that might warrant further study or explanation. Percentage of science instruction time is used as a grouping variable because statistics show that self-contained elementary teachers do not provide as much time for science instruction as they do for other content areas (Banilower et al., 2013; Dorph et al., 2011) and that they sometimes avoid science instruction (Appleton, 2007). The reasons for this could be related to administrative control or autonomous motivation, depending on teacher beliefs and circumstances. It was inferred that obtaining the largest possible range of teaching time from a larger group of teachers would help provide qualitative data from a smaller group within the overall sample that varies in relation to Organismic Integration Theory (OIT) behavior regulations.

For the first phase of this study, the quantitative data were collected through the administration of a survey to 136 elementary teachers from 20 elementary schools in 11 school districts participating in professional development (PD) programs with the K20 Center at the University of Oklahoma. The data include teacher demographics, the amount of time spent on science instruction (frequency), and whether the teachers primarily utilize reform-type (constructivist) or more traditional

teaching methods. Results from the analysis of these data were used to create three profile groupings representing low, moderate, and high frequency science instruction. This use of quantitative data to establish frequency groupings was intended to increase the breadth of the study and provide a practical method for the comprehensive collection of qualitative data (Greene, Caracelli, & Graham, 1989; Johnson et al., 2007).

In the qualitative phase of the study, eleven purposefully selected individuals from each of the three profile groups participated in in-depth interviews. Care was taken in the selection process to include interviews from teachers using both reform-type and traditional teaching methods at a variety of grade levels. Interview data were analyzed using an inductive approach to look for common patterns within and between profile groups (Shank, 2002). The data were used to explore connections between perceptions of autonomy and teacher practice through the SDT lens. The intent was to more comprehensively address the research questions because of the maximum variation in the range of perspectives of the participants provided by the quantitative selection process (Onwuegbuzie & Collins, 2007).

Collins, Onwuegbuzie, and Sutton (2006) identify participant enrichment and significance enhancement as two of the major rationales for employing a sequential mixed methods design. Both issues are addressed in this study. The use of quantitative data to inform participant selection provides a way to enrich the participant pool by purposefully sampling for maximum variation, which optimizes the sample without having to increase the sample size (Patton, 1990). A pre-survey given to a larger number of teachers to determine instructional frequency, teaching

methods, and grade level ensures a participant group for interviews that represents a wide spectrum of teacher practice, which might not necessarily be the result from interviews conducted with a random sample of elementary teachers who have not been screened in advance for these factors.

Using a participant group which exhibits a variation in practice provides an opportunity to more effectively reveal any relationships that exist between practice and teacher autonomy perceptions. The increase in explanatory potential, in turn, enhances the significance of the study findings. This also gives the study more pragmatic value for informing teacher education and professional development. For this study, ultimately, the increase in significance could result in a more practical, effective avenue for addressing the overarching need for the type of elementary science instruction currently recommended by science education researchers.

The mixed methods approach provides complementarity through the purposeful collection of qualitative data informed by quantitative findings, (Greene et al., 1989). Complementarity occurs when a research study utilizes the results of one method to provide elaboration, enhancement, illustration, or clarification for another method. The quantitative findings in this study not only enhance the qualitative findings through the formation of profiles for further study, they also help to elaborate on possible connections between topics from science education and motivation literature that have not been connected before, such as reform-type practices and autonomy supportive behaviors in the classroom.

Quantitative Design

Participants

Participant recruitment. Participants were recruited from 20 schools in 11 school districts after their administrator provided permission to allow recruitment during a PD session provided by the K20 Center. I attended a PD session in each school to recruit teachers in person. Teachers took the survey at the time of recruitment. The survey includes a section asking for participants' consent to be contacted for interviews. They were told that they could take the survey without consenting to be interviewed and that they may or may not be asked to participate in the interview process.

Only teachers who have self-contained classrooms were asked to participate in the study. A self-contained classroom is defined for this study as one in which a single teacher is responsible for teaching all core content areas to one group of students. Self-contained teachers were chosen as the best population to examine because they may have the ability to make choices about when and how to teach science within their curriculum parameters and standards. This teaching situation provides a reasonable context in which to study teacher perceptions of their autonomy because they have choices about what, when, and how provide instructional activities. Elementary schools sometimes departmentalize their teachers rather than having them teach all content areas to single groups of students. In this case, individual teachers teach only one or two subjects, but to a larger group of students. This most often happens in the upper elementary grade levels (3-5). These teachers were not considered as participants for this study because they have less choice in what they

teach and cannot provide the best picture of how often or in what way teachers choose to present science to their students.

The main reason for recruiting in person was to ensure that the teachers who were asked to take the survey truly teach in a self-contained classroom. In a pilot study with 90 teachers from 10 schools participating in a STEM PD grant with the K20 Center, it was found that the term "self-contained" may have different meanings for different teachers. Some teachers think it means that the teacher simply has their own classroom where they teach or that they teach a limited number of subjects to a set of the same students, as is often the case with special education teachers. Recruiting in person was the best way to ensure that both conditions for a self-contained classroom (all core subjects taught and single group of students) were met. It provided a way to carefully explain the teaching situation required for the study.

Another important reason for recruiting in person was to reassure teachers that the information gathered in the survey would remain completely anonymous and that their administrator will not have access in any way to what they say on either the survey or the interviews. Teachers may be uncomfortable with providing their information or participating in an interview if they believe it will be shared with the person who is responsible for their evaluation or that it will take time away from their classroom. They were also told that, if asked to do an interview, I would work with them to schedule a convenient time that would not interfere with their teaching duties. The personal appeal with strong assurances of participant anonymity helped encourage teachers to participate. The overwhelming majority of eligible teachers recruited in

this way agreed to do the survey and approximately half of them provided contact information for a future interview.

IRB and participant confidentiality. Permission was obtained through the Institutional Review Board (IRB) to conduct this study. All requirements of the IRB were met in the implementation of the research methodology. At a pre-scheduled time during K-20 professional development sessions, I explained the purpose of my study and invited teachers to participate. Those agreeing to participate were given an explanation of their rights and the voluntary nature of the study and were asked to sign an IRB consent form. After consent, they completed a paper and pencil survey. The survey results contained no personal identification information. However, in the cases where teachers provided contact information for a future survey, those that eventually agreed to a survey were assigned a pseudonym. Identifying information for teachers who did not participate in a survey was removed from the database.

Participant description. There were 136 elementary teachers from 20 elementary schools in 11 school districts who agreed to participate in this study. Grades Pre-kindergarten (PK) through 5 are taught in these schools. The 11 districts come from K20 Center's network of approximately 350 urban, suburban, and rural schools across the state of Oklahoma. The K20 Center is an educational research center at the University of Oklahoma providing PD to schools in the areas of technology, reform-based teaching, and professional learning communities. Teachers in the study participated in sustained PD provided through the K20 Center emphasizing STEM practices and reform-type (constructivist) teaching methods. For

purposes of this study, districts were classified into three groups based on population. Distribution of numbers of teachers from various district sizes is shown in *Table 3.1*.

Table 3.1
Teacher Distribution by District Size

District Type	Population in School District	# of Districts	# of Teachers
Rural Town	<5,000	4	28
Rural/Suburban City	5,000 - 50,000	4	68
Large City	50,000 - 700,000	3	40

This is a convenience sample since the schools were selected because the researcher had access to them through PD programs as an employee of the K20 Center. The fact that it is a convenience sample is another reason the mixed methods quantitative sampling strategy was important for obtaining maximum variation for the qualitative data. The school districts vary widely in size and are geographically diverse from one another. This provided a variety of school contexts for exploring similarities and differences in teacher perceptions. It also helped to broaden the scope of the study and provided an opportunity for a more diverse pool of participants while still maintaining an optimal and feasible number of participants for analysis of the qualitative data. The diversity in types of school districts helped to address the goal of obtaining maximum variation within the research design to provide broader applicability of the findings than would a study of participants from a single school or school district.

A variety of grade levels were represented in the teaching assignments of the 136 participating teachers. Table 3.2 indicates the grade level distribution reported by these teachers.

Table 3.2
Grade Level Distribution of Study Teachers

Grade Level	Number of Teachers
PK	2
K	15
1	27
2	25
3	26
4	26
5	11
More than 1 grade level	4
Total	**136**

Teaching experience of the participants varied from 0 years to more than 20 years as shown in *Table 3.3*. A majority of the teachers (79%) reported taking an elementary science methods course in college, while the other 21% reported having no instruction in science pedagogy in their pre-service education.

Table 3.3
Teaching Experience of Study Teachers

Teaching Experience	# of Teachers
0 - 2 years	22
3 - 5 years	38
6 - 10 years	32
11 - 20 years	22
More than 20 years	21

All the teachers are in a self-contained classroom and reported teaching at least four of the five major elementary subject areas (language arts, reading, mathematics, social studies, and science) to their students. The reported average number of students in each teacher's class is 23.

In this group, 96% of the teachers are female. This is consistent with statistics showing that the overwhelming majority of elementary teachers in Oklahoma as well as nationally are female (NCES, 2011; UNESCO, 2016). Since gender differences are not a key variable in the research questions and it is common for teachers to be females, it is unlikely that this disproportionate statistic will affect the generalizability of the results of this study.

Quantitative Data Sources

The quantitative phase of the study focused primarily on a single variable, frequency of science instruction. The data were collected to answer the first research question, "*What percentage of time do elementary teachers in self-contained classrooms report devoting to science instruction?"* Additional variables of interest or value for selecting participants for the qualitative portion of the study were instructional method for teaching science, demographic information, and open-ended clarification responses. Although these variables were not primarily considered in creating groups for possible interviews, they were utilized to achieve sample diversity in cases where many teachers in a particular profile group provided similar responses.

Survey instrument. The researcher-constructed survey instrument used to measure the major variables and variables of interest can be found in *Appendix B*. The instrument contains items addressing three types of variables.

- Demographic information
- Science teaching frequency (how much total teaching time is spent doing science instruction)

- Instructional method (types of instructional methods teachers use to teach science)

Instrument construction. A pilot study was done in September 2012 with a group of 90 teachers from 10 schools participating in a STEM PD grant with the K20 Center to determine if the survey had the ability to establish the levels of teacher practice sought by this study. After analysis, it was determined that a distribution of the teaching frequency data would function effectively as a means for creating science teaching frequency groups. A wide enough range of instructional patterns and time spent teaching science was noted to warrant three frequency groups which could be labeled low, moderate, and high. Some corrections were made to the item choices for calendar patterns of teaching practice for this study to obtain numbers that could be used to better calculate total teaching time. Some ambiguities were found in the wording of the teaching methods items which made it difficult to determine multiple teaching method groups. It was decided that it would only be possible to create two groups (traditional and non-traditional) with the limited amount of information obtainable in just a just a few multiple-choice items. It was determined that two items would be sufficient to roughly determine these groups, since they could be verified later in the interview. The two groups were labeled as traditional (mostly textbook) and non-traditional (mostly teacher generated from various resources).

An important outcome of the pilot survey was teacher reporting of whether they were in a self-contained classroom. Despite providing them with a description in the question, a large number responded to this item in a manner inconsistent with their subsequent responses, suggesting that they were still unclear about the definition of a

self-contained classroom. This resulted in some data inconsistencies which interfered with calculating total teaching time spent doing science instruction. This was the main factor in the decision to recruit in person for this study.

Demographic items. The first three demographic variables in the survey (*Items 1-3*) are: type of school (urban, suburban, rural), grade taught, and subjects taught. If teachers are truly self-contained they should select all the subjects listed in *Item 3*. A question was included (*Item 4*) asking about any subjects that were not selected in *Item 3*. This served as a check on whether respondents were truly self-contained. It also provided information for instances when one subject was not included because of a local policy. For example, some schools do not teach social studies at certain grade levels, so it is not a subject that a teacher would select for that item. The other variables (*Items 5-8*) are: number of students, years of teaching experience, gender, and whether teachers have taken a science methods course in college. The last item was used to determine if teachers have potentially been exposed to constructivist teaching methods such as inquiry in their educational experience. Gender was not expected to be an important factor in this study because a large majority of elementary teachers are females. However, it was collected in the unlikely case that a larger than expected number of males volunteered as participants and also exhibited differences in their responses that might pertinently affect the study.

Teaching frequency items. For the frequency variable teachers were asked about their yearly and weekly scheduling patterns for science (*Items 9 and 10*), the length of their science instructional sessions (*Item 11*), the total number of teaching hours in their instructional day (*Item 12*), and an estimate of the percentage of their

instructional time spent on science over the course of a year (*Item 13*). The responses to the frequency items (*9-12)* were used to calculate an approximate percentage of total teaching time they devote to science instruction in their classroom. This calculation was used as the major grouping variable. The teacher estimate of how much time they spend in science instruction (*Item 13)* was included as a rough triangulation or check of the CPSIT grouping variable.

Instructional method items. For the teaching practice variable, teachers were asked to choose the primary method they use to provide science instruction from a list (*Item 14*). One of these choices is "I never teach science." It was not expected that a self-contained teacher would readily admit to this but it also served as another way to determine if teaching science is a choice or a mandate for the teacher. This also served as a check on the demographic question asking which subjects they teach. Additionally, teachers were asked to choose any additional science teaching methods they use from a similar list (*Item 15*). In both cases, they were offered a category called "other" to provide information not included in the lists. This was intended to help teachers who wished to describe what they do in detail because they were not familiar with or did not understand choices from the list. The choices in the list were designed to very generally fall into two types: textbook instruction and teacher generated instruction using various resources for science activities. The latter included examples such as online resources, hands-on activities, and teacher created curriculum.

Quantitative Data Analysis.

The main purpose of the quantitative data in this study was to ensure a wide range of teacher practice from which to sample for in-depth interviews. This type of sampling for maximum variation was accomplished through the formation of profile groups, taking full advantage of the range of teacher practice found in the quantitative data from in the participant pool (Onweugbuzie & Sutton, 2007; Patton, 1990). Data from the survey were analyzed in multiple ways using each of the three categories of data from the survey (demographic, frequency, and instructional method).

Demographic data. Analysis of the demographic data included frequencies, means, and ranges, with a goal of determining an overall picture of the participant pool to ensure the largest possible amount of variation in grade level, school population, and teaching experience. This analysis was also taken into consideration secondarily for determining variation in choosing interview participants. Within the pool of teachers taking the survey, participant teaching experience ranged from 0 to more than 20 years and included teachers from grades PK-5. The populations of the 11 represented districts ranged from approximately 300 to approximately 600,000 persons.

Teaching frequency data. The teaching frequency data were used as the primary criterion for qualitative participant selection. The data on teaching frequency were analyzed to calculate an approximate percentage of total teaching hours devoted to science instruction by the participants. Certain general assumptions were made in calculating this percentage to obtain the best possible estimate. The legally required length of a school year is 180 days. Using a school week length of 5 days, this results

in a school year of 36 weeks. Since most elementary schools have a regular schedule for organizing instruction that varies from school to school, teachers were asked specific questions about their science teaching patterns to help them report the amount of time they spend teaching science.

Teachers chose whether their pattern is to teach science throughout the year (all 36 weeks), only one semester (18 weeks), or only one quarter (9 weeks). In my experience working with schools, these are generally the three most common patterns teachers report for scheduling science in elementary schools. Next, they reported how many days per week science is included in their teaching schedule. These two numbers were used to calculate the total number of days they teach science during the school year. They also reported the length of time scheduled for teaching science during the days it is taught. This was reported in 15 minute (quarter hour) increments. When multiplied with the total number of days, this provided an approximate number of hours that science instruction is provided in the teacher's classroom per year.

Teachers were also asked to report the total number of hours per day they spend providing direct classroom instruction. They were told not to include scheduled lunch time or planning periods, since these times vary between schools. Multiplying this number by 180 (total number of school days) provides a total number of yearly direct hours of classroom instruction (in all subjects). Using the previously determined number of yearly hours of science instruction, a calculated percentage of science instructional time (CPSIT) was found for each teacher. This was intended to approximate the actual amount of time spent teaching science unless teachers considerably over/under-report on all or some of the items. This statistic was used to

construct a frequency distribution showing a range of the approximate percentage of their time teachers in this sample devote to teaching science.

Instructional method data. The responses to the instructional method items were used to place respondents into two teaching method categories. Since there was not enough information in two questions to determine the nuanced complexity of teachers' philosophical approaches to science instruction, these items were used to place teachers into two general categories: traditional and non-traditional. Teachers reporting in the first item that they use a textbook as their primary mode of instruction were placed in the "traditional" category. Teachers reporting that they use other methods were placed in the "non-traditional" category. Specific "additional methods" that teachers provided in the second item were used to get a better picture of overall teaching practice. In some cases, this was used to make decisions about teacher grouping when multiple selections were made in the first item.

Quantitative Data used for Qualitative Participant Selection. Survey data were analyzed before beginning the qualitative portion of the study. The frequency continuum constructed with the CPSIT data was used as the primary grouping strategy for participant selection. Since there is no established "ideal" amount of time for teaching science, the range from the data set was used to represent extremes of practice. The CPSIT ranged from 0% to 13.5% in this sample. This distribution was divided into three groups representing low, moderate, and high amounts of instructional time relative to the sample. These groups, along with some demographic and instructional strategy characteristics from the survey, were used to place teachers giving permission for surveys into final groupings to ensure maximum sample

variation. Characteristics such as grade level, district size, teaching experience, and primary teaching method were used to refine the groups to ensure the widest possible variation in teacher characteristics in the qualitative sample. The goal for this process was to achieve representation in the qualitative sample with the widest possible variation in CPSIT and demographic factors in order to answer the qualitative research questions.

Qualitative Design

Participants

The 11 interview participants in the qualitative portion of the study represent a variety of characteristics as described in the previous section. Grade levels range from 2nd to 5th grade, with the following distribution: 2nd grade (1 teacher), 3rd grade (2 teachers), 4th grade (4 teachers), and 5th grade (4 teachers). Teaching experience ranges from 3 to 23 years. Approximate district population ranges from 300 to 600,000 people. Three primary curriculum types are represented: textbook, teacher created, and kit-based. A teacher created curriculum indicates that the teacher puts together activities, labs, and reading materials on their own to meet the science standards at their grade level. For this study, a kit-based curriculum comprehensively includes activities, labs and reading materials and meets all the grade level standards at minimum with no need of supplementation.

During the interviews, each participant was asked to verify the answers they provided in the survey to check for accuracy. Most interviews were conducted 1 to 6 months after the survey was taken and it was assumed that some changes may have occurred to the teaching assignments and schedules of the interviewees. Many

surveys were administered at summer PD sessions. It is not uncommon for teachers to find there have been changes made to the schedule or their teaching duties when they return to school in the fall. This turned out to be true for 6 of the 11 teachers. Each of these changes was taken into consideration in the analysis and, in all cases, the changes contributed interesting findings to add to the study.

Demographic profiles of each of the eleven interview participants are found in *Table 3.4*. The changes reported in the interviews are reflected in each profile. Some additional specifics are also included in the profiles, such as exact numbers for years of teaching experience and approximate populations of the cities where they teach.

Table 3.4 - Profile Data from Interview Participants

Pseudo-nym	Grade Level	District Population (approx.)	Teaching Exp. (years)	Primary Instruction Method	College Major(s)	Science Methods Course?
Addie	5	24,000	11	Teacher created	Psychology and Elementary Ed	Yes
Brooke	2	96,000	7	Teacher created	Elementary Ed	Yes
Carol	4	600,000	3	Kit Curriculum	Broadcast Journalism	No
Diane	3	23,000	7	Textbook	Elementary Ed	Yes
Ellen	5	23,000	11	Textbook	Business Admin and Elementary Ed	Yes
Faith	4	17,000	5	Teacher created	Elementary Ed	Yes
Gayle	4	600,000	8	Kit Curriculum	Political Science	No
Hannah	4	24,000	7	Teacher created	Elementary Ed	Yes
Iris	3	300	6	Textbook	Elementary Ed	No
Jenna	5	600,000	5	Kit Curriculum	Elementary Ed	Yes
Kelly	5	600,000	23	Kit Curriculum	Elementary Ed	Yes

Qualitative Data Sources

The selected participants provided the interview data that were used to address the qualitative questions for this study:

- *How does elementary teachers' autonomous motivation for science teaching relate to their choices regarding the amount of time they spend teaching science and the methods they use to teach it?*
- *How does elementary teachers' orientation to autonomy support for their students in science relate to their choices regarding the type of science instruction they provide their students?*

Face-to-face interviews were conducted with 11 selected participants. Interviews were arranged via email contact and I went to a location chosen by the interviewee. Nine of the interviews occurred at the teacher's school site at a time chosen by the teacher. Two of the interviews occurred at a field trip site during the school day where two of the teachers said they could each spare an hour to talk while other teachers supervised their students. The length of the interviews ranged from 20 minutes to 65 minutes with an average of 42 minutes. Care was taken to adhere to a promised limit of 60 minutes in order to honor teachers' time and available energy. All interviews were audio recorded for transcription with the permission of each teacher.

Interviews. Interviews were conducted using a semi-structured interview protocol (*Appendix C*) that contains broad, open-ended questions organized into major categories related to the research questions. These open-ended questions were designed to elicit responses that reflect the participants' perceptions with as little input

from the researcher as possible for exploratory purposes (DiCicco-Bloom & Crabtree, 2006). The interview protocol includes possible probing questions for each main question to assist the interviewer, although other questions were asked as they emerged from the interview dialogue.

Interview protocol. The interview protocol is organized into five major sections: general teacher information, teaching practice, autonomous motivation for teaching, autonomy support for teaching science, and teacher orientation to student autonomy support. Each of these corresponds to an aspect of one or more of the research questions. Each section contains from one to five open-ended questions encompassing broad ideas related to the research questions for a total of 18 questions. Most questions include a set of suggested probing questions designed to help participants provide the researcher with information that will relate to the research questions. The sections of the interview protocol are described briefly below.

General teacher information. The six questions in this section (#1-#5) repeat items found in the survey. They enable the researcher to verify the participants' original answers and allow the participants to provide a more detailed description of themselves as a teacher. An additional question asks about the reason they became a teacher. This one was designed to elicit the intrinsic/extrinsic factors related to the teachers' overall motivation for teaching in general.

Teaching practice. The three questions in this section (#6-#8) ask teachers to describe their teaching practice in general, where and how science fits into their teaching routine, and the methods they use to teach science. The probing questions were designed to help teachers paint a comprehensive picture of the way they teach

science and how often they do it. Included in the probing questions are some prompts about the scientific practices from the Science Framework (2011). These are the defining points for constructivist science teaching practice and provided information on the extent to which the teachers are employing reform strategies.

Autonomous motivation for teaching. The three questions in this section (#9-#11) address two main qualities of autonomy according to SDT, locus of causality and volition (Reeve, Nix, & Hamm, 2003). Locus of causality reflects the perception that an individual's behavior is initiated either from within themselves or from something external to themselves. Volition refers to how free or forced people feel when participating in an activity. While these two qualities overlap, there is a slight difference in that locus of causality refers to an internal/external dichotomy of control while volition refers to the perception that one is free to do something regardless of internal or external attribution.

The first two questions in this section address locus of causality. The first one asks the teacher to articulate their perception of the control they have over what happens in their classroom. The probing questions are directed to both autonomy and control to determine the teachers' perspectives in relation to science teaching. This also includes perceptions about the perceived value of science that might affect decisions related to autonomy. For example, a teacher with high perceived autonomy might not teach science because they feel it has no value or, conversely, a teacher with high perceived control who values science might feel guilty about teaching science when told to emphasize reading. The second question addresses teacher efficacy for science teaching. Efficacy is related to autonomy according to SDT because

competence is a necessary condition for integrated and intrinsic regulation, both of which are types of autonomous regulation (Niemic & Ryan, 2009). Efficacy is also tied to introjected regulation because people may be motivated by what they or others think of their competence.

The third question in this section relates to volition and asks teachers for their perceptions of the amount of freedom they have for making decisions about science instruction. Some of the probing questions ask about teachers' views on accountability and educational reform. These were important for establishing the extent to which teachers feel they themselves have the freedom to teach what they feel is necessary and important, or if that decision is made for them.

Some of the probing questions in this section were informed by a quantitative instrument developed by Roth et al. (2007) to specifically measure autonomous motivation for teaching. This questionnaire utilizes subscales that reflect each of the types of extrinsic regulation from the OIT continuum. The questions found in these subscales target teaching in general and not specific subjects such as science. The questions were not used in the form they were found in the instrument because they were written for scaled responses as continuous variables. Rather, the wording and terms associated with each subscale were incorporated into the wording of the probing questions to ensure that each type of regulation could be captured in the teacher interview responses. These subscales can be found in *Appendix D*.

Autonomy support for science teaching. The question in this section (*#12*) addresses teacher perceptions of the amount of support they receive for teaching science from administrators, fellow teachers, parents, and other stakeholders. This

was important for understanding whether teachers feel that they have support to be autonomous in their teaching practice for science. The question is concerned with eliciting the type of support received in the form of feedback, encouragement, and scheduling rather than classroom supplies and curricular materials, although teachers did mention these as well in the interviews.

Teacher orientation to autonomy support. The final section contains five questions (#13-#17) relating to how teachers support their students to be autonomous in their own learning. This is an indirect way of determining teacher orientation to reform learning strategies such as inquiry and it also provides information to address the research question regarding the relationship between autonomous motivation for teaching and orientation to autonomy support. The questions were informed by questionnaires and results from two studies examining teacher autonomy support. Bieg, Backes, and Mittag (2011) utilized a series of scales to measure relationships between teacher self-report of autonomy supportive behavior and student perception of autonomy support. The combined items from these scales can be found in *Appendix E*. Stefanou et al. (2004) conducted an observation study of seven 5th and 6th grade mathematics teachers to identify relevant instructional features of autonomy support. A table of these strategies can be found in *Appendix F*. These resources were used to create probing questions to elicit responses related to autonomy support. Adaptations were made to reflect constructivist aspects of science teaching related to the features of autonomy support described in these studies.

The first question in the section (#13) relates directly to the teachers' beliefs about the nature of science. It was hoped that asking for a definition of science would

capture whether teachers see science as a process of uncovering ever-emerging ideas or a collection of enduring understandings that must be obtained for learning to occur. It was important to assure the interviewees that there is no right or wrong answer to this question because they were sometimes fearful of getting it wrong, which might have kept them from responding candidly. The next question (#14) ties to the nature of science question because it asks teachers how students learn science best. Their answer was weighed against their response to the previous question about the definition of science to see if they see learning science as analogous to the process of "doing science." This was done to help to establish their beliefs about science to see how they align with the descriptions of their practice.

The next three questions (*#15*-#17) relate to some important features of autonomy support: choice, informational feedback, and scaffolded opportunities for problem-solving that provide optimal challenge. Each of these has application in inquiry learning and are generally not present in more traditional teacher-centered instruction. It is important to note that not all types of choice given to students fall under the definition of autonomy support, particularly pertaining to cognitive motivation. It has been shown that simple choices such as what color to make a project cover or making a random guess prior to a science experiment do not contribute to students' perceived autonomy. The choices must be learning related, such as choosing your own way of demonstrating competence or making supported hypotheses (Assor, Kaplan, & Roth, 2002; Katz & Assor, 2007).

The final interview question asks the participant if they have any other information they would like to provide that would add to the relevance of their previous responses.

Other qualitative data. I occasionally asked to see classroom or student artifacts at the conclusion of the interview to help illustrate or exemplify what the teacher said in the interview. Because of privacy issues, I did not collect these artifacts. I simply recorded descriptions in my field notes. I also recorded field notes of each interview for relevant observations before, during, or after the interview not included in the protocol.

The original survey contains two items that are open response. One item asks teachers to provide reasons they did not check certain classroom subjects as content they teach in their classroom. Although this was originally intended as triangulation of their self-contained status, it also provided some interesting information about choices teachers make about providing science instruction. These were included in the qualitative analysis. The other asks teachers to provide any additional information about how they teach science in the second instructional methods item. Some of these details were used to classify teachers into traditional and non-traditional groups. However, there were several cases in which this data was useful for clarifying teacher practice in the analysis of the interview data.

A code book, memos, and diagrams were used to keep the research organized and current during the collection process (Corbin & Strauss, 2008). I also recorded field notes after each interview to help keep each interview in context and provide

additional clarification to the interview data. These tools helped me to more efficiently assign meaning to the emerging categories and themes during the analysis.

Qualitative Data Analysis

All interview data were transcribed and analyzed inductively for common patterns and themes (Shank, 2002). The unit of analysis for this study was the three profile groups created from the survey data using CPSIT and other variables. The data in each group were coded line-by-line for units of meaning associated with statements from the transcripts. Throughout the coding process constant comparison was employed to synthesize the codes into broader units of meaning. As the data were being coded, attention was focused on looking for patterns within and across participant responses in the profile (Corbin & Strauss, 2008). Using this process, categories were created that were eventually consolidated into common themes (Charmaz, 2006). This is an open process which is totally data dependent. However, it was also necessary to create theoretical connections between codes that ultimately resulted in themes relating to the research questions. The theoretical connections came from the theories associated with this study, primarily SDT but also self-efficacy and goal theories. The use of the SDT framework as a theoretical lens served to "ground" the data in a way that was useful for answering the research questions in a meaningful way (Ezzy, 2002; Glaser & Strauss, 1967).

As the data were being collected and analyzed, some discrepancies were revealed between the survey data and what was being discovered in the some of the teacher interviews, particularly regarding CPSIT. Most of these discrepancies were caused by changes to teaching schedules and assignments for certain teachers between

the time they took the survey and the time they were interviewed. This ultimately resulted in slightly different analysis groupings than had originally been assigned for participant selection. The original intent of the grouping variables was to attain maximum variation for the qualitative analysis. Based on the demographic and CPSIT variation obtained from the final group of interview participants, this goal was accomplished. The changes made to the profile groups for the final analysis did not affect the diversity of responses in any significant way. In two cases, it led to some new findings related to the research questions.

The seven themes that emerged from the data were contrasted across the three profile groups to look for similarities and differences. These themes are broad ideas, and are related in some way to elements of pertinent motivation theories from the literature review. Similarities and differences between groups were identified within each broad theme. For example, self-efficacy emerged as one theme, so the data were examined for differences in self-efficacy between groups. Distinct perception and practice differences were found between the high and low CPSIT groups on most of the themes. As expected based on previous studies of teacher attitude and practice with conflicting results, the middle group exhibited characteristics within the selected themes that were not totally consistent with a pattern matching CPSIT. Since this is an exploratory study, there was no a priori hypothesis about what connections between the profile groups might be. The goal was to look for data-driven, emerging patterns that might result in possible theoretical linkages explaining relationships found between teacher practice and autonomy perceptions (LeCompte & Preissle, 1993). The next step was then to determine if patterns could be more clearly explained using

the OIT continuum to closely examine teachers' autonomous motivation for science teaching.

In Self-determination Theory (SDT), autonomous motivation is a term used to describe an individual's perception of control versus autonomy within a given context. It manifests itself through three factors: locus of causality, volition, and choice. Respectively, these factors are the degree to which people feel their participation in an activity comes from: 1) an internal (personal) endorsement of the behavior; 2) freedom from pressure forcing them to participate in the activity; and 3) and the perception that they are truly the ones making the choices about how they participate in the activity. When all these conditions are met, people are experiencing autonomous motivation (Koestner, Otis, Powers, Pelletier, & Gagnon, 2008; Roth et al., 2007). When any or all of these perceptions are absent, people feel controlled and, therefore, perceive less autonomy. The degree to which these perceptions motivate people to participate in an activity is represented in the OIT continuum for externally regulated behavior. For purposes of this study, the activity being addressed is teaching science in elementary classrooms.

Using the finer grain of analysis provided by the OIT continuum, autonomous motivation categories related to each theme were determined for teachers within all three groups. The goal was to further clarify teaching behaviors in different groups regarding time spent on science instruction and teachers' endorsed pedagogy beliefs. Examination of different levels of extrinsically motivated teaching behavior was employed to consider teacher practice in a new way and determine if it could provide

new insight into ways to help teachers provide more robust science instruction in elementary grades

Triangulation. The data were triangulated in multiple ways to increase the validity of the study (Patton, 2002). The frequency and method data from the survey were triangulated using questions from the interview. These questions requested the same information that was gathered in the survey to provide a check on the accuracy of the profile groupings. This was used to ensure correct placement in the final profiles, confirming the validity of connections made in the cross-profile analysis.

Member checking was also employed for the interview data to verify that the meaning intended by the participant was understood by the researcher. During the interview process, I repeatedly restated or summarized what was said by the participant to ensure that the meaning they intended was understood. I also shared themes emerging from the study with the interview participants in order to determine whether their intent was captured.

Since the process of coding and theming is subjective, the coding and resulting themes were reviewed by another researcher for agreement and triangulation. An additional researcher also reviewed a set of interview transcripts and coded them independently, comparing them with my original codes to establish a check on the coding process.

I asked to look at classroom artifacts during interviews to triangulate what teachers said about their practice. Artifacts included lesson plans, learning organizers (worksheets, lab notebooks, exams, etc.), and student work produced in the classroom. I also made notes about the layout of the classroom and artifacts on the walls and other

places in the room that might give insight into teacher practice that could be compared with what was said in the interview.

In Chapter 4, the results of the data analysis are presented as they relate to the research questions. The quantitative data analysis is presented first with a description of how the data were used to create groups for interview selection. This is followed by the analysis of the qualitative data and resulting themes.

Chapter 4: Findings

Introduction

Chapter IV presents results of the analysis of quantitative and qualitative data from this study. In the first section, the quantitative research question is addressed and the participant selection grouping strategy resulting from the analysis is described. In the second section, adjustments made to the initial grouping strategy are explained. The definition and description of autonomous motivation used in the analysis are also provided. The two qualitative research questions are answered through thematic analysis of the qualitative data in the next section. A summary of the findings related to the research questions is presented in the final section.

Results of Quantitative Analysis and Participant Selection

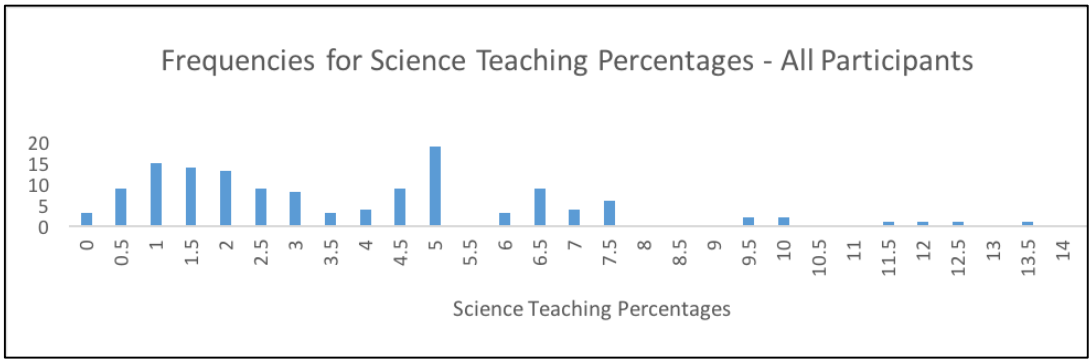
Distributions of the calculated percentage of science instructional time (CPSIT) from the survey taken by 136 elementary teachers provided a means for creating groups for participant selection for interviews in the qualitative phase of the study. These data were analyzed prior to participant selection to make groupings representing maximum variation in CPSIT.

Research Question 1: Percentage of Time Spent Teaching Science

In order to answer the research question, "*What percentage of time do elementary teachers in self-contained classrooms report devoting to science instruction?"* a frequency continuum for the CPSIT survey data was constructed to determine the range and distribution of teacher time devoted to science instruction. The CPSIT ranged from 0% to 13.5%. Patterns noted were that the majority of teachers (123 out of 136) in the sample spend less than 7% of their time on science

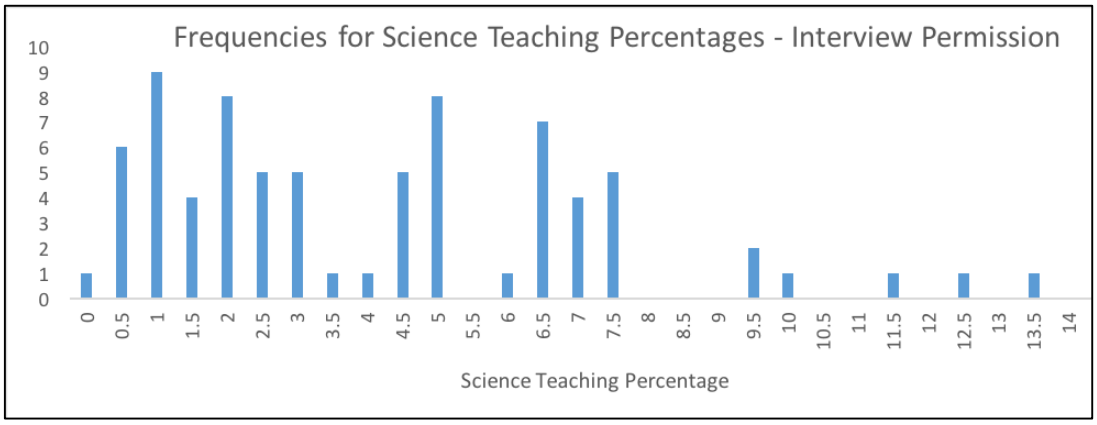
instruction and that the mode of the distribution is 5%, although a substantial number of teachers fall in the 1-2% range. The frequency data are shown in *Table 4-1*.

Table 4.1 - CPSIT Frequencies for Survey Participants



A separate distribution was also created for the 76 teachers who provided contact information for interviews. This distribution, shown in *Table 4-2*, mirrors the distribution of the overall sample. It was used to create groups for maximum variation in CPSIT, with the demographic variables of grade level, district size, teaching experience, and primary instruction method as secondary considerations.

Table 4.2 - CPSIT Frequencies for Teachers Providing Interview Permission



Grouping for Interview Participant Selection

Three CPSIT groups were initially created based on the following distribution of 76 participants who provided contact information: low (0-2%), medium (2.5-6.5%), and high (7-13.5%). Percentages were calculated at one decimal place and rounded to the nearest 0.5%. There were 28 teachers in the low group, 33 teachers in the medium group, and 15 teachers in the high group. The high group had fewer teachers but this reflects the overall distribution pattern of the sample. Teachers were contacted for interviews based on these groups, taking care to ensure that at least one person from each grade level and district size was represented. A lower than expected initial response rate to interview requests made it necessary to contact all 76 teachers which resulted in responses from 20 teachers who indicated they would be willing to schedule an interview. Interestingly, no kindergarten or 1st grade teachers agreed to participate, although originally 22 of them provided contact information. Notably, 55% of the K-1 teachers fell in the low CPSIT group.

Ultimately, 11 interviews were completed from the 20 teachers who responded affirmatively to arranging an interview. Four teachers from the original group of 20 subsequently declined to be interviewed due to various reasons. Five of the teachers were not interviewed because there were already interviews scheduled with teachers having similar CPSIT and demographic characteristics. A reasonable range of CPSIT was obtained from the group of 11 teachers, although the higher percentages in the continuum (above 7%) were slightly underrepresented in the interview sample due to low numbers at the high end of the continuum and fewer participants in the lower end of the continuum agreeing to provide interviews. *Table 4.3* shows the CPSIT numbers

of the final set of interviewees in ascending order, along with pseudonyms and salient demographic characteristics reported on the survey. The CPSIT of the sample ranged from 1.0% to 9.0%. Grades 2-5 were represented in the sample. It should be noted that 5 of the 11 teachers in the interview group teach 4th grade. However, when the K-1 teachers are excluded, 60% of the teachers providing contact information were 4th grade teachers. Districts from all three population size groups, a range of 0 to >20 years teaching experience, and both traditional and non-traditional primary instruction methodologies are represented in the selected qualitative sample.

Table 4.3 - Initial Grouping for Participant Interviews

Low

High

Pseudonym	CPSIT (%)	Grade Level	District Size	Teaching Experience (years)	Primary Instruction Method
Addie	1.0	5	Rural City	6-10	Non-traditional
Brooke	2.0	2	Large City	6-10	Non-traditional
Carol	4.0	4	Large City	0-2	Traditional
Diane	4.5	2	Rural City	3-5	Traditional
Ellen	5.0	4	Rural City	6-10	Traditional
Faith	5.0	4	Suburban City	3-5	Non-traditional
Gayle	6.5	4	Large City	6-10	Non-traditional
Hannah	7.0	4	Rural City	6-10	Non-traditional
Iris	7.0	3	Rural Town	3-5	Traditional
Jenna	7.0	5	Large City	3-5	Traditional
Kelly	9.0	5	Large City	>20	Non-traditional

Results of the Qualitative Analysis

Introduction

The qualitative interview data were analyzed inductively to generate themes related to the research questions. Data from each of the themes were analyzed to look for patterns occurring across the CPSIT continuum from low (1%) to high (13%). Observed patterns were used to answer the research questions and make inferences through the lens of self-determination theory (SDT) and its subtheory Organismic Integration Theory (OIT).

Final Grouping for Analysis

As previously mentioned in Chapter 3, it was discovered during the analysis of interview transcripts that some changes of science instruction hours and various contextual factors had occurred to the originally reported survey data from 6 of the 11 interview participants. These changes occurred between the time the surveys were taken at summer PD sessions and the start of a new school year. They were primarily related to new teaching assignments and district changes in adopted or prescribed curriculum. Two teachers were moved up one grade from the year before. Scheduling changes for three of the teachers resulted in a different amount of science instruction time than they had previously reported. This caused changes in their CPSIT numbers, all of them increases. Four teachers also changed from a textbook to a kit-based science curriculum. In some cases, the curriculum changes were associated with schedule changes that caused CPSIT numbers to increase. Another teacher was moved from a self-contained classroom to a departmentalized situation in the school year following the summer she took the survey, where she was teaching only science,

social studies, and some reading. This was an administrative adjustment that she did not request. Additionally, five teachers misreported their teaching experience in the survey by anywhere from 2-5 years. Since 4 of the 11 participants changed to a kit curriculum, this was added as a primary instruction method for the final sample statistics because the curriculum change was something mentioned frequently in their interview responses.

The corrected CPSIT and demographic results based on interview responses are shown in *Table 4.4*. Carol was moved from 3rd lowest to 3rd highest CPSIT. Her curriculum and teaching schedule were changed at the beginning of the school year and the amount of time she teaches science increased from 4% to 12%. Kelly and Jenna, who were at the top of the distribution, switched to a kit curriculum and also to a new schedule which resulted in increases in CPSIT. Jenna's number went from 7% to 13% and Kelly's increased from 9% to 12.5%. Both remained at the high end of the distribution, although Jenna moved up to the highest CPSIT. All participants who reported changes from their original survey data, were asked about their perceptions before and after the change was made. Their responses were noted accordingly and taken into consideration in the coding process.

Addie is the teacher who changed from a self-contained classroom to a departmentalized situation. She was asked to provide responses based on her perceptions from both self-contained and departmentalized perspectives. She was also asked about any changes in perception she experienced from one situation to the other. These differences were noted and reflected in the analysis. A CPSIT of 1% was

utilized for Addie from her self-contained survey results because it was not possible to calculate a new percentage for her as a departmentalized teacher.

Table 4.4 - CPSIT and Profile Data from Interview Participants
(Corrections Added from Interview Responses Are Highlighted in Gray)



Pseudonym	CPSIT (%)	Grade Level	Teaching Exp. (years)	Primary Instruction Method
Addie*	1.0	5	11	Teacher created
Brooke	2.0	2	7	Teacher created
Diane	4.5	3	7	Textbook
Ellen	5.0	5	11	Textbook
Faith	5.0	4	5	Teacher created
Gayle	6.5	4	8	Kit Curriculum
Hannah	7.0	4	7	Teacher created
Iris	7.0	3	6	Textbook
Carol	12.0	4	3	Kit Curriculum
Kelly	12.5	5	23	Kit Curriculum
Jenna	13.0	5	5	Kit Curriculum

*Addie changed from a self-contained classroom to a departmentalized configuration by the time she was interviewed.

Definition and Use of Autonomous Motivation as an Analytical Lens

Self-determination Theory (SDT) uses the distinction between motivation for individuals to act based on internal interests and values (intrinsic) or external factors and pressures (extrinsic) (Ryan & Deci, 2000) to explain human behavior. Intrinsic motivation is the inclination to act based on interest or enjoyment of the activity and represents complete autonomy (lack of external control). In a complex world of decisions and responsibilities, this ideal is seldom attained. More often our actions are motivated by factors external to the self, such as making a living, following rules, or seeking material or psychological rewards. These factors are perceived as controlling our behavior in some way and may keep us from acting purely out of interest or

enjoyment. Autonomous motivation is a term used to describe an individual's perception of the amount of autonomy or control they have over their actions within a specific situation. This is not a unitary construct. The SDT subtheory known as Organismic Integration Theory (OIT) proposes varying levels of extrinsic regulation and, accordingly, perceived autonomy that are increasingly more internalized. These levels are shown in *Table 4.5* below.

Table 4.5 - OIT Levels of Extrinsic Regulation

Level	Rationale	Autonomy Perception
External	Compliance, external rewards or punishments	High external control
Introjected	Ego-involvement, internal rewards or punishments	Moderate external control
Identified	Personal importance, deliberate valuing of an activity	Moderate internal control
Integrated	Self-awareness, incorporation into personal value system	High internal control

In this study, SDT and the OIT continuum are used as the analytical lens through which to assess differences between groups on their motivation to teach science and the choices they have about teaching it. The analysis compared patterns of autonomous motivation relating to autonomy versus control to the CPSIT continuum generated in the quantitative analysis. The goal was to determine if external motivation regulation patterns are related to teacher differences in perception and practice within the seven themes generated by the qualitative analysis.

Themes

Seven themes emerged from the analysis of the qualitative data. These themes are related to the research questions and reflect motivation constructs and issues

associated with elementary science teaching as detailed in Chapter II. These themes are briefly described in *Table 4.6.*

Table 4.6 - Study Themes

Theme	Description
Valuing of science	Perceived importance and instrumentality of science and science instruction by teachers and school communities
Perception of student ability	Teacher belief in student ability to succeed in learning science
Efficacy for science	Teacher belief about their science content and pedagogical abilities
Attitude toward effort required for science instruction	Teacher attitude toward preparation, instructional time, and curricular demands for science teaching
External factors affecting science instruction	District and school level mandates, responsibilities, and conditions affecting science instruction over which teachers have little control
Support for science instruction	Support provided for science instruction by administrators, colleagues and other stakeholders in the school community
Endorsement of student-centered learning in science	Teacher beliefs about science learning as a constructivist pursuit

Research Question 2: Relationship between Autonomous Motivation and CPSIT

In order to answer the question, "*Does elementary teachers' autonomous motivation for science teaching differ depending on the time they devote to science instruction? If so, how and why?,"* a continuum from lowest to highest CPSIT was created based on teachers' reported time spent on science instruction. In-depth interviews were conducted with each of the teachers to determine similarities and differences between the lower and higher end of the continuum related to their perceptions of autonomy within each of six of the identified themes: valuing of science, efficacy for science, perception of student ability, attitude toward effort required for science instruction, external factors affecting science instruction, and

support for science instruction. The seventh theme (endorsement of student-centered learning in science) was utilized to answer the third research question in a later section.

Theme: valuing of science. In order for an individual to be motivated to engage in a particular activity, it must have value for them in some way (Eccles & Wigfield, 2002). People might value an activity simply because they enjoy it, which indicates pure intrinsic motivation. A more common reason people engage in activities is because they feel it may be useful for them in some practical way. This is referred to as instrumentality, and is associated with varying levels of extrinsic motivation on the OIT continuum. The most controlling perception of instrumentality is the anticipation of a separable outcome (such as a reward), indicating external regulation. The next most controlling perception of instrumentality is the view that the activity is valuable for helping an individual avoid guilt or enhance (or maintain) self-esteem in the view of others, indicating introjected regulation. The least controlling (mostly internal) perception of instrumentality is the acceptance of the importance of the activity into the individual's belief system, which is manifested as identified regulation or integrated regulation. In the case of identified regulation, individuals deliberately value the activity and endorse it as part of their personal value system. Integrated regulation represents not only a deliberate valuing of the activity but also a more complete assimilation into the individual's self-identity (Ryan & Deci, 2000a).

Results. When asked how they feel about science as a discipline, most of the interview participants state with varying levels of enthusiasm that they like (or even

love) science or science teaching. However, the data show that the teachers with highest CPSIT seem more intrinsically motivated for teaching science than the others. Jenna (13% CPSIT) talks about how much she loves to teach science. It was her major in college and has always been her favorite subject. Kelly (12.5% CPSIT) is supposed to alternate teaching science and social studies in her schedule but says she prefers to teach science. She admits that, "Social studies kind of goes by the way because I like science." Carol (12%) also likes science but is not quite as enthusiastic in her endorsement. She says, "If I had to teach just straight-up science, I'd be fine with it. I like science."

Teachers with lower CPSIT often say they like to teach science for reasons other than simply loving science. Some say they like it because their students like it. Addie (1% CPSIT) says, "I do like to teach science, and I think it's mainly because the kids like to do science," although she prefers social studies over science and says math is her favorite subject. Iris (7% CPSIT) says, "It's not my favorite, but I do like it. I think it's important [for students]." Many of the teachers talk about not being in their comfort zone with science teaching. Diane (4.5% CPSIT) states, "It's not a topic that I would say I'm super comfortable with, but I do like science." Brooke (2% CPSIT) is an exception in this category. She comes from a family of science teachers and says she loved taking science courses in college and even took astronomy "for fun." Although she likes science and feels students learn best when exploring rather than reading, she is not providing them with very much science instruction. She talks about various barriers to her ability to do this and these surface within the support themes.

When asked specifically about the importance of adequate science instruction for students at their grade level, all participants indicate that they feel science is important for students. However, when pressed for additional information, most at the lower end of the CPSIT continuum say that science is important mostly because their students enjoy it. The most consistent reason given for this is that science is active or hands-on. A typical response comes from Diane (4.5% CPSIT), "My kids love science. They like experiments." These teachers seem to feel that science is "fun" for students, thus making it a novel experience they can provide as a change from the learning activities that are set forth in the curricula of other subjects involving reading and seat-work. Addie (1% CPSIT) states, "I think the kids enjoy science more than they enjoy anything else, partially probably because we don't have a science curriculum and they know it's more hands-on." The implication is that a "curriculum" is a book or a set of prescriptive learning activities that is less enjoyable for students because it is a more serious, or even boring, type of learning. It also implies that there are fewer restrictions on science instruction, so hands-on activities are acceptable, although maybe a bit less rigorous. Iris (7% CPSIT) says, "It (science) needs to be more fun and on the lighter side." She goes on to say that students can "get serious" about science later in high school. Gayle (6.5% CPSIT) feels that her students love science, but only when it's hands-on. "When we're doing science, if it's hands-on, they're completely engaged, loving it. When it is definitions or going over a section in the textbook, it is like pulling teeth." The teachers are focused on the activity itself as a motivator for students but do not make a case for the science itself within the activity as being something that engages students. Diane (4.5% CPSIT) does activities with

her students because she feels the hands-on approach makes a "bigger impression" on them and helps them to understand things they read in their textbook. The teachers with lower CPSIT appear to use science primarily to engage students without acknowledging it as being a necessary part of the process of doing real science and developing conceptual frameworks for science understanding. Its value seems to be more as a distraction or a reward than as a serious pedagogical strategy to attain science knowledge.

In contrast, the teachers with the highest CPSIT see science activities and investigations not only as enjoyable and engaging for students, but also as the most important way to provide students with the science instruction they need to attain mastery of science concepts. Jenna (13% CPSIT) describes setting a classroom climate for science that is focused on learning. "[Students] are so engaged in everything that we do. Every single thing we put together… we set the standards really early in the year. These are not toys. These are things that we're using for investigations." Kelly (12.5% CPSIT) feels she understands what her students need to learn in science and takes pride in the fact that students want to be in her class because of it. "I find that kids want to be in my class, because I'm the 'science lady'." Carol (12% CPSIT) states that it is her job to help students be prepared for science in middle and high school. "I think [teaching elementary science] is important, because if you wait until you get to middle school, you don't understand your basics and you can't move on."

Although all the teachers indicate they feel science is important, when asked about its importance in relation to other disciplines, specifically math and reading,

most on the lower end of the CPSIT continuum admit that they think science is the least important of the three. An observation provided by Ellen (5% CPSIT) is typical, "I think [students] need to know reading and math as a basis for everything." Some of these teachers express that science is important because it helps students do well in math and reading. Hannah (7% CPSIT) states, "I think science just gives them more focus, because what they're learning in science can also transfer over to the math. It makes them more detail-oriented."

Those on the higher end of the continuum seem less convinced of this. Rather than seeing it as a hierarchy, they see the disciplines as more entwined and look for opportunities to take advantage of this, often in the form of integration. Kelly (12.5% CPSIT) says, "If I can figure out how to get it in with my reading program, I'll kind of sneak it in because the reading now is a lot of text-based fact reading that ties real well into [science content areas]." Jenna (13.5% CPSIT) talks about using the reading materials that are integrated into her science kit curriculum, noting that, "We have done everything [including the reading materials in the kit curriculum] and my kids are so excited about science!" An interesting exception to the pattern is Faith (5% CPSIT) who thinks science may be even more important than reading and math. She says, "Well, you have to read, obviously. Can't get through life without reading. But I don't know. If you have the reading down, if you have the skill, do you necessarily need to know what a verb is? No." She highly values science instruction but has also found barriers to teaching it in her situation.

Connections to SDT. Since love of science alone is probably not sufficient for teachers with many teaching priorities to invest significant amounts of their time in

science instruction, they need to be motivated by something more external. One of these motivating factors could be in perceiving a value for significant others to whom they feel connected, in this case, students (Ryan & Deci, 2000a). The teachers in this sample all see science as important for their students. When examining the valuing of science and science teaching for these teachers, two different perceptions are apparent in their endorsement of the importance of science instruction for students.

Those at the lower end of the CPSIT continuum see science as something that is fun or engaging for their students. If the students enjoy this type of activity, it may be intrinsically motivating for them but it does not necessarily mean they are developing science conceptual understanding (Hubbard & Abell, 2005). The hands-on approach that teachers mention is associated with active learning, which is defined as anything students are asked to do in the classroom other than merely watching, listening, reading, or taking notes (Felder & Brent, 2009). Active learning does not necessarily involve the inductive or deductive approaches that are required to involve students in constructing their own knowledge in the way that science learning is prescribed by the current science standards (Lee, 2012). Just because students are doing hands-on learning does not necessarily mean they are doing a form of inquiry that requires making inferences, using evidence to construct explanations, or engaging in problem solving. When asked about how often they have their students use these higher-order skills for science activities, most of the teachers with lower CPSIT say they only do this occasionally. For example, Ellen (5%) says, "Not as much as I would like, no. Because of the timeframe on it, I mean, they work in groups to do things, but not so much." When it comes to their own motivation for having students

do hands-on activities, the teachers on the lower part of the continuum often seem to do it simply because having their students enjoy learning gives them a good feeling. This can be viewed as an introjected form of regulation which involves doing an activity for an internal reward, in this case receiving approval from your students or feeling good about providing them an opportunity to do something they love. It reflects moderate external control and, therefore, implies a lower amount of autonomy.

At the higher end of the CPSIT continuum, teachers are more focused on the "fun" as being a necessary element of conceptual understanding and engagement in scientific practices. This is more congruent with an internal value system which sees engagement as a necessary element of science learning. Although these teachers talk about how much their students love science, they also express how important it is for them to engage with what they observe and explore in a meaningful way. The descriptions of the learning experiences they provide their students include multiple ways of engaging them in scientific practices and conceptual development. When Jenna (13%) is asked how she expects her students to show what they have learned, she mentions using journals to gather their ideas and see how they are thinking. "They don't always know the right answers, but they can totally justify why they thought it worked that way." The teachers with higher CPSIT recognize and endorse the value in providing true inquiry experiences to their students. They see student enjoyment of the activity as a positive outcome of active learning. This reflects an external regulation pattern that is identified and represents moderate internal control which, therefore, signifies higher autonomy.

There is not a sharp distinction in the sample between low and high CPSIT, as evidenced by the fact that there are two teachers at the lower end of the continuum, Brooke and Faith, who seem to clearly endorse engaged and active science learning as having value for students beyond "fun." However, these teachers report other factors as barriers to providing what they feel is adequate science instruction for their students. External regulation in the OIT continuum is not a unitary construct, and the examination of other themes in this sample will be used to determine overall motivation patterns in the sample which may explain ways in which teacher perceptions of autonomy are either supported or thwarted.

Theme: efficacy for science. In order to feel autonomous, individuals must have a sense of competence, which includes a belief in one's ability to complete a task or succeed in a specific situation (Deci & Ryan, 2000). Since self-efficacy is a belief, it is internal and can influence behavior. When an individual feels competent, it affects the extent of internal regulation and provides a necessary condition for higher perceived autonomy directed toward an activity. When self-efficacy is low, an individual may perceive it as a threat which may discourage them from attempting an activity. Low efficacy for science content and pedagogy have been linked to the avoidance of science teaching by elementary teachers (Appleton, 2007; Joseph, 2010). In this study, teachers were asked about efficacy perceptions for both science content and science pedagogy. Both constructs were themed as 'efficacy for science' because the participants generally put them together in their responses even though they were asked about content and pedagogy separately. Connections between efficacy for science teaching and content knowledge have been reported but not confirmed in

science education literature (Knaggs & Sondergeld, 2015). Both types of efficacy address the overall competence aspect of SDT.

Results. The pattern from the data shows that the three teachers with the highest CPSIT have a stronger sense of self-efficacy for science than the rest of the group. Jenna (13%) has very high efficacy for science teaching. She is confident in her science content knowledge and considers science to be her forte. Though she does not consider herself an expert in science pedagogy, she is confident in her ability to provide her students with science instruction in multiple ways. "I could teach science all day, every day. My kids would eat it up… I could teach all the other subjects around science. I could teach my math around my science and [the students] would be perfectly happy. I could teach my reading, obviously, around my science." Kelly (12.5%) also feels comfortable with teaching science. Although she does not appear to be as sure of her content and pedagogy as Jenna, she is confident in her ability to do what needs to be done. She says, "I just kind of go for it. I know what's supposed to be on the test and it guides what I do." She adds, "If there is something I don't understand, we are going to learn it together." Kelly also feels validation for her science teaching methods because her students do well on the science test and score high compared to students in other classrooms and even other schools. Carol (12%) also professes confidence in her ability to teach science and talks about "using her brain" to figure out what her students need and how to provide it for them. She attributes this to her own past experiences in science, including her own elementary education. "I guess I was lucky that I did have good teachers to teach me when I was

younger. Like I said, I have never taken an education class for science, and I think that if I had not had good science classes, it would probably be very intimidating."

In contrast, the teachers with lower CPSIT indicate much lower self-efficacy levels. Four teachers (Diane, Hannah, Gayle, and Addie) admit to struggling with science teaching. Hannah (7%) says she is having trouble figuring out the standards and states that she does not have enough background to help her. She tries to learn as she goes. Gayle (6.5%) says she knows what she is supposed to teach but does not know how to teach it. Addie (1%) struggles with finding experiences for her students that apply to the standards. She says she "wishes somebody could just tell her what to do."

Other teachers provide different perspectives on their feelings of self-efficacy for science. Ellen (5%) would like to be a better science teacher but, when she goes to professional development, she leaves feeling bad about what she does not know. "I thought I [knew what I was doing] until I started going through the STEM program, and then I realized that I don't think broad enough or have enough [content knowledge]." Iris (7%) feels comfortable only with what she has done before, which is very little, and is also having trouble with the new standards. Brooke (2%) states that she feels "comfortable" in teaching science but she calls her science teaching a "hodge-podge" and admits she leans heavily on her teaching partner for guidance in science teaching because it is hard for her to keep up with the standards and the changing curriculum. This indicates her lack of confidence in pedagogy, even though she says she feels good about her science content knowledge. Faith (5%) does not

elaborate on her feelings of self-efficacy other than to state she feels very confident. Her focus seems to be on external barriers to her science teaching.

Connections to SDT: In general, the data reveal a pattern showing that teachers in the sample with higher CPSIT also exhibit higher levels of efficacy for science knowledge, science pedagogy, or both. According to SDT, individuals who have higher efficacy for an endeavor are more likely to experience autonomous motivation and will be more likely to attempt and persist in the undertaking because their perceived competence needs are being met (Vansteenkiste, Lens, & Deci, 2006). Teachers are more likely to pursue a mastery approach to teaching if they perceive higher levels of competence (Ciani, Sheldon, Hippert, & Easter, 2011; Maehr & Zusho, 2009).

Overall, teachers with lower CPSIT exhibit lower levels of efficacy for science knowledge and pedagogy than the higher CPSIT teachers. Although their low efficacy may keep them from placing science instruction as a major priority, many of them express regret or even resentment (e.g., Faith) at the inability to do more science with their students. Several teachers talk about "doing the best they can" in their situation to give their students opportunities to learn science. Although their efficacy may be a controlling factor (albeit internal) for them, their valuing of science for their students is in conflict with this perception. It is likely that efficacy is not the only factor affecting their sense of autonomy. Other themes from the study shed light on some of these factors.

Theme: Perception of student ability. The data show differences in teacher beliefs about their students' ability to do science, especially regarding the expectations

in the new science standards. An underlying principle of the new standards is that science should be learned, taught, and assessed through three integrated dimensions, scientific and engineering practices, interdisciplinary crosscutting concepts, and disciplinary core ideas (NRC, 2011). This integrated learning approach necessitates a more inquiry-oriented instructional approach involving active investigation, construction of scientific explanations, and learning strategies that engage students in the process of science to make sense of interactions between elements of the natural world. It represents a constructivist view of science teaching and involves a significant shift in pedagogical practice, especially for those who have been using traditional methods in the classroom such as reading textbooks and answering questions or taking lecture notes. It involves a more student-centered approach to instruction in which students must take a more active role in their learning, while the teacher acts more as a facilitator (Bransford, Brown, & Cocking, 2000). As teachers struggle to implement the new standards using new teaching methods, they may hold certain beliefs about their students' ability to learn in these conditions (Turner, Meyer, & Christensen, 2009). These beliefs may affect their motivation to embrace or even try to give students more control of their own learning.

Results. The overall pattern in the data shows that teachers with lower CPSIT have more negative beliefs about their students' learning ability in science than teachers with the highest CPSIT. Some of these beliefs relate to students' ability to learn science concepts and vocabulary. Others relate to students' ability to participate in and learn from activities that are active and have less structure than traditional reading and seat work.

Some teachers with lower CPSIT feel their students are unable to handle the rigor of science because their reading and math skills are below what they should be at their grade level. Addie (1%) says her students have low vocabulary skills and she thinks this explains why they have trouble learning science. Ellen (5%) thinks that "we go sometimes too deep into some concepts that make it difficult for kids to learn." She skips around the textbook when she does science to avoid exposing students to this. Hannah (7%) reports that her students are very "low" in math, so integrating with science is not an option for her.

Gayle (6.5%) thinks that even activities from her curriculum kit are too hard for her students. She states, "There was one activity where they had to build basically the components of the earth with the soil, then the next layer, then the next layer, and layer it up. My kids that are struggling readers and struggling intelligence-wise, they couldn't do it." When asked if the activities could be done in a different way so students could understand them she says, "It would take some work by someone over the summer to kind of take the activities and figure out how that could be done easier for kids who are struggling and harder for those that are really talented." She ties the success of the activities to her students' abilities and attributes their inability to succeed to the difficulty of the activity rather than seeing her role as a teacher to look for ways to engage students at different levels within the same activity. She feels "someone" else should fix the activities.

Even those who feel their students have the capability to learn science perceive barriers to learning related to their ability or intelligence. Iris (7%), whose primary methodology is the textbook, does not really think her students can learn that much

from reading. "Expecting the little kids to just sit and even listen to you talk for a long period of time, or even just to sit and read the chapter, you know, they get tired of it. They just aren't meant to sit that long." She says she sometimes provides them with hands-on learning activities so they can "experiment and play with stuff" to give them variety, although she does not really think students need to know that much about science in 3rd grade. Still, she feels reading is the most important learning approach. She goes on to say, "There are some things you just need to read actual facts about. You know, look at pictures and things like that?"

Many of the teachers, even some who have more optimistic beliefs about student ability, express that their students are unable to handle the distraction of activities that are more open-ended which provide students with varying levels of choice. They do not seem to feel that classroom management is the problem, and attribute failures in attempting active learning to their students' need for high structure. Brooke (2%) only does hands-on activities when she thinks her students can "handle it." She says, "Whenever I taught in Texas… we did a lot more, but they could handle it. I think this class will be able to handle it in a couple of months. My group last year, they couldn't. We did probably five or six things that were kind of hands-on like, but they couldn't handle it." Even Carol (12%), who has higher CPSIT, says regarding her current students, "These kids can't handle open learning. They need a lot of structure just because of 'the way they are'." She generally keeps her science activities very guided and does not do much open-ended inquiry.

The teachers with the highest CPSIT feel their students can learn science content and feel that the inquiry approach is the best way to do it. Classroom

management is not a problem for them. When asked if she feels her students are capable of learning science through the 3-dimensions of the standards, Jenna (13%) states, "Definitely. As long as it's got those hands-on components where they're not just reading it. When they get to experiment with those things, they totally get it." Kelly (12.5%) feels her students are capable of active learning and says, "The classroom management is not a problem, because students will do anything to be a part of that experiment… You have to give up a little bit of control and trust that your kids can do the right thing. And they do."

Connections to SDT. Teacher beliefs influence their perceptions, including those about the abilities of their students. This can result in different effects on their teaching practice (Nespor, 1987; Pajares, 1992; Jones & Carter, 2007). Within the complex web of science teaching, where beliefs and practices interact, every aspect of instruction can be affected, including instructional choices (Keys & Bryan, 2001). Teachers see student ability as an asset but they may also perceive it as a challenge or barrier to learning. This has been shown to be significant in the implementation of student-centered teaching methods (Buehl & Beck, 2014). Savasci and Berlin (2012) found evidence to show that teachers are more likely to use constructivist teaching methods with higher ability students than with those they perceive as having lower ability. These perceptions were reported as a significant constraint to practice. The findings in this study are congruent with those of Savasci and Berlin. The teachers with lower CPSIT perceive their students' lack of ability, age, and prior knowledge to be a barrier to their ability to learn with an inquiry-type approach, even though most of them say they think it is a better way to learn science.

From an SDT perspective, it could be said that the teachers are perceiving the low academic ability of their students as a barrier to using a more constructivist approach in science. This is an external factor that is hindering their perceived autonomy. This type of motivation is more controlling and falls into the category of external regulation. It may provide a reason (or even an excuse) for avoiding science instruction.

Some teachers may also feel that science is a difficult subject no matter what methodology is used to teach it. It may be that the perception that science is too hard for their students is really a reflection of the teachers' perception of the difficulty of science. Ellen (5%) provides some insight into this possibility. She thinks there are some things elementary students cannot learn and uses the current chemistry unit she is teaching as an example. She says,

> I think, yeah, that it is too difficult for the kids. I think it's too involved. I think we need to kind of maybe change that a little. And that may just be me, because it's kind of difficult for me to even teach, so maybe I'm thinking of it more about myself instead of the kids.

Even though she feels the concept is too hard for students, she is still teaching it because it is part of the textbook curriculum. This reflects a perception of high control and external regulation because the motivating factor is compliance. The teacher perceives low autonomy. This also relates to competence because the teacher has low efficacy for the chemistry topic. When competence needs are not addressed, low perceived autonomy results and has the potential to affect the way the teacher approaches science instruction. It is not apparent from the data that this is true for all

the teachers, but it is likely that some of the other teachers with a lower sense of efficacy feel this way.

In this sample, the two teachers with the highest CPSIT have a positive view of their students' ability to learn science through hands-on, inquiry-type instruction. This fits the developing pattern relating CPSIT to teacher perceived autonomy. However, as with the previous themes, there are exceptions to the pattern. From the lower end of the continuum, Faith (5%) is confident that her students can learn science concepts. She talks about how students are always surprising her with how much they can learn but she also feels that they have trouble expressing it in writing. She states,

> I think that they surprise me sometimes, but it's having them put it on a piece of paper. They lose that. They have so many things going on in their brain, that they can share a lot easier [verbally] than they can write it down right away.

While she sees their writing ability as a barrier to students expressing their learning, she does not see it as keeping them from learning science concepts. She simply assesses it in a different way. Carol (12%) who has one of the higher CPSIT numbers, is not at all confident in the ability of her students to handle open inquiry. Rather than back away from teaching science, she finds ways to scaffold it to minimize the ambiguity and make it fit their need for structure. Both these teachers work to overcome barriers that their perception of students' ability might otherwise cause them to think about offering fewer opportunities for science learning.

Theme: attitude toward effort required for science instruction. It is commonly understood that the conceptual teaching of science using hands-on methods

requires some extra time for setup, cleaning, procurement, and storage of materials. Teachers may also feel that science instruction involves extra effort for a variety of individual reasons. The attitude toward this extra effort can vary from teacher to teacher. It has been shown that teachers often make instructional decisions based on their beliefs about the demands it will put on them as teachers rather than on student needs (Jones & Carter, 2007). The extent to which teachers see this effort as an external barrier to science teaching may translate into differing perceptions regarding their autonomous motivation for science teaching.

Results. In general, most of the teachers with lower CPSIT perceive the effort needed to teach science as a barrier to their ability to teach science. The teachers with the highest CPSIT acknowledge that extra effort is required, but do not seem to perceive it as an obstacle to their ability to provide science instruction. In some cases, teachers talk about ways they try to overcome the difficulties they encounter in finding time and energy for the extras required to teach a hands-on curriculum.

Although Addie (1%) managed to pull together a lot of resources for teaching science when she became departmentalized, she finds that managing, sorting, and selecting which resources to use is overwhelming for her. Consequently, she has not used very many of them. "It's still a matter of coming [to where they are stored], finding them, and matching them all up. It's really exhausting." Diane (4.5%) says that lesson preparation and resources are the things she hates most about science teaching. After school is the only time she has for preparation and she does not feel she should have to sacrifice her personal time to get ready for science activities. She states, "I've got two kids. I've got to go home at 4:00 and start dinner, and it just

doesn't happen like that." Gayle (6.5%) has a new kit curriculum with all the supplies she needs, but she is required to share it with another teacher. She resents having to do this and is finding it difficult to get access to what she needs from the kit to meet her teaching timeline. She became so frustrated that she finally purchased (with her own money) a curriculum at a teacher supply store that has worksheets and tests she can give her students so she does not have to look for supplies. She views this as overcoming a barrier, but it appears to be more of a way to avoid teaching a curriculum with which she admits she is struggling.

Another common category related to effort for science instruction is time. There is the time it takes for preparation, but teachers also talk simply about lack of time to teach science. This manifests in several ways. Some teachers are overwhelmed by the time it takes to plan science instruction. Diane (4.5%) feels it takes too much time to plan for integrating science with reading on top of all the planning she must do for the reading activities themselves. Addie (1%) tries to plan with another teacher who is a coach. She says, "Even doing the science lesson plans are exhausting. You have to find time after school to do them together." She goes on to say, "We can do our social studies plan in like, 30 seconds for a whole week and it takes three hours for science because we have to look at the skills and figure out which ones we should teach." She does not have a clear understanding of how to match science standards with instruction, likely due to the recent introduction of new standards and her lack of efficacy for science pedagogy. Other teachers are concerned with the fact that hands-on teaching requires more class time than traditional textbook or worksheet curricula. Additionally, inquiry-type science instruction cannot

generally be assessed with a traditional multiple choice format. It involves ongoing formative assessment and the use of rubrics for written work or journals. This requires extra time and effort. Gayle (6.5%) feels that grading journals is overwhelming, especially when the students have the wrong answers. She thinks the worksheets she had with her textbook were much easier to grade.

The three teachers who are on the highest end of the CPSIT spectrum each have a science kit curriculum. They feel they have the resources they need to successfully teach science. Kelly (12.5%) acknowledges that the science kits take some extra time but manages to do what she needs to do with them in the time she is allotted. She says. "I'd like to have more time with it, but you know, it's what I've got." Jenna (13%) is very willing to put in extra effort for science instruction and is frustrated with other teachers who are not willing to do the same. She feels other teachers are not even trying to use the curriculum even though the opportunity is there.

> "[The other teachers] are not even opening those kits. They don't even know what's in them. I was like, I could actually show you what's in here, and then it's becomes a time constraint. 'Where are we gonna do this?' 'You mean we have to volunteer to stay after school one day?' Do you think anyone wants to stay after school one day?"

Her goal for next year as science chair is to get all the teachers using the kits. Carol (12%) was not able to get as much of her curriculum covered as she would have liked but she still feels that she has provided her students with a good experience in science and has learned what to do next year to improve on her implementation of the kits for her next students. She feels that there are always challenges with the implementation

of a new curriculum. "With anything, your first year, you try the best you can. But you don't know how it works. You haven't figured out your flow with it yet."

All three of the high CPSIT teachers describe ways of going beyond the minimum for their science duties. Carol (12%) felt sorry for her students last year because all they had for science was a textbook and worksheets, which she was required to do in science. "I did some research online to try to make it as much fun as I could, but my kids were so bored. I felt so bad for them…and even for me. I remember science. It was pretty much all hands-on when I was growing up and going to school." Kelly (12.5%) does a "Science Day" every year so kids who are in other classes where they get no science can experience some science learning.

Connections to SDT. Although every teacher in the sample feels that hands-on science instruction requires some extra effort, those who have the highest CPSIT accept this as part of the territory for providing good science instruction for their students and do not feel constrained by the extra effort. They are willing to put forth this effort, and often go beyond because they feel it has value for their students. This reflects a more intrinsic approach to their science teaching. It can be described as an internal perception of autonomy, showing that these teachers perceive personal importance and deliberate valuing of inquiry-type instruction for their students and indicating at least identified regulation on the OIT continuum. This sense of autonomy allows them to persist and find value in their science teaching even though there are certain constraints that must be accepted or overcome.

On the other hand, teachers with lower CPSIT perceive the extra effort as a barrier to inquiry-type instruction, even though they might feel that it would be good

for their students. Since the effort is a barrier they see it as controlling. This is consistent with a more external perception of control. They see the effort as keeping them from being able to teach in a more constructivist way which obstructs their sense of autonomy which drives them to avoid or say they are unable to teach science.

Once again, the exception to the pattern is Faith (5%). She does not see the extra effort as a barrier and tries to overcome it. However, she feels a sense of external control in other ways which results in few opportunities for her to teach science to the extent she would like. She says, "If I had more time in the day, I'd probably do more [science]." She talks about spending part of her summer with a colleague at another school to put together a curriculum that aligns with the new science standards. "We took our new science standards, kind of pieced them apart as best we could, just printed them off, because we had never seen them before, and then we went through and found activities and STEM things that went along with each standard, and that's what I'm teaching to them."

Theme: external factors affecting science instruction. This theme encompasses a variety of aspects related to the way elementary schools operate, including mandates, initiatives, and resources. The three specific areas that teachers mention most are: materials and curricula for teaching science, priorities related to mandated state testing, and implementation of new science standards. These are all things generally required by an outside entity as a condition for schools to function and even receive funding. They drive the way schools are run and influence aspects of schooling that dictate how teachers do their jobs. One of the most important of these is scheduling. The schedule teachers are asked to follow considers priorities

determined by state mandates and their interpretation by individual school administrations. In its most basic form, the amount of time allotted for and placement of different content areas in the schedule reflects these priorities (McLeod, Fisher, & Hoover, 2003). It directly influences the amount of time teachers have for teaching science. In this study, teachers are asked about these factors in relation to their science teaching.

Results. Teachers were asked specifically how their science time is scheduled for them. They were also asked to talk about other types of mandates and resource availability for science. Many of the teachers expressed how these factors affect their science teaching practices.

Schedules. All but two of the participants reported that they have a specific time in their schedules allotted for science. The length of scheduled time ranges from 30 minutes to 90 minutes. This amount is important because it dictates the extent to which teachers can provide students the opportunity to examine concepts in-depth or provide hands-on labs to explore scientific ideas. Lab activities often take longer than other types of activities. Science is scheduled daily in some schools and a specified number of days per week in others. Science is also scheduled at different times of the day in different schools. Teachers gave detailed descriptions during their interviews to explain how their science time is scheduled. These can be found in condensed form in *Table 4.7*.

Table 4.7 - Time Schedules for Science Instruction

Teacher	Length of Science Class (minutes)	Number of Days per Week	Alternates with Social Studies	Time of Day
Addie (self-contained) (1%)	60	1 per month	N/A	Not specified
Addie (after departmentalization)	90	2-3	Yes	Multiple times
Brooke (2%)	Only if there is left over time		N/A	End of the day
Diane (4.5%)	35	4	No	End of the day
Ellen (5%)	30	3	Yes	End of the day
Faith (5%)	60 minutes to finish what did not get done during the day and also to do science, and social studies		Yes	End of the day
Gayle (6.5%)	45	2	Yes	Afternoon
Hannah (7%)	45	2	No	Morning
Iris (7%)	45	2-3	Yes	Right after lunch
Carol (previous year) (4%)	60	1	Yes	Not specified
Carol (current year) (12%)	90	2-3	Yes	Not specified
Kelly (12.5%)	30-60	5	No	Afternoon
Jenna (13%)	60	5	No	Not specified

There are several noticeable patterns in the data. Obviously, increasing total science teaching time is noted from the top to the bottom of the table, as is reflected by the grouping variable for the study, operationalized as CPSIT. It is also worth noting that most of the teachers with the lowest CPSIT are required to alternate teaching science and social studies in the same time block. Other subjects generally have their own specified block of time occurring every day. This implies that the administrators who create the schedules place a lower value on science and social studies than they do on other subjects. The two teachers who do not alternate science and social studies are required to teach science in their math block. Hannah (7%) is supposed to

integrate science and math but she does not do this very often. She says, "Right now, I'm teaching science and math separate, because [my students] are so low with the math." She says she tries to teach science two times a week but "that's just trying to fit in the science." In Brooke's (2%) school, the last 60 minutes of the day are allotted to math. The teachers are told they should do science and social studies "only if they have time" at the end of that hour. This means that she does not get to do science (or social studies) very often.

An interesting pattern occurs in the length of time that science is taught in a single day. If we think of Addie as an exception because of her change from a self-contained to departmentalized classroom, we see that as the CPSIT goes from lower to higher, the amount of time scheduled for science in a single day increases. This means that the teachers at the higher end of the continuum are likely to have the most time available for lab activities and in-depth learning with their students. This takes away a barrier for inquiry-type learning, which generally takes additional time. It also provides them with instructional continuity because they teach science every day.

Another pattern is that the teachers on the lower end of the continuum are scheduled to teach science at the end of the day. The teachers provide evidence that this implies a lower prioritization of science by the administration. Brooke (2%), Diane (4.5%), and Ellen (5%) talk about how science gets crowded out because it occurs at the end of the day. Lots of things happen at the end of the day in an elementary school that are necessary for wrapping up and getting students ready to leave so they can be where they need to be to arrive safely home with all their belongings. Diane talks about the rush at the end of the day. Her science teaching

time starts at 2:55 PM. She states, "I'm very particular. About 3:15, we have to shut everything down to leave by 3:30 because I've got to have everything clean and organized." This reveals that, in fact, her science time usually lasts only about 20 minutes when she teaches it. Brooke says, "If we do our math and science and then pack the backpacks, they miss their bus. So, they have to pack their backpacks, and then we can have more instruction, even though [it makes them] think school's over." Ellen says, "[Because it is at the end of the day] I really don't think they get enough hands-on activities and enough time in science to actually understand the concepts that we're expected to teach." CPSIT is calculated from teachers' report of their science schedule. For teachers who have science scheduled at the end of the day, it may be that the actual percentage of their total science teaching time is less than the reported CPSIT.

It is worth noting that administrators in the low CPSIT schools often choose to use the time scheduled for science to do test preparation or to pull students out for remedial instruction. Five of the teachers with lower CPSIT report that this happens in their classroom, which takes away time for all students to receive science instruction. Iris also talks about how often all her students are pulled out of her class in the afternoon so she never gets to do science at the end of the day. "Our afternoons, just with our schedule, we've got pull-outs for computer and art. Computer twice a week, library once a week, art once a week, and you know, I just don't get to science sometimes."

New science standards. As mentioned earlier, the new science standards are considerably different from those that were previously utilized because they focus on

the integration of science content with scientific practices and crosscutting interdisciplinary science concepts (3-dimensional learning) rather than content and process as separate components. The new standards went into effect in the 2014-15 school year and will be assessed for the first time at the end of the 2016-17 school year. The interviews were completed before the assessment year but within the time that the new standards came into effect. At that time, teachers were just beginning to have experience with teaching under the new standards. Since the new standards exhibit major differences from the previous standards, even the most experienced teachers find themselves grappling with ways to implement them into their teaching. In the interview, many teachers talk about their response to the new standards.

There is no specific pattern in the CPSIT continuum regarding teacher perceptions of the new standards. Several of the teachers admit they are not very familiar with the new standards. Kelly (12.5%) says she has read them but states, "I am not sure what I am doing." When asked if she is familiar with the new 2nd grade science standards, Brooke (2%) replies, "A little bit." Gayle (6.5%) and Addie (1%) still use the old standards. Addie admits, "It was easier to go back to the old standards, because I can hit those skills with what we have available to work with." Ellen (5%) tries to address the standards by "skipping around" to different places in the textbook.

Teachers seem to have different levels of concern when it comes to the integration of the new standards. The data show that many of the teachers are struggling, but most say they are trying to figure out ways to implement the new standards. Hannah (7%) concedes that she has trouble figuring out what she is

supposed to teach from the new standards but thinks they are important for justifying what she is doing in the classroom. In terms of SDT, she is exhibiting introjected regulation because she finds it necessary to justify her teaching practice to her principal. Faith (5%) reports the most success with understanding and aligning activities to the standards. She thinks it is important for her to do this since she does not have a lot of time to teach science. In terms of SDT, Faith is showing more autonomous regulation because she thinks science is important for her students and is exerting effort to be sure they get what they need in the little time she has available to teach science.

Mandated state testing. High stakes end-of-year testing is frequently referred to in the interview data. In Oklahoma, reading and mathematics are tested each year. Additionally, the 3rd grade reading test has a higher risk value because, by state law, students are not allowed to move to 4th grade unless they score 'proficient' on this test. The math and reading tests scores are aggregated by school and grade level and count toward Academic Performance Index (API), a metric which is used to determine if schools are successfully educating their students for purposes of federal funding and state school ratings. Science is tested at 5th grade only, and the state does not use this score for API. This obviously has implications for prioritization of different content areas in schools.

The data in this study show that teachers consider state-mandated testing to be an important driver of educational priorities, climate, and learning culture in their schools. Without exception, all the teachers express the feeling that testing has pushed science into the background in their school. Addie (1%), who is a 5th grade teacher,

talks about feeling pressure to raise math and reading scores but does not feel the same pressure for science since it does not "count" for API and statewide school ratings. Many other teachers express this same view. Gayle (6.5%), a 4th grade teacher, says the students come to her with very little science background. She says, "Third grade has to focus so much on that reading test that the students don't get a lot of the science knowledge that they need. I feel like I have to start from scratch with them in science every year." Several teachers report that test preparation is built into their schedule in its own required time slot, taking away from instructional time.

Clearly, the state mandated tests pose a barrier to science instruction and manifest themselves as externally controlling elements from an SDT standpoint for most elementary teachers. A small glimmer of more autonomous motivation for science teaching is shown by teachers with the highest CPSIT. When Jenna (13%) is asked if she thinks testing pressure affects the way she teaches science, she replies, "Not me, because I integrate. I can add science anywhere, but it takes creativity." Carol (12%) says she has found that the administrators are so preoccupied and overwhelmed with juggling mandates that she has a lot of freedom to do what she wants in science because they do not necessarily pay attention to it. Although this reflects a lack of support for science teaching, it also allows her to teach science more often if she thinks it is necessary.

Curricula and materials for science teaching. For purposes of this study, a curriculum refers to the "means and materials with which students will interact for the purpose of achieving identified educational outcomes" (Ebert, Ebert, & Bentley, 2013). This includes textbooks, activity and lab materials, science kits, teacher guides,

pacing guides, or lesson plans or provided by the district. It also includes resources teachers gather from the internet or other sources and materials they pay for themselves to use in the classroom. Textbooks are usually purchased by the district as part of a curriculum adoption. Some textbooks come with lab materials and others do not. Some districts purchase materials for science investigations and others do not. It is not uncommon for elementary science teachers to put together their own curricula, with or without the help of the district. Logically, teachers who wish to provide hands-on experiences such as those indicated in 3-dimensional learning need to have materials available to them that can be used to engage their students in the practice of science. It is also important for the curriculum they employ to be aligned to the science standards. Since the standards are so new, it is currently difficult to find high-quality, standards-aligned curriculum that can be purchased by districts. This means that teachers are often left to their own devices in finding activities that align with the standards. This is a very important consideration for teachers to be able to teach science and can be viewed as either a barrier or a support to their science teaching endeavors.

A noticeable pattern that emerged from the data is that teachers with the highest CPSIT in this sample have science kits as their curriculum. These teachers are all from a school district that recently adopted and paid for a kit curriculum for every elementary school, grades K-5. The science kits provide almost everything teachers need to implement the curriculum. This includes a detailed teacher guide, materials for a class of 32 students, online resources, reading materials aligned to the activities, and professional development opportunities to learn about the curriculum.

Additionally, the kits are aligned to the new standards. This contrasts with the lower CPSIT teachers who have outdated textbooks and limited access to standards-aligned curricula.

The lower CPSIT teachers are all trying to provide some level of hands-on science activities for their students because they feel it has value for their students in terms of engagement and enjoyment, exposure to the scientific practices in the standards, or both. Even those using text books try to find ways to do some hands-on activities. Both Brooke (2%) and Ellen (5%) rely heavily on the science fair to ensure their students are exposed to science. They do this because they have limited access to resources but mostly because it is something their principals mandate. Even though it is not standards-based instruction, they count it as science instruction because it is what their principals want to see. Brooke notes,

> [My principal] really likes for us to do the science fair. All the older kids in our school are required to have an exhibit in the science fair. And then she likes for the younger ones to have a classroom experiment. If they want to do an individual, they can, but she likes for my class to have a class experiment.

Ellen's principal also requires all students to do the science fair. She says she tries to help them make connections to the "scientific method" in class during the time they are working on their projects but admits that that does not involve much class time. She says, "To be honest, on the science fair, most of it is being done outside of school, the experiment of it and all." She does not give science tests because they only have 30 minutes for science and that would take up too much time. She uses the textbook during her science time because activities take too long and she really does not have

many materials for activities anyway. She states, "We don't have 'stuff.' We were watching [experiments] on YouTube, but they [administration] have shut YouTube down now, so we can't even do that." These teachers are working under a perception of high control and their actions represent external regulation rather than autonomy.

Every teacher in the lower CPSIT grouping says they often buy their own materials for science activities. The reason they give for doing this is that the school will not pay for supplies and that their students will not be able to do activities unless they buy supplies for them. It is a barrier to science teaching and provides them with a reason for avoiding science. An interesting perspective comes from Iris (7%) who has a textbook curriculum. She thinks it is her responsibility to pay for extra materials if she wants to use them for science. When asked if she has ever requested the school to pay for materials she says, "I haven't asked for anything? If it's extra, I feel like I should pay for it to do it, you know? If I want to do an experiment, it's not really [part of the curriculum]." She very seldom does hands-on activities and seems to have internalized this reasoning because she may feel highly controlled in this aspect of science teaching. On the other hand, Faith (5%) asked her principal for some materials for science activities and was told, "You have a textbook. You can use that." She bought her own materials and did the activities anyway. She almost never uses the textbook. She feels she can get away with this because nobody notices. She says, "Nobody cares about science. They don't necessarily know that I'm not using the textbook." Although she has a controlling perception of her situation, she feels empowered because she is not too worried about getting in trouble because she is situated in way that they will not know what she is doing. It takes away a bit of the

control and moves her into the area of higher autonomy, but for the wrong reasons. This falls in a "fuzzy" area between introjected and identified regulation. She wants to avoid getting in trouble but convinces herself that she can get away with it simply because she has up to this point. She attributes this to the external factor that nobody in power cares about this aspect of her teaching.

Some of the low CPSIT teachers talk about "scavenging" for science supplies that have been stashed in various places in the school over the years. This strategy works well for getting a collection of random supplies. Addie (1%), who went from teaching no science the previous year to teaching only science the next year, enlisted the help of her custodian to sneak supplies into her room from other places in the school. The problem was figuring out which of these supplies she really needed to go with activities that address the standards. "We stayed until about 6:00 one night and just kind of randomly chose things. 'We think we'll use that. We don't think we'll use that.' Essentially, just to get [anything that might work]." While this is very resourceful, the fact that she felt she was "sneaking around" to do it indicates external control. Much like Faith, she is trying to avoid being told she cannot do it.

Another threat to science instruction frequently mentioned by teachers is the mutable nature of district curriculum initiatives. Brooke (2%) sums it up by saying, "You know educators. They just jump on the newest bandwagon of whatever works for one district. Then they decide we are all going to do it." This perception is very controlling because it keeps teachers from fully embracing anything new such as new standards, constructivist teaching methods, or new curricula. Brooke indicates she has no confidence that any new district mandates will last or be supported for any length

of time. Gayle (6.5%) is one of the teachers with a new kit curriculum and worries about what will happen if the district does not replace supplies that are used up in the kits so they can be used again. She feels that the district never follows through on anything they start and there is no stability in the administration. These perceptions do not come out of nowhere. They are reinforced by seeing initiatives pushed on them that come and go that either did not work or were given no chance to succeed (Murphy, 2014).

While textbooks not aligned to the new standards, lack of supplies, and lack of district-provided activities are perceived as threats or barriers to science instruction for the low CPSIT teachers, teachers on the highest end of the CPSIT continuum do not feel they need to struggle with curricular issues because their science kits have everything they need to provide activities for their students that are aligned with the standards. They see their curriculum as a supporting factor for giving students what they need to learn science rather than as a barrier. Jenna (13%), who was required to use a textbook the previous year says she teaches much more science this year than before. She feels the kit curriculum reflects what she has learned in professional development about good science teaching and has no need for anything to supplement it as she did last year with the textbook. She says, "When I make my lesson plans, I copy and paste from the web resources for the kit curriculum." Kelly (12.5%) talks about having to provide her own materials in previous years to do what she needed to do but says, "Now we have kits so we don't have to buy everything." Carol (12%) made her students do science the year before even though they "hated" the textbook because she thinks it is important for them to have science and that was all she had.

She is thrilled to have the kit curriculum. Her CPSIT was 4% when she took the survey after teaching the previous year. It jumped to 12% by the time she was interviewed in the next school year after the kits were adopted in her school. The data show that curriculum is clearly an important factor for helping teachers increase their science teaching time.

SDT connections. The factors from this theme are perceived in different ways by the teachers. From an SDT perspective, they are mostly external and, therefore, have the potential to pose a threat to teachers' ability to do science instruction and thwart their sense of autonomy. The results show that each of the factors has an inhibiting and a supportive aspect, depending on context and approach. Using CPSIT as an indicator to examine differences, there is a general pattern that emerges regarding the controlling or supportive aspects of each factor, with those at the lower end of the continuum perceiving threats and barriers while those at the highest end feel less threatened and even in some cases supported because of conditions in their school.

In a national survey of over 7,500 science and mathematics teachers, Banilower et al. (2013) identified factors that promote or inhibit science instruction. Among these were the importance the school places on science instruction, testing/accountability policies, and the management of curricular materials. The data on external factors in this study bear this out. The scheduling patterns examined in these schools say a great deal about the differences in the valuing of science between the high and low ends of the CPSIT continuum. At the higher end, teachers have a dedicated time for science every day and at least an hour for instruction. These

decisions are made at the school site level, often with teacher input. At the lower end of the continuum, science is relegated to 30 minutes at the end of the day where unrelated teaching and organizational demands crowd it out. Even though a teacher may value science instruction, if the place in which they do their work does not value it, they will have a very difficult time reconciling their beliefs with the perception of control and their teaching practice will reflect it.

Testing and accountability are always present in the minds of elementary teachers because they teach more than one subject. Because of this, they sometimes have choices to make. If external pressure comes chiefly for reading and math scores, they may feel their only choice is to comply and focus their efforts in these areas, giving science lowest priority. In this statement, Hannah (7%) captures the conflict the teachers feel between what they believe to be right and what they are required to do.

> I wish I had more time to teach, because I only have an hour and a half [total for math and science], and I feel the struggle with the math scores being … Having math scores, that's my fight. I need to teach them math to pass the test, but I need to teach them science so they can learn about the world.

The decreased emphasis on science scores affects the teachers with higher CPSIT in a very different way. Undoubtedly, they still feel pressured in reading and math, but having dedicated time and support for teaching science allows them to relax around this aspect of their responsibilities and provide students with instruction that aligns with their beliefs or understandings about effective science teaching. They are

teaching from a more intrinsic place and perceive autonomy rather than control for science teaching.

The data provide a sharp divide between low and high groups in their experiences and perceptions of curriculum and curriculum materials. Teachers with lower CPSIT perceive the struggle to pull curriculum together as a significant barrier. They are attempting to address the science standards by scraping up or purchasing materials and activities, using outdated textbooks, or both. Most are meeting with marginal success and perceive the time and effort as a barrier in their busy teaching lives. They have low autonomy in terms of SDT. Since the higher CPSIT teachers perceive their curriculum as meeting both their needs and the needs of their students in multiple ways, they perceive no such barrier. Without external barriers to their ability to teach in a way that addresses both the standards and their beliefs about how students learn science, they feel supported and, therefore, more autonomous. The next theme addresses other areas of support described by teachers in the data.

Theme: support for science instruction. Research on autonomy support for teachers is scarce (Roth et al., 2007). Factors that support teacher autonomy have not been specifically identified in the research to date. However, a considerable body of literature addresses factors that encompass autonomy support for students. In the case of students, autonomy support is described as ways in which teacher behaviors, or the learning conditions they provide, support students' perceptions of autonomous motivation for the goal of successful learning. When teachers provide autonomy support to students, they say and do things during instruction that increase student perceptions of their own autonomy (Reeve, 2008), thereby increasing active

engagement in learning (Assor et al., 2002). Teachers giving autonomy support to their students provide positive feedback about competence, offer choices in their learning, and create an environment in which students are encouraged to be creative and utilize higher levels of cognitive engagement (Stefanou et al., 2004). When students receive autonomy support, it is to help them achieve a desired learning goal such as mastering a unit in science or understanding a relevant disciplinary core idea.

Although teachers want students to attain mastery and success in their learning, their goals are directed toward how their teaching can help to make this happen. An intrinsic goal for teachers might be working toward becoming a better teacher or creating caring relationships with students. Teachers may simply want to teach in a way that will allow then to see their students succeed (Butler, 2014), a more extrinsic goal. Either way, autonomy support for these teaching goals necessarily looks different than it does for students, because teaching goals are tied up in how their teaching can ensure the success of their students. Researchers who have studied teachers' autonomous motivation look for contextual conditions that facilitate (rather than inhibit) teacher autonomy. The contextual factors considered in this study could constitute previously undefined factors that constitute autonomy support for science teaching. The 'support' theme in the next section encompasses additional, more direct types of support from administrators, colleagues, or professional development that could also be included in a definition for autonomy support for science teaching.

Results. The most significant types of support identified in the data are collegial support, administrative support, and teacher professional development.

Collegial support. Collegial support for science does not seem to be a factor for differentiating teachers across the continuum. The two teachers with the highest CPSIT report that they do not plan science with other teachers because none of the others are using the kit curriculum. Jenna (13%) feels other teachers who are not doing science should be supported and even forced to do science. These teachers indicate that they would enjoy planning with another teacher if they could. Carol (12%) reports that she plans to work with her colleagues to make the second year of the kit implementation better.

Many teachers talk about collaborating with other teachers but it usually occurs in content areas other than science. An example is Iris (7%) who says of her co-teacher,

> We do everything together with reading and math. We try to stay together because we want them to learn the same things in third grade, but this year, with science, we've done different things. I say, 'I'm doing this. Do you want to do it?' And she says, 'no, I like this better.'

This example indicates that science may not be something to which they give priority and reinforces a previous theme indicating the lower CPSIT teachers find less educational value and more entertainment value in science.

Addie (1%) experienced the opposite of collegial support when she taught in a self-contained classroom. She says,

> Last year six of us planned together. We didn't [have science in our schedule.] They actually got upset with me last year when I did just a couple of little things. They said, "You're actually teaching science?" And I said, "Well, no,

> I'm really not. We just [did a short experiment with conversation hearts.] And then we wrote down what happened…" I said, "That's really not teaching science. That is just one little thing. We didn't even have time to discuss [what happened.]"

After that, she never mentioned science again to any of the teachers. Now that she is departmentalized, she plans with one other teacher. She does not think he likes planning science very much because he just lets her tell him what to do. She is not sure he actually does what she says. His classes seem too quiet during science.

Gayle (6.5%) who is also in the district with the recently adopted kit curriculum is not experiencing much success with the kits and states that part of her problem is teacher collaboration. She talks about being frustrated with having to share her kit with another teacher. Brooke (2%), on the other hand, talks about how she has a co-teacher with whom she plans science. The other teacher has more experience and has been very helpful to her in implementing the new standards, an area where she is struggling. Faith (5%) feels she can manage on her own but would really prefer collaborating with somebody. She originally worked with another teacher to put together the curriculum she is using, but she was transferred away to another school in the district. She is sad and a little angry about this.

Teacher collaboration around science does not appear to be the norm in this sample, although many of the teachers collaborate in other content areas. It is implied that this is something they all wish was happening, but there is not enough momentum around science instruction to make it a priority. Some teachers are frustrated by the

lack of collaboration, a few are excited by the prospect, and others seem not to care. There is no discernible CPSIT pattern to these perceptions.

Administrative support. Teachers in this sample overwhelmingly indicate that their principals take a mostly hands-off approach when it comes to their science teaching. Faith (5%) is the only teacher on the lower end of the CPSIT continuum who has ever had a principal come into the classroom to evaluate one of her science lessons. Her principal asked her to choose a subject for her evaluation observation and she chose science. She says, "I feel like I didn't get much feedback on what I was teaching, but more on how I was doing it and my classroom management, that type of thing." Faith turns in all her lesson plans, including science, to her administrators but she does not think they look at them very closely. She states, "…if they wanted to look hard enough, they would know exactly what I'm doing." Brooke (2%) says she receives "constructive feedback" from her principal on her teaching, but never in science. Diane (4.5%) avoids being evaluated in science because she seems to place less value on it. "We choose when we want [the principal] to come in for evaluations. So, I could choose science, but I usually choose math. I did reading too. I like to do one of each, reading and math, because those are bigger areas." Hannah (7%) indicates that her principals do not want to evaluate science. She notes, "They want to see a math or reading [lesson] for evaluations." For most of the lower CPSIT teachers' schools, science teaching does not seem to be a priority for teacher evaluation. In some cases, it is the teachers, rather than the principals, who opt out of science evaluations. Evaluations play an important role not only in teachers' continuing employment, but also the state ratings of the school and district. It reveals

something about the valuing of science in the school system that science teaching is seldom included in teacher evaluation, a high stakes element for schools. Also, both teachers and principals may feel a lack of competence in science instruction, causing them to avoid using it for an important aspect of accountability like teacher evaluation. This represents introjected regulation, in which individuals engage in behaviors to avoid the appearance of incompetence.

Teacher evaluation is something the teachers with the highest CPSIT embrace. Because they feel competent, they welcome feedback in any subject area, including science. Kelly (12.5%) says, "I am fine with evaluation and I don't feel threatened by it. At my age I think, 'You don't like it? Fire me.' My scores are good so it is not an issue with me." Jenna's (13%) principals indicate support for her science teaching by deliberately choosing to evaluate her in science. She says that she gets to pick the subject in which she will be observed for evaluation, but she usually asks the principals what they would prefer. She indicates that they "always choose science." She is proud of this. It supports her sense of efficacy for science teaching.

Kelly and Jenna talk specifically about the amount of autonomy their administrator provides them for teaching. Jenna feels she can talk to the principal about the needs of her students and get support for changes she would like to make. Her grade level began the year departmentalizing for certain subjects. She felt that the needs of her students were not being met in this situation, so she requested to go back to a self-contained classroom with her own students, and was given permission to do so.

> When we started [the year], we were departmentalized, and I finally went in [to the principal], and said, 'It's taking me 20 minutes to calm down a class coming in to me.' I said, 'I can't, I'm losing over an hour of instruction a day. I've got to go back to just my class.' So, I went back…

Jenna also received permission to deviate from the district blueprint to help her students when they were struggling in math. Her goal was to be sure they were ready for the mandated math test. She felt they needed help beyond the prescribed curriculum. Kelly says she often takes liberties with the schedule to ensure that her students have enough time to complete science labs and do the discussion and writing that are needed to finalize their learning. When asked if she thinks this might get her in trouble with the principal she replies, "No, she has enough faith in me. She knows my scores. She knows how my kids achieve. I have freedom to do what I need to do to teach." Although Carol (12%) does not specifically mention her administrators, she feels she has the freedom to make her own schedule and adjust it to the needs of her students. She adjusts days and times for social studies and science teaching depending on the time demand for the activity she is doing.

> So, where I might say I do social studies every day, it is really some days are not even that long. So, I think it evens out the same because when I do the science I just give it a little more time… I just make my own schedule… You can have that if you want it.

She makes these adjustments to accommodate for extra time to do lab activities as they occur in the curriculum.

Like Jenna, Kelly, and Carol, the lower CPSIT teachers also report that their administrators give them freedom to teach science in any manner they choose. However, the way most of them perceive this freedom differs from the high CPSIT group. As a group, these teachers have lower efficacy for science and/or science teaching. Since they feel less competent in science than in other content areas, the independence is perceived as a lack of support rather than an opportunity for autonomy. Addie (1%) states, "I feel right now that I almost have too much freedom. There's no structure for [science instruction]." Diane (4.5%) states that her school has a prescribed curriculum but it does not follow the standards. "I need to be given a curriculum that helps me and not one that I have to come up with on my own." Brooke (2%) talks about her struggle with constantly changing curriculum and pacing guides from the district.

These teachers also collectively feel that their principals have little or no interest in what they are doing in science. Hannah (7%) indicates that her principal voices support for science and hands-on activities but never monitors them in any way. She does not think her principal has any idea what she is doing with her students in science. Diane (4.5%) says her principal encourages her to teach science, but does not think she would be in trouble if she did not teach it. She states, "I feel like I actually have quite a bit of control, just because they haven't adopted a curriculum that well. They've pretty much left it in our hands." She feels she can justify what she does (or does not do) because there is not a curriculum she can be held accountable for teaching. The standards, which many of them do not know very well, also seem to be something they feel they could use to justify what they are doing in science to the

administrators. Ellen (5%) states, "Related to science, I think [my principal] pretty well will let me do whatever I feel like I need to do to meet my PASS objectives or my standards." (Note: PASS is the acronym for the old science standards.) Iris (7%) indicates that her administrator lets her teach any way she wants in all content areas as long as what she teaches meets the standards.

Even though the lower CPSIT teachers are given the freedom to teach science in whatever way they want, it does not necessarily mean they perceive high autonomy. Most are struggling with the standards, time constraints, lack of curriculum, and the low valuing of science. Since they have so many barriers, it is difficult to imagine that teaching science is something they freely choose to do. To make it a volitional act, they need to have some support and a more compelling reason for going to the trouble of doing it. They are not getting this from their administrators, forcing them into a more controlled and external motivational stance.

Teacher learning (professional development). Another type of support that emerged in this theme is specific professional development (PD) for science. Since all the participants were recruited through voluntary PD sessions, it can be assumed that these teachers are motivated in some way to seek out professional development. The data show that all teachers find value in professional development. The difference between the higher CPSIT teachers and the lower ones seems to be in how the professional development is assimilated into practice. Teachers with higher CPSIT report significant impacts on their teaching practice from participating in multiple PD opportunities. Carol (12%) reports that PD she attended for implementing the kit curriculum over the summer "helped her confidence level" for using them in the

ensuing year. Jenna (13%) attended five PD sessions over the summer that helped her attain skills as a science leader. She talks about a shift in the way she thinks about PD. She says she has taken all the PD she has attended and synthesized it into big ideas about science teaching rather than thinking of them as individual trainings. This is a very self-determined way of thinking.

The lower CPSIT teachers talk mostly about how they wish they had access to more science PD. They feel that the focus is on other content areas and they need to look for science PD on their own. Gayle (6.5%) says, "We get enough reading and math PDs, but we don't get any for science." Hannah (7.0%) refers to a recent STEM workshop she attended that "changed her mind about not liking science." She says she is learning to appreciate it more.

Ellen (5%) and Addie (1%) both express that sometimes PD makes them feel bad about how much they do not know. Addie talks about seeking out some online PD with her colleagues to help her with a concept she was trying to teach. She says, "It was a little over our heads but we watched it anyway. I didn't realize I didn't know how to teach [the concept] until I watched the video." An exception to the pattern is Faith (5%). She is attending as much PD for science as she can manage, either on her own or through her school. She says it has opened her eyes to opportunities for new learning about science pedagogy.

Parental support. Certain types of support that might be expected to be important did not emerge in this data set. Parental support for science appears to be relatively low in this group across the continuum. Several teachers talk about receiving donations of science materials but none are significant or consistent. Several

teachers talk about money they receive for school supplies from their parent organization but it is never specifically for science and they must spread it out over every content area. Most teachers indicate that parents are uninvolved, even uninterested, in science.

SDT connections. Studies of the workplace have shown a significant correlation between perceived autonomy support in the work climate and intrinsic need satisfaction (Baard, Deci, & Ryan, 2004). Autonomy support factors in these studies were operationalized as understanding subordinates' perspectives, providing choice, reflecting feelings, and providing rationales for requested behaviors. While these types of factors have not been studied for teachers in the school context, it is reasonable to assume that an aligned curriculum, time for teaching and planning, and administrative interest and valuing of teacher efforts could be factors that constitute autonomy support for teachers.

The data show that support is a key need for elementary teachers trying to provide science instruction. Practical supports such as curriculum materials and professional development can help ease the load for teachers who are responsible for multiple content areas, taking away external barriers that keep them from being motivated to teach active, engaged science. Psychological support in the form of institutional valuing of the science teaching efforts and feedback for their teaching is also needed to increase their perception of autonomy and help them take on a teaching task that requires extra effort because it involves high active and cognitive engagement.

Summary: Relationship between autonomous motivation for science and CPSIT. When viewed broadly, the data in this study show a discernible difference between the perceived autonomy of self-contained elementary teachers who provide the most science instructional time and those who provide the least. This general difference is noted between the group of three teachers who have the highest CPSIT and the group of eight teachers who have the lower CPSIT numbers. While not specifically grouped this way at the outset, these differences became evident over the course of the qualitative analysis. Overall, the perceptions of the higher CPSIT teachers indicate more intrinsic motivation for science teaching than do those from the lower CPSIT group. Since teaching cannot be entirely intrinsically motivated because of the controlling nature of the system of schooling (Ryan & Deci, 2000a), an examination of the differing levels of extrinsic motivation within teachers in each group provides some insight into motivational differences and exceptions occurring within groups.

Self-determination theory proposes that "the regulation of intentional behavior varies along a continuum from autonomous (i.e. self-determined) to controlled" (Deci & Ryan, 1987, p. 1024.). The data in this study were examined through this lens. According to OIT, the two most controlled behavior regulations are designated as external and introjected because the locus of causality is mostly external. The two least controlling regulations are designated as identified and integrated because the exhibit a more internal locus of control (refer to *Table 4.5*). These regulations can also be thought of in terms of least to most autonomy as they become less controlled and more internal (Ryan & Deci, 2000a). Using a metric of control versus autonomy, the

lower CPSIT teachers largely exhibited the perception of external control, based on themes analyzed in the study, and the higher CPSIT teachers exhibited more autonomous perception of control for science teaching.

When looking at overall group responses, the high CPSIT teachers indicate more valuing and efficacy for science and science teaching than those in the lower group. Teachers in the high group find enjoyment in teaching science but also feel that it is very important for their students and even society. They have very high efficacy for teaching science and see value in the effort that must be expended to do it well. These teachers also believe in the ability of their students to succeed in science, especially when they participate in active learning involving the three scientific dimensions sanctioned by the new standards.

On the whole, teachers in the lower group assign less value to science and have lower efficacy than the high group. Many of them say they enjoy teaching science or are learning to enjoy it, but their own learning experiences (or lack thereof) have left them with low efficacy for science and/or science teaching. They find the effort required to teach 3-dimensional science to be a barrier, multiplied by their lack of content and pedagogical knowledge that forces them to be in a constant state of unresolved disequilibrium. They also see student ability as a barrier to science teaching, although this may actually reflect their own lack of understanding of the content and structure of the new science standards.

Exceptions to the pattern of certain themes from the study show that the factors related to autonomy perception are not a unitary construct. Each contributes in its own way to autonomy perception and, depending on context, some are more influential

than others. For example, Brooke (2%) has a very intrinsic view of science even though her efficacy for teaching it is low. She enjoys teaching science and providing the opportunity to her students, even though her efforts are not always directly aligned to the standards, with which she is struggling. Other barriers are affecting her feeling of autonomy and shifting her toward a more external perception of control. Faith (5%) has high efficacy and extremely high valuing of science teaching. She believes strongly in her students' ability to learn science through the 3 dimensions and feels it is well worth the effort required to teach it to them. When looking at only the more internal aspects from the themes, it appears she should be experiencing a high perception of autonomy. However, in her school context, the barriers to her teaching in the form of low institutional valuing of science, lack of support, and a highly controlling administrator have forced her to go against her best instincts. She teaches science subversively, but always worries that somebody will notice and she will "get in trouble." She is very unhappy and even angry about her situation. This supports the research showing that autonomous motivation is correlated with job satisfaction and good mental health (Darner, 2009; Ryan & Deci, 2000; Trepanier, Fernet, & Austin, 2013). These exceptions also point to the importance of external factors and administrative support as important elements in determining the amount of time elementary teachers devote to science instruction. A number of studies (Appleton, 2007; Banilower et al., 2013; Keys & Bryan, 2001; Ryan & Sapp, 2005) have borne this out.

It is clear from the data that external factors such as scheduling priorities, high stakes testing, and district initiatives play a role in teachers' perceptions of autonomy.

In fact, these factors are often the main driver of elementary schedules. As such, they likely provide a larger influence on CPSIT than some of the other themes examined in this study. This could explain why some of the teachers in the low CPSIT group exhibit motivational regulations inconsistent with some of their internal beliefs about science teaching and learning. It also explains why the CPSIT continuum (from 1% to 13%) does not reflect consistency when individual teachers are viewed in terms of the OIT continuum. Faith's data provide a case in point, illustrating this inconsistency. This means that, while CPSIT may be an acceptable way to group teachers for maximum variation in autonomy perception, it cannot serve as a predictor. The variables related to teacher perceptions of autonomy and control are complex and function in diverse ways within different contexts.

Research Question 3: Relationship between Endorsement of Student-Centered Learning and CPSIT

In order to answer the research question, *"Does elementary teachers' endorsement of student-centered learning for science differ depending on the time they devote to science instruction? If so, how and why?,"* a continuum from lowest to highest CPSIT was created based on teachers' reported time spent on science instruction. In-depth interviews were conducted with each of the teachers to determine similarities and differences between the lower and higher end of the continuum related to the theme of endorsement of student-centered learning.

Theme: endorsement of student-centered learning in science. Student-centered learning is a comprehensive term that has been used by many educators to refer to constructivist learning and teaching practices. Constructivism is related to

both theory and epistemology, and entails the view that people construct their own knowledge through experiences that occur in authentic contexts rather than simply acquiring it as facts or information. Its application to the classroom involves active learning that occurs in "learner centered" environments where students' prior knowledge, attitudes, and beliefs are considered in providing them with experiences within structures that allow them to construct their own knowledge (Bransford et al., 2000). For science, inquiry teaching has been the recommended method for actively engaging students in the process of "doing science" as a means to acquire and construct scientific knowledge (Bransford & Donovan, 2005; NRC, 1996). More recently, the view of scientific inquiry in the classroom has shifted to what is referred to as a 3-dimensional conception of science learning (Krajcik, 2015; NRC, 2011). This involves the integration of scientific practices, crosscutting concepts, and disciplinary core ideas in order for students to learn relevant science content by "doing science." This instructional paradigm is reflected in the Next Generation Science Standards (NGSS, 2013) which is the guiding document for the new Oklahoma Academic Standards. These initiatives reflect the principles of student-centered learning.

For purposes of this analysis, student-centered learning is defined using ideas relating to the paradigm of 3-dimensional learning. Teachers' reports of their perceptions and practice of active learning incorporating a significant emphasis on gathering evidence, constructing explanations, and arguing from evidence as required by the new standards are examined. Perceptions of the teachers' fundamental views of the nature of science (Lederman, 2007) as either a body of knowledge or a "way of

knowing" through observation and investigation are compared. The epistemology associated with the new standards characterizes the nature of science as a way of knowing, and reflects the constructivist (student-centered) perspective.

Results. Three primary science teaching methodologies were reported by teachers in the interview sample: textbook, kit curriculum, and teacher created curriculum. Three of the teachers (Diane, Ellen, and Iris) from the lower end of the CPSIT continuum primarily use textbooks as their curriculum. A textbook is generally considered to be a teacher-centered (non-constructivist) methodology because it delivers knowledge to students rather than engaging them in active discovery of science concepts through investigation and explanation. The three highest CPSIT teachers (Jenna, Kelly, and Carol) and one teacher from the low CPSIT group (Gayle) use a district-purchased kit curriculum. This curriculum utilizes a constructivist approach to conceptual development. The other four teachers from the low CPSIT group (Addie, Brooke, Faith, and Hannah) report that they pull together a curriculum from various online, textbook, and teacher-sharing resources. These teachers also occasionally make up their own activities. It is not possible to tell if a teacher-created curriculum is student-centered without knowing more about how it is delivered and sequenced.

It would not be logical or valid to assume a teacher's endorsement of student-centered learning based on the curriculum they use, because this is not usually a decision they get to make themselves. It is part of the external factors that govern their teaching context. What may provide information about their perspective on

student-centered learning is their feelings about the curricula they are using. This is the basis for the categories gathered from the coding in this theme.

Use of structures for student-centered learning. As described in the analysis of the previous research question, most of the teachers report that they do "hands-on" learning with their students when they can. All three teachers who have textbooks as their primary curriculum say that they feel they must do some additional hands-on activities in order to address the standards because scientific practices are part of the performance expectations. Diane (4.5%) states, "I use the chapters that kind of go with [the standards]. We're usually pretty much forced to get on Teachers Pay Teachers, things like that, to try to find lessons, experiments… I mean, you're kind of on your own." When she does activities with her students, she likes to have her students work in groups. Ellen (5%) talks about a chemistry chapter her students are reading and says that they need to stop and discuss often because "they are not used to talking about chemicals and polymers and other things." She states, "Unfortunately, we do more reading than we have been doing science projects." Ellen talks about how difficult it is to do active learning with her students. She says, "managing the group with an activity like that becomes almost a nightmare, since they're not used to learning that way." Iris (7%) thinks there should be a balance of reading and activities, but sees the activities as an add-on that the students do for fun. She tries to do one activity a month but finds it difficult to fit in the schedule. These teachers all seem to recognize value in active learning and have tried to do it with their students, but are either unsure how to be successful with it or are not completely convinced that it is worth the effort it will take. When asked if they have their students justify or

explain the ideas they discover in the activities, all three of them admit that they very seldom ask their students to do this.

The higher CPSIT teachers have kit curricula that provide them with the learning structures and materials they need for student-centered instruction. They are using these materials and feel they are interacting with their students in a way that is consistent with their own learning philosophy as well as what they have learned through professional development about how students best learn science. Carol (12%) appreciates that the kits have everything they need to provide students with an interactive learning experience. Kelly (12.5%) likes to use focus questions to get students thinking about science concepts. She says, "My favorite thing to do, and the way my kids are learning best now, is I'll just throw out a little focus question and leave it with them a while." Jenna received professional development on the 5E learning cycle and uses this lesson structure as much as she can with her students. The 5E lesson model is a learning sequence based on experiential learning rooted in constructivism (Bybee, 2014). She notes that the science kits are consistent with this structure and she has the freedom within the curriculum to make changes as she feels they are needed. All three teachers utilize discussion and notebooks to have their students explain and justify their reasoning based on their experiences from the kit activities. Gayle (6.5%) has a kit curriculum as well. She is overwhelmed by the preparation and planning required to use it and feels she did not get enough training. She has fallen back to a text-based instructional delivery using worksheets because she is more comfortable there. She attempts to have students use journals to construct

explanations but has not had much success, since she states she is unsure how to grade them.

The other four teachers, Addie, Brooke, Faith, and Hannah (all from the lower CPSIT group), utilize a mixture of strategies to attempt to address the standards. Addie (1%) is required to teach science for most of her instructional time since she is now departmentalized. She admits to struggling with finding ways to do active learning with her students since they do not do well without a lot of structure and she often falls back on the textbook. She does not like to do this because she finds the outdated textbook is often "wrong." Addie saves labs to do as a reward for good behavior and uses "worksheets" as her main method for engaging students. She also talks about using Bill Nye (the Science Guy) videos as a staple because she found some good worksheets that go along with the series. She has time to do science, but uses most of that time for non-constructivist types of learning. Brooke (2%) loves to do science with her students and, because of her limited time and resources, she tries to make the few opportunities she has for doing it as active as possible. She looks for opportunities to do activities in conjunction with what her students are reading. She also chooses activities based on the time of year. For example, she has them plant seeds in the spring. Her active science opportunities are aligned according to organizational rather than standards-based considerations. Neither Addie nor Brooke have students do much explaining or justifying. They do not feel their students are capable of it.

Hannah (7%) talks about using an "interactive science notebook" strategy that goes with a textbook she has available. She says this gives students opportunities to

justify and explain their reasoning. She also has science kits from a previous adoption that she uses to piece together activities that align with the standards. In addition, she has a "required" science weekly magazine that she must use with her students. She uses reading strategies with students when they read the magazine. Hannah tries very hard to pull together all the resources that are available to her to address the standards. She keeps that task as the primary focus for her science teaching.

Faith (5%) is very comfortable with using structures for student-centered learning and tries to use them exclusively. She states, "We have a science textbook that's about 15 years old, and my kids don't even know it exists because I don't use it. [Instead I use] my own creative abilities." She feels she is successful using active learning with her students. Her students work in groups and share ideas through discussion and science notebooks. They are asked to explain or justify all their ideas in writing in their notebooks. She also uses discussion to formatively assess their understanding so they will be able to construct evidence-based explanations. She makes sure all her instruction is tied to the new standards.

Teachers in the highest CPSIT group use a curriculum that supports student-centered strategies and indicate that this aligns with their thinking about the best way to learn science. The lower CPSIT group reports mixed use of student-centered strategies. The range goes from mostly teacher-centered textbook and worksheet structures to 5E-type strategies that engage students in investigation and conceptual development through explanation and justification. All these teachers report utilizing hands-on activities, although at different levels of cognitive engagement. As previously discussed, using a hands-on approach does not necessarily guarantee

cognitive engagement that allows students to construct their own knowledge (Lee, 2012). Hannah and Faith exhibit a more constructivist approach in designing their own curriculum than Brooke. Although Gayle has a curriculum that would allow a more student-centered approach, she falls back into her comfort zone of providing students with information rather than discovering it for themselves.

Attitude toward science learning. When examining attitudes toward science learning, teachers in the highest CPSIT group advocate for a more constructivist or student-centered approach to science. Jenna (13%) provides evidence for her endorsement of student-centered learning when asked what she does if her students want to go in a different direction than where the lesson is supposed to go. She replies, "Oh yeah, we take it there. We absolutely take it there. I'm not rigid when it comes to that. This is our science time, and if it's spent doing this instead, then that's fine. We'll come back and hit [what we are supposed to be doing] later." When it comes to assessing student learning, Kelly (12.5%) grades for mastery and lets students change their journal entries as often as they need to. She says,

> I grade on participation mostly, a rubric type. I often just sit back and watch the child and keep a kind of sheet to see if they [discovered what they were supposed to]. I don't let students flunk anything. Honestly, if we didn't have to do grades, I wouldn't do them.

Carol (12%) exhibits a slightly less constructivist view of science learning. She feels confident the kit curriculum gives students what they need and is more focused on implementing it with fidelity. However, she does talk about making sure she does not just give answers to students. She wants them to come up with their own

justifications. She says, "Even on answers that are wrong, I try to say, 'Why did you choose that?' I don't just straight out tell them it's wrong. I say, 'Explain to me why you choose this," and then try to work it that way."

Teachers in the lower CPSIT group show differing stances toward student centered-learning. The four teachers lowest on the CPSIT continuum have a vocabulary-first view of science learning. They think that students must be provided with vocabulary before they interact with a concept in an activity in order for them to understand it. This is the opposite of the constructivist view that concept learning can (and often should) occur before vocabulary development so that students can develop conceptual understanding that goes beyond simply knowing the definition associated with a concept (Bransford et al., 2000). For example, Brooke makes a comparison to mathematics learning by stating,

> I think sometimes things are developmental with kids, and you can't expect them to know… for example, in math. Sometimes I think for little kids, it's better to learn the method and then they can learn the reason why behind it later because they don't get it. And if they get so wrapped up in the why, they never get the how because they're trying so hard to get the why. Next year, it might click.

Ellen (5%) talks specifically about how students need to read about a concept before they experience it.

> I think [students] have to read about it, and then I think they need to experience what they read in something hands on. I think they need both, because sometimes I think if we just go straight to the hands-on activities that they

don't get the meanings or the lessons behind it. So, I think you need to have a good balance of both, reading and hands on.

While she advocates for balance, reading is what comes first in her view.

Teachers on the higher end of the low CPSIT group have a slightly less vocabulary-centered view of science learning, although they still view science as mostly a body of knowledge to be understood and acquired. Hannah (7%) states that she thinks, "The [best way to learn science is] hands on, and then to relate it to the information in a textbook or [some other kind of] text." She goes on to say that elementary students do not have the "attention span" for reading information they need to know like older students do. It is not clear that she sees the activity as a way to develop conceptual understanding. When asked about what she feels is the best way for students to learn science, Iris (7%) replies, "Getting to do hands-on, experiencing things. You know, I still think some of the book work [is needed]. There are some things you just need to read actual facts about. You know, look at pictures and things like that."

Faith (5%) is the teacher in the low CPSIT group who seems to most clearly embrace student-centered learning. She says, "[STEM] is the perfect place to foster the curiosity that [students] will need to go on and do anything." She goes on to say that she thinks elementary school science is the perfect place to learn and develop critical thinking skills. Faith provides a considerably stronger endorsement of student-centered learning than others in the low CPSIT group. In fact, it may be stronger than that of any of the teachers in the entire sample.

Integration of science with other content areas. When teachers were asked what science instruction might look like for them in a "perfect world," a common idea mentioned was cross-curricular integration. An idealistic example response comes from Brooke (2%).

> I just think that… you could do so much if everything in your classroom could be kind of a scientific exploration. If we were doing all the seeds that we did today, we could write about it. We could use that in our writing. You could do it in math. You could measure it. It wouldn't just be about the one lesson. It could be a whole [integrated experience]."

She also notes that it is very hard to do, especially with math.

Most of the teachers attempt to integrate science in various ways. In most cases, it seems to be a matter of convenience or opportunity rather than a purposeful, planned strategy. This description from Carol (12%) captures much of what teachers said about integration.

> Sometimes [I integrate]. To be honest, it's more of kind of an accident. Like, if we're reading something and it talks about…like, we talked about national parks. [Students] will read or talk about [a science topic], so then I will talk about it, Google it, and watch a video. It incorporates like that. Sometimes within our reading, there will be social studies or science links, and if I have time, I do that. But I don't plan out, okay, this is how it all connects together.

Other teachers say that their situation does not give them the flexibility in math and reading to do much integration at all.

Although integration of science with other content areas seems like it should be a great way for elementary teachers to manage time demands and provide students with a holistic, student-centered learning experience, there is little research to show that this strategy provides elementary students with opportunities to increase conceptual understanding of science (Appleton, 2007). Research also shows that true integration is hard to do successfully. In a research synthesis addressing integration from a science perspective, Venville, Wallace, Rennie, and Malone (2002) concluded that integration is difficult to accomplish in school settings because it challenges aspects of established practices and beliefs related to the structure of schools. There is no indication that any of the teachers across the CPSIT continuum have managed to successfully implement integration that improves student conceptual understanding of science. However, most who make the attempt feel they are offering their students opportunities to make connections that will utilize prior knowledge to provide better learning experiences. They perceive this as being a way to make their teaching more student-centered. There is not a distinction between low and high CPSIT in this perception.

Summary: Relationship between Endorsement of Student-Centered Learning and CPSIT. Endorsement of student-centered learning is implied by both use of student centered strategies and by self-reported beliefs in its importance for science learning for young students in the analysis of this theme. The data show an overall pattern of higher use of student-centered learning in the high CPSIT teachers than the lower CPSIT teachers. An exception is Faith, who employs a very student-centered approach with her students, although her CPSIT is only 5%. Notably, the

higher CPSIT teachers are required to use a kit curriculum based on student-centered learning strategies. Even though the high CPSIT teachers have a student-centered curriculum available to them that the other teachers in the sample do not, supporting evidence for their endorsement of its use is provided by the teachers themselves. The teachers say the curriculum is consistent with their beliefs about how students learn science best. They also say that they are using it even though many other teachers in their schools have not embraced the opportunity. This indicates choice on their part, since others seem to be getting by the mandate with no consequence.

When it comes to attitudes toward student-centered learning, the pattern is less distinct. Teachers appear to be trying to integrate science with other content areas in an attempt to provide students with science in a manner that will allow them to relate to it in an authentic way, given the constraints on their time for science instruction. All the teachers believe, to varying degrees, that students need to actively "do" science, mostly because of the requirements for the integration of scientific practices in the performance expectations of the new standards. However, many of the teachers with low CPSIT report that they do not employ the higher order elements of the scientific practices to allow students to construct their own scientific understanding. These include constructing explanations, supporting conclusions with evidence, and communicating scientific understanding. Their perception is that the hands-on features of the learning are either sufficient or better than nothing. This is most prevalent in the lower end of the CPSIT continuum. Again, Faith (5%) is an exception to the pattern. Brooke (2%) also expresses a positive attitude toward student-centered learning, although her efficacy and skills for employing them are low.

Although the data show that teachers are aware that the elements of 3-dimensional learning in the standards are desirable for teaching science, they do not always utilize these strategies to any great extent in their classrooms. There is a broad pattern to the data showing that, overall, teachers with higher CPSIT show higher endorsement for student-centered learning than do those with lower CPSIT. Exceptions to this pattern indicate that CPSIT may not be a reliable predictor of the endorsement of student-centered learning. Teachers may hold this view and still not be able to spend significant time on science instruction due constraints from external factors like scheduling and testing mandates as discussed in the previous research question.

Conclusion

The CPSIT data were organized as a continuum from low to high at the outset of the analysis to determine if the CPSIT showed an ordered pattern in relation to the each of the identified themes. As the analysis progressed, it became clear that the differences fell more into two unbalanced groups. The three teachers with the highest CPSIT emerged as a group having similar perceptions within each of the themes, mostly in the form of higher perceived autonomy. The other eight teachers with lower CPSIT did not always share perceptions with each other but, in general, their perceived autonomy was lower on most themes than the highest CPSIT teachers. The most obvious exception within the group is Faith, although others show occasional deviations from the pattern on various themes. Faith has one of the lower CPSIT numbers but exhibits some of the characteristics of the high group.

Although a correlational pattern was not observed in the qualitative data between CPSIT and autonomous motivation for science teaching or endorsement of student-centered learning, examination of the exceptions to the overall pattern of teacher autonomy through the lens of the OIT continuum generated some interesting findings that show the complexity of the construct of autonomous teaching. These could have implications for elementary science teacher practice. Identifying factors that support various aspects of autonomous motivation has the potential to inform professional development, curriculum improvement, and administrative decision-making. The quantitative data in this study align with previous research showing that elementary science is not being taught at needed levels for science proficiency in U.S. schools (Banilower et al. 2013; NRC, 2007). Considering the importance STEM education has for the US economy and the environmental future of the planet (Madden, Beyers, & O'Brien, 2016), it is important to find ways to isolate and mitigate factors that serve as barriers to quality science instruction. Using SDT as a framework to examine teacher autonomy could provide a means for identifying these factors to provide support to teachers in their efforts to overcome these barriers.

The next chapter discusses the potential for SDT to provide a fresh perspective on the examination of teacher motivation for science instruction. Implications from this study for the identification of factors that serve as motivational and actual barriers and supports to elementary science teaching are also discussed. The chapter describes limitations to the study and provides suggestions for future researcher in the area of autonomy support for elementary science teaching.

Chapter 5: Discussion and Implications

Introduction

In Chapter 5, the findings from the study are discussed and related to SDT and OIT as a framework for exploring teacher motivation for science instruction in elementary schools. First, the problem statement for this study is revisited in order to briefly discuss the quantitative findings. Next, the motivational stances regarding perceived autonomy of teachers in the study are discussed in relation to one another. The possible explanatory value of the OIT continuum shown by the results of the study is considered. Finally, implications for practice, limitations and directions for future research are presented.

Discussion of Findings

Quantitative Findings

Reform efforts in science education are currently focused on ensuring that students learn science as a process of evidence-based theory building through the pursuit of scientific questions and issues (NRC, 2007). This process signifies a progression from conceptualization of foundational scientific ideas and practices that can be learned at the elementary school level to the more complex ideas that explain the natural world studied at higher grade levels. The importance of elementary science instruction is elevated within this vision. Simply stated, we need to find ways to support science teaching and learning at the elementary level. Despite its importance, research has shown that elementary teachers spend very little time providing science instruction for their students, which hinders the ability to enact science education reform.

Data from a national study conducted by Horizon Research (Banilower, et al., 2013) show that self-contained elementary teachers in grades K-3 spend an average of 19 minutes per day teaching science and those in grades 4-6 spend an average of 24 minutes per day. In relation to total instructional time in core subjects, this translates to 9% for grades K-3 and 8% for grades 4-6. For the quantitative sample in this study, the overall average CPSIT for K-5 teachers is 3.6%. The average CPSIT for teachers in grades K-3 is 3.0% and those in grades 4-5 average 5.4%. These numbers are lower than the Horizon study, possibly because the percentages in the Horizon study were calculated with core subjects only (math, language arts/reading, science, and social studies). The CPSIT was calculated from total instructional time, which also includes electives. In both studies the science teaching percentages are lower than the total instructional time in relation to other subjects. This provides additional evidence to show that the lack of elementary science education is a critical and pervasive problem nationwide.

Another pattern in the data is that teachers in the primary grade levels (K-3) spend less time on science instruction than those in the higher elementary grade levels (4-5). This pattern is also seen in the Horizon study, although no inferences are drawn from these statistics. In the survey for this study, teachers were given an opportunity to provide a reason why certain subjects were not taught in the teacher's classroom as a clarification for the previous item asking which subjects they teach. This item was left blank most of the time. However, there were a few responses worth noting from respondents in grades K-2 who had a CPSIT of less than 2%. Three teachers indicated that they do not have time for science. A second grade teacher wrote, "Long reading

books required, very little time left for science and social studies." Two teachers mentioned standards. One said that there are "no current standards for science" (although there are standards for this grade). The other one said that science is not "mandated" in the standards. Two teachers indicated that they are told by their administration not to teach science. One simply said "district and administrative directives." The other was more explicit, "We have been told to focus on reading and math, and social studies was added this year." One teacher indicated that science and social studies are taught with reading. Although no inferences can be drawn from these comments, they show that some teachers at the lower grades perceive controlling conditions when it comes to teaching science. These are in line with the findings from the lower CPSIT teachers in the interview group.

Beliefs and Practice Disconnect

Like many previous science education studies on teacher beliefs, data in this study show that teachers see value in student-centered learning for science and believe that it is important for their students to receive science instruction in elementary school, yet the amount of time and effort they expend on science in their instructional day does not consistently match these beliefs. Many research studies have clearly shown that teachers' cognitive beliefs affect the way they approach their teaching practice (Keys & Bryan, 2001; Nespor, 1987; Pajares, 1992). It has also been shown that these belief systems are complex and function within the context in which they are enacted (Cronin-Jones, 1991; Jones & Carter, 2007; Mansour, 2009; Trumbull, et al., 2006; Wallace & Kang, 2004). Attempts at describing the mechanism through which cognitive beliefs and attitudes are translated into instructional practice have

resulted in multiple explanatory models (Davis, et al., 2006; Jones & Leagon, 2014; Samuelowicz & Bain, 1992; Song et al., 2007; Wee et al., 2007). So far none of these has been able to unambiguously explain why teachers often have a set of beliefs about their efficacy, their students, or science pedagogy that are not reflected in what they do in the classroom (Hutner & Markman, 2017). Additionally, many of these models depict or mention motivation as a single factor or unitary construct contributing to the larger model.

In Chapter 2, an example was provided (*Appendix A*) of a diagrammatic model proposed by Jones and Carter (2007). This model was revised in a subsequent publication based on additional findings in the science education beliefs and practice literature (*Figure 5.1*). The new model (Jones & Leagon, 2014) has more detail and complexity than the original model. Their summary of the model is as follows:

> In 2007, Jones and Carter proposed a sociocultural model of the factors that contribute to beliefs and attitudes. In light of the research that has emerged… we propose a revised model that places greater emphasis on the roles of self-efficacy, epistemic beliefs, self-regulated learning, and metacognition. This model is to be interpreted as a dynamic process versus a static product. Each phase of self-regulation is cyclic, with no definitive beginning or ending point. (pp. 841-842)

It should be noted that the authors state the "overall system has yet to be fully tested" (p. 842). One notable thing has not changed from the original model. Motivation is still depicted as a unitary construct, although it now has its own place in the model; whereas previously, it shared a location in the model with "knowledge and skills."

The new model proposes that efficacy, epistemic beliefs, attitudes, other affective factors, and other cognitive factors all contribute to "motivation," but it does not specifically indicate how these factors influence "intrinsic/extrinsic" motivation or what role they play in determining goals for science instruction. This limitation in the model and others like it is where the OIT continuum, as examined in my study, provides additional explanatory utility. If considered in a complex model such as this one, it might even clarify or simplify pathways that could make it easier to verify. However, the intention here is not to analyze this model in order to modify it. The purpose is to provide a comparison showing that there could be another way to explain how teachers enact (or do not enact) their beliefs in the classroom by considering motivational constructs from SDT.

Figure 5.1 - Integrated Beliefs Model (Jones & Leagon, 2014) (p. 842)

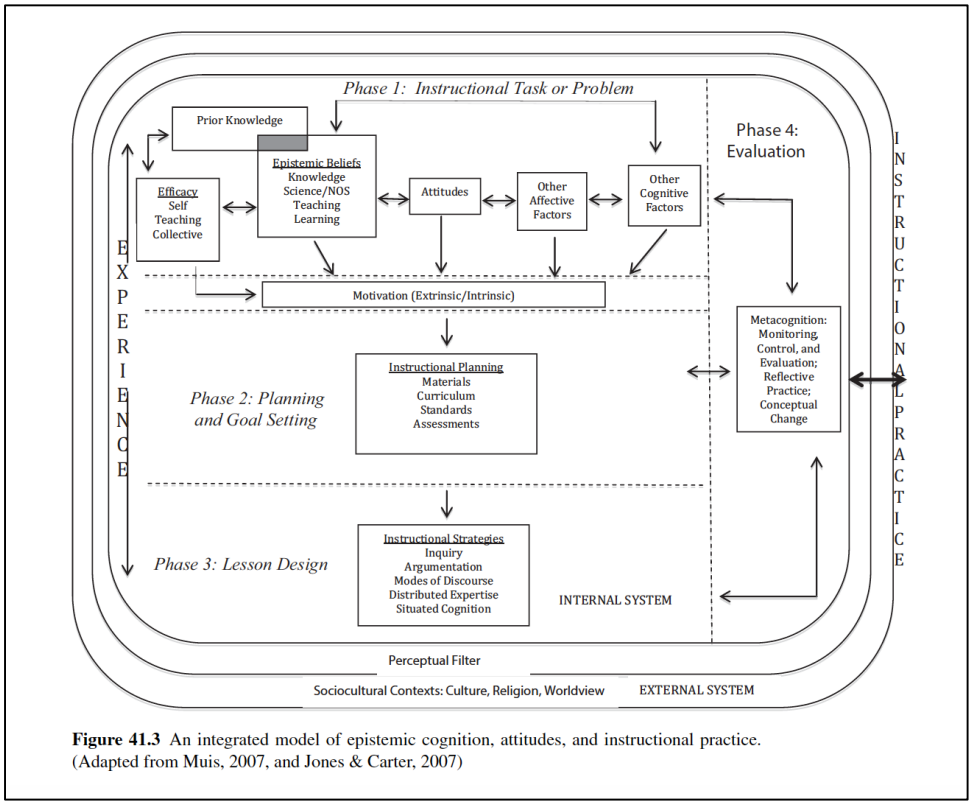


Figure 41.3 An integrated model of epistemic cognition, attitudes, and instructional practice. (Adapted from Muis, 2007, and Jones & Carter, 2007)

Clearly, elementary science instruction occurs within a complex system of internal and external factors. The epistemological approach employed in this model, as well as many other studies of science teacher beliefs, lacks the ability to integrate context into the reasoning structure in a purposeful way. The needs fulfillment lens of SDT used in this study allows consideration of factors external to the self as part of the motivational picture for a complex task such as science teaching.

Satisfaction of Psychological Needs in SDT

Self-determination theory proposes that individuals are motivated to action based on the perception that their psychological needs for relatedness, competence, and autonomy are being met. The extent to which these needs are met dictates the level of self-determination. The needs approach considers cognitive assessments of contextual factors that support or thwart perceived psychological needs and influence behaviors.

Need for relatedness. Although the need for relatedness was not purposefully explored in this study, it emerged on its own from the data. There is some evidence that relatedness is a contributing factor to the beliefs of the teachers in the study. When asked why they became a teacher, most of the participants gave student-related or altruistic reasons for their career choice, such as wanting to make a difference for students or because it was part of how they saw themselves from childhood. This response from Hannah is typical, "I wanted to be a teacher. I knew I wanted to be a teacher since first grade. I've always wanted to help. I've always helped, tutored, everything since I was a little kid." Ryan and Deci (2000) assert that the sense of relatedness supports intrinsically motivated behaviors. The teachers express a sense of

relatedness to their students as an important aspect of their goals for teaching when they articulate that they teach science despite barriers because their students like it or because they feel it is an important part of their learning. They are drawing on a feeling of relatedness as a source of autonomy for making their teaching decisions (Bieg, Backes, & Mittag, 2011).

Need for Competence. There is ample evidence in the literature to show that teacher efficacy influences many aspects of science teaching (Jones & Leagon, 2014; Tschannen-Moran & Hoy, 2001) such as persistence with students (Allinder, 1994; Gibson & Dembo, 1984) and valuing of mastery teaching (Guskey, 1988). Teachers' efficacy for science and science instruction contributes to their overall sense of competency. The results of this study show that the teachers with lower efficacy spend less time on science instruction than do those with higher efficacy. This corresponds with previous research on teacher efficacy. However, there is one teacher in the study, Faith, who exhibits a pattern of high efficacy but has a lower CPSIT of 5%. In order to examine exceptions from the data such as this one, *Table 5.1* was created to show rough approximations of binary levels reported on factors related to teacher autonomy in themes from this study. The highest relative levels for each theme are indicated by highlighting these cells in gray. This has been done to illustrate the pattern of controlled versus autonomous perceptions for the participant group. The gray cells indicate teachers with the highest relative autonomy within each theme for this group of teachers.

Table 5.1 - Levels of Perception for Study-associated Themes

	SCL Endorse-ment	Effi-cacy	Valuing of science	Student ability beliefs	Attitude toward effort	External factors	Support Factors
Addie (1%)	Weak	Low	Lower	Lower	Barrier	Barrier	Lacking
Brooke (2%)	Weak	Low	Higher	Lower	Barrier	Barrier	Lacking
Diane (4.5%)	Weak	Low	Lower	Lower	Barrier	Barrier	Lacking
Ellen (5%)	Weak	Low	Lower	Lower	Barrier	Barrier	Lacking
Faith (5%)	High	*High	Highest	High	Not a barrier	Barrier	Lacking
Gayle (6.5%)	Weak	Low	Lower	Lower	Barrier	Barrier	Available-not accessed
Hannah (7%)	Weak	Low	Higher	Lower	Barrier	Barrier	Lacking
Iris (7%)	Weak	Low	Higher	Lower	Not a barrier	Barrier	Available-not accessed
Carol (12%)	Moderate	High	Highest	Lower	Not a barrier	Can overcome	Available
Kelly (12.5%)	High	High	Highest	High	Not a barrier	Can overcome	Available
Jenna (13%)	High	High	Highest	High	Not a barrier	Can overcome	Available

For the efficacy theme, response data indicate that seven teachers have relatively low efficacy and four teachers show higher efficacy in comparison. *Faith

is an exception in the lower CPSIT group. Her efficacy is high for teaching science and, although her content knowledge is not her strongest area, she is confident in her ability to learn along with her students. Examination of other factors is required to further explicate her low CPSIT.

Need for autonomy. The factors explored in this study are related to teacher perceptions of autonomy, especially as they contrast to the perception of control. The more teachers sense higher levels of autonomy, the more likely they are to pursue valued goals (in this case student-centered science teaching) and persist in the effort, even in the presence of barriers. Self-determination theory maintains that competence and autonomy are strongly associated with intrinsic and internal approaches to action. In fact, the theory says that competence is a necessary condition for autonomy (Deci & Ryan, 1985), and that in order for an individual to experience self-determined behavior, they must feel competent. On the other hand, an individual can have efficacy for a specific activity and still not feel autonomous (Ryan & Deci, 2000a). This is likely what is happening in Faith's case.

Faith - introjected regulation and frustration. By most indications, Faith should be experiencing high levels of autonomy. She has a high sense of efficacy. She believes her students can learn science through learning structures that provide them with opportunities to construct their own scientific knowledge. She indicates a high valuing for science and science teaching. In fact, she thinks it may be possible that science is more important for students than reading and math, because she feels the latter two can be learned in the context of doing science. However, the tenor of her interview indicates that her needs for autonomy are not being met. She is angry

and resentful about the barriers she perceives as keeping her from teaching the way she would like. Faith feels her principal does not value her ability and enthusiasm for science because she is too focused on reading and math accountability. She is locked into a schedule that limits her ability to make choices about her instructional methods. She even exhibits characteristics of introjected regulation because she is forced to find ways to avoid "getting in trouble" for doing things she feels are in her students' best interest. It is not that she avoids science teaching because she does not value it or wants to protect her ego. Rather, she feels compelled to prioritize reading and math over science to avoid the repercussions she has experienced in the past from attempting to provide science through integration and other creative strategies. Despite all the internal resources she possesses, she still perceives control rather than autonomy. Her lack of autonomous motivation affects her sense of well-being and her emotional state (Deci & Ryan, 2000; Gagné et al., 2010; Gagné & Deci, 2005; Trepanier, Fernet, & Austin, 2013). When I tried to check back with Faith to follow up on her interview, I found out that she left her job at the end of the school year to teach in another district.

Addie, Diane, Ellen, and Gayle - external regulation. It is worth noting once again that all teachers in the sample express valuing of science instruction in some way. Those that are listed as "lower" in *Table 5.2* (Addie, Diane, Ellen, and Gayle) are given this designation because they specifically indicated that they feel science is not as important as other subjects. They are less invested in teaching science than the other teachers. The rest of the profile for these teachers shows their internal source of efficacy is low, they do not feel their students can do conceptual science, and they see

effort for science teaching as a barrier in addition to the external barriers and lack of support they are experiencing. These teachers are mostly externally regulated and currently cannot see how teaching student-centered science can be a reality for them in any meaningful way. This could possibly allay some of the guilt that might otherwise be associated with their failure to engage wholeheartedly in teaching something they feel might be helpful or enjoyable to their students. This could apply not only to time, but also to quality of instruction.

Brooke, Hannah, and Iris - introjected regulation. There are three other instances in the data in which certain autonomy factors do not fall neatly in line with the CPSIT groups. Brooke was designated as one of the lower CPSIT teachers who expressed higher valuing of science, though maybe not as much as those in the high CPSIT group. Brooke loves science and feels competent in her ability to share science knowledge with her students. She feels considerably less certain about her ability to provide an environment in which students can learn science concepts in the 3-dimensional structure necessary for mastery of the standards. In fact, she is struggling with understanding how to implement the standards. She sees integration as a way to address science learning but does not know how to make it happen in meaningful ways. When she actually does science, she tries to make it hands-on but admits that science often gets pushed out of the schedule. This is justifiable to her because she is not getting to teach it the way she believes she should anyway. Even though she feels science is important, she also believes that second graders really are not yet ready to grasp the complex ideas of science. She says, “I think sometimes things are developmental with kids, and you can’t expect them to know… the ‘why’ of it.

Maybe it will click next year." Even though Brooke loves science and wants her students to experience it, there are many things that interfere with her sense of autonomy. She avoids it because she is unsure how to do it successfully and attributes much of that to external factors such as schedule, student ability, and the effort it takes to do science rather than her uncertainty about her ability to teach the new standards. This avoidance behavior falls in the category of introjection. Given Brooke's love of science, it is possible that she would be doing more science instruction if she had some support in the form of professional development in science pedagogy and more time in her schedule for science, indicating institutional valuing of science teaching.

Hannah's schedule gives her 90 minutes to do both math and science. This has placed her in a philosophical "struggle" between the two subjects. She says science is important for her students so they can learn about the world around them, but also feels that math has equal importance. In this clash of values, math usually wins because her students need to "pass the test." This is an external form of control, and it is a powerful driver in elementary schools regarding instructional decisions in an era of accountability (Au, 2007; Banilower et al., 2013). Although Hannah is allowed to teach science any way she wants, she does not feel supported in these efforts. There is no expectation for science in her school (low institutional value) so she does not have to feel bad when she chooses to do math over science. This is another example of introjected regulation. Although science is something Hannah values, there are barriers to enacting it in context.

Iris works hard to provide science instruction for her students because she thinks it is important for them, but also because she thinks students need to do

something that is "fun" for them. The textbook is her main curriculum and she feels students get important "facts" from it, but she does as much hands-on science as she can so her students will have a good experience. She does not see the extra time needed to do science instruction as a barrier because she is willing to do it for her students. Although she is focused on the needs of her students, her teaching may not be student-centered because she is concentrating more on engagement than allowing them to construct their own knowledge. Although there is definitely an altruistic internal endorsement for hands-on learning for her students, it appears to make her feel good that she is providing them with something extra that is fun for them. This represents introjected regulation, albeit at a relatively higher level of autonomy, because she receives an internal reward for doing something that she feels her students enjoy.

OIT and the importance of contextual factors in belief systems. Faith, Brooke, Hannah, and Iris each show different expressions of introjected regulation. All of them feel that science has value for them, their students, or both, yet all of them avoid science teaching in some way. Simply stated, their beliefs do not match their actions. This an obvious over-simplification because of the complexity of the system in which their beliefs are functioning. However, when beliefs are considered as cognitive representations rather than affective perceptions (Nespor, 1987; Pajares, 1992), it is easier to understand this disconnect. Teaching is inherently a goal-directed activity. It is not undertaken strictly for purely intrinsic reasons, although many teachers do it out of love for learning or a desire to help and relate to children. Consequently, the extrinsic reasons for teaching become very important. OIT

considers different types of extrinsic motivation from an aspect of control vs autonomy, providing a way to obtain more information about the way in which certain external factors or internal perceptions and beliefs motivate the actions of individuals.

SDT is focused on why people do or do not pursue various types of goals rather than explaining the attributes of the goals themselves. Since beliefs are cognitive, people have a choice about whether or not to act on them (Hutner & Markman, 2017). The more autonomy a person perceives, the more likely they are to act on a goal. The amount of perceived control in the form of external barriers or internal beliefs about ability serves as a filter for these choices. The importance of context and contextual barriers makes sense in OIT. In fact, some barriers may be more significant than others, depending on the context. If an individual is intent on a specific goal that cannot be cognitively reconciled (or rationalized) within their belief system, frustration and extreme guilt can result, as in Faith's case. Beliefs are filtered through contexts and the more important the barrier, the less likely an individual might be to act on a specific goal. Conversely if there is perceived support within the context or the individual has the internal or external resources to overcome barriers, they might be motivated to act on the goal. This might occur to varying extents depending on the results of their actions.

External Factors as Barriers and Support

An important reason for using OIT as a lens to examine the beliefs/practice disconnect is its inclusion of external barriers and supports as part of the control versus autonomy view of autonomous motivation and self-determined behavior. Ryan and Deci (2000a) state that OIT "was introduced to detail the different forms of

extrinsic motivation and the contextual factors that either promote or hinder internalization and integration of the regulation for these behaviors" (p. 61). The differences between the low and high CPSIT teacher groups in this study are most pronounced in the areas of external factors and support from others. Teachers in the low group see most of the external factors in their context as barriers, while those in the higher group see them as something they are able to overcome. This is because they also perceive they have institutional and educational support from their principals and districts in addition to their high sense of efficacy.

When teachers are provided with curriculum materials, time in the schedule, relevant science professional development, and at least the perception of principal endorsement of what they are doing, their motivation to persist and work toward improvement is enhanced. In this study, curriculum materials stand out as a critical source of support. All three of the teachers in the high CPSIT group have a kit curriculum that provides them with materials, lessons, and a detailed implementation guide for teaching standards-aligned science in their classroom. This gives them an opportunity to teach science in a way that aligns with the beliefs about science teaching they have internalized through education, experience, and professional development.

OIT continuum example from the data. There are four teachers in the study from a district that has adopted the kit curriculum (Jenna, Kelly, Carol, and Gayle). A closer look at these teachers provides a snapshot of how the OIT continuum can provide insight into the different factors that result in different types of regulation.

Gayle - external regulation. Gayle is in the low CPSIT group. She is alternatively certified, so she never had a science methods course. Her administrator takes a hands-off approach to science and has delegated leadership responsibilities to the lead science teacher. Gayle feels the lead teacher does not have enough time to provide her with the assistance she needs. She feels the kit curriculum was forced on her with no chance to learn about it, or time to implement it. Professional development was offered, but it would have been on her own time and she did not take advantage of it. She does not feel it would have been enough anyway. Even though she likes science and thinks it is important, she has low efficacy for any type of instruction that does not involve intensive vocabulary development and textbook reading. In addition, Gayle was required to share kits with another teacher, which she feels was inconvenient and impossible to manage. She finally used her own money to buy a science test curriculum book with readings and worksheets she can give her students because she cannot get access to the materials in the kits. She says this works better for her anyway because she can see if her students are learning by grading the worksheets. She does not know how to effectively and fairly grade the notebooks they use with the kits because she says her students do not write very well.

Gayle perceives almost every resource available to her as a barrier. She also feels unsupported by her school and district. She exhibits external regulation because she perceives control almost exclusively rather than autonomy. She has few internal resources to draw on because of her low efficacy, low student ability perceptions, and a disconnect between her beliefs about how students learn and the constructivist curriculum she feels was forced on her with no support.

Carol - introjected regulation. Carol teaches in the same school as Gayle. She does not mind that the administrator leaves her alone because it allows her to do what she wants. She feels she gets adequate help from the lead teacher when she needs it and works well with her science partner teacher. She likes science and is glad she is able to teach with the kits because her students like it much better. They were "bored" with the textbook last year. She has very high efficacy for teaching and, even though she is alternatively certified and does not know a lot of science content, she is willing and able to learn what she needs to know to provide her students with adequate science instruction. She wants them to have a good background when they go to 5th grade so they will do well on the test. She likes the kits because they have everything she needs to address the standards. She wants to be sure that, when her students get to a science class in middle school, their teachers will not be able to say, "What school did you come from because you're just stupid." She goes on to say, "So, I guess, it's kind of a reputation thing too." She admits to having some struggles with learning to teach the kits, but she and her teaching partner are taking it into account and are making plans to do it better next year. Carol says she does not feel she has much autonomy because everything is decided for her by the school or district, including the kit curriculum. She says she works hard to teach science because it is her job and it is what she is supposed to do for her students. She is beginning to like science more than she used to.

Carol is exhibiting introjected regulation. She teaches science to the best of her ability because she wants to do a good job. She also wants to make sure that others see that she has done what she needs to do for her students. It appears that she

is starting to identify with the goals that are thrust upon her with regard to science and may be developing some characteristics of identified regulation.

Kelly - introjected-identified regulation. Kelly is a 5th grade teacher, which means her students take the state mandated science test at the end of the year. They always do well and she does not feel a lot of pressure about it because she thinks science standards and testing are not a priority for the district. She is gratified by the fact that her students do better on the science test than the students of other teachers. She also takes pride in being known as the "science lady" in her school. She says students ask to be in her class because of this. Kelly is comfortable teaching science and is gaining confidence for teaching it as time goes on. She feels her science methods course in college was adequate and has helped her understand what it means to teach science effectively. She likes to attend professional development and seeks it out on her own because it helps her be a better teacher. Although she is supposed to teach equal amounts of science and social studies, Kelly admits to teaching more science because she likes it better. Her administrator supports her efforts to teach science and even included teachers in the creation of the master schedule which resulted in a dedicated block of time for science each day. She also does integration of science with her reading block as often as she is able. She believes that integrating science process with content is the best way to teach science and talks about giving students control of their own learning.

Kelly exhibits characteristics of both introjected and integrated regulation. Some of her motivation comes from her reputation as a good science teacher who knows how to engage students. The internal reward for this is prestige from the fact

that students want to be in her class and get good scores on the science test. However, she also shows characteristics of identified regulation in that she is teaching the way she feels students learn best. She attends science professional development to learn pedagogical strategies that match her beliefs and works on her content knowledge in order to become a better teacher. She has administrative support for science and states that she appreciates support from the district in the form of the expectation to teach science, which should also affect students other than her own. Her high sense of efficacy and belief in student ability provide her with the internal resources needed to perceive a higher level of autonomous motivation.

Jenna - identified-integrated regulation. Jenna is also a 5th grade teacher. Her students do well on the science test, which she says gives her good information about how she is doing with her students. She does not really worry about other teachers' scores. She endorses student-centered learning and uses it with her students. She is excited to have the kits to help her provide the type of learning she endorses. She feels she has the freedom to go beyond what is done in the kit curriculum to be sure her students are able to experience more opportunities for the 3-dimensional learning that is specified by the new standards. Even though her students will not be tested on the new standards this year, she is using them to guide her teaching because she feels confident her students will learn better this way and will still be able to do well on the old test. Jenna has high efficacy for science and science instruction and considers science to be her "forte." She would like it if her school departmentalized so she could teach more science. Her administrator provides her with support for teaching science and Jenna is comfortable asking her if she can make changes to the

curriculum pacing schedule if she sees a specific need for her students. Jenna calls herself a rule follower, so she always asks permission to do anything outside the rules or schedules set for the teachers by administration. She is confident that she will be supported in doing this because she always has good rationales for making changes and her administrator trusts her judgement. As department chair, the success she has experienced with the kit curriculum in the current year has inspired her to make sure that every teacher in her school uses the kit curriculum next year, since many are not currently doing it. She decided to wait until she was sure the curriculum was something worth supporting. Her experience has validated this position and she is determined to use her leadership role to make it a priority for others.

Jenna exhibits an identified regulation pattern. She personally identifies with reasons for the importance of student-centered science teaching and is acting on them out of volition rather than control. It is possible she is moving in the direction of integrated regulation, although her rule-following tendencies might interfere with her ability to achieve full autonomy. She seems on her way to accepting and integrating the behavior into her own internal value system, making student-centered science instruction a largely volitional activity for her.

Autonomous motivation and the OIT continuum. These four examples show a full range of extrinsic motivational stances as described in the OIT continuum. While the overall pattern in the data may appear to show that an aligned, active learning curriculum is all teachers need to shift their motivational stance from control to autonomy, Gayle (and even Carol) demonstrate otherwise. These examples indicate that there are multiple ways in which beliefs and perceptions influence instructional

time, persistence, and methodology for elementary science teachers. First and foremost in this study are the internal resources that teachers possess providing them with the belief that they have the capability to provide science instruction and that what they do will have a positive outcome. This aligns with previous research on teacher efficacy beliefs about science instruction (Cronin-Jones, 1991; Czerniak & Lumpe, 1996; Evans, 2011; Jones & Carter, 2007; Knaggs & Sondergeld, 2015; Palmer, D., 2002) showing a direct effect of beliefs on teacher practice. Self-determination theory holds that competence is a necessary condition of autonomous motivation. The data in this study show this relationship as well. Although competence appears to play a big role, the data in this study also show that this is not the only factor affecting teacher autonomy. Belief in student ability and valuing of science for students also affect the decisions teachers make about the amount and type of science instruction to provide for their students.

A key finding in this study is the extent to which external factors influence teachers' autonomous motivation. In the OIT continuum these factors represent barriers that thwart autonomy and are controlling in the teaching context. Scheduling is a highly controlling factor in the world of an elementary teacher. Schedules usually come from administration and are important for making the school day manageable for student learning and safety. This is generally not negotiable to any significant extent and can often serve as a barrier to science instruction, especially if the time is short and not valued by administration to the overall success of the school. Although a pattern emerged from the data with relation to CPSIT and teacher autonomy, instructional time cannot be considered a predictor of teacher autonomy because of its

controlling nature. However, using CPSIT provided a means to select teachers for maximum variation in science practices to explore differences in autonomy as they relate to practice.

Other external factors emerging as significant barriers for low autonomy teachers are their unfamiliarity with the new standards and priorities given to other subject areas because of high stakes testing. Banilower et al. (2013) found similar results in a national survey of mathematics and science teachers. The extent to which teachers perceive these as controlling factors that interfere with their autonomy determines the degree to which they engage in science teaching behaviors. If they perceive the effort it takes to do student-centered instruction as a major barrier, it has an even greater effect on their motivation to engage. These teachers can be identified as falling on the lower (more controlled) end of the OIT continuum. Simply speaking, they need more support for science instruction than they are getting.

Curricular support in the form of materials and lessons that address the standards emerged in this study as the most important support needed for elementary teachers. It makes sense that curriculum and materials are high on the list of needs from the perspective of a busy teacher with many mandates to address in multiple content areas. Elementary teachers in self-contained classrooms must budget their time and instructional effort. In a system where science is undervalued, support in the form of curriculum and time seem reasonable if science is to be included in students' educational program, especially given its important role in the new science education standards. Addie expresses her frustration this way, "I really wish the State

Department would just give us a list of science experiments that every 5th grader should do instead of us trying to pick some."

Gayle's situation illustrates an example where curriculum materials are not enough to increase her sense of autonomy. They may even have contributed to her perception of high control, given that she has a lower endorsement of student-centered learning and a required constructivist curriculum. With her low efficacy, she likely needs professional development experiences specific to her curriculum and success using it to increase her confidence. The amount and type of support teachers need appears to be related to their place on the OIT continuum and the combination of specific factors that put them there. Support can remove barriers and increase teachers' overall perception of autonomy, moving them to higher levels in the OIT continuum. When teacher practice is viewed through this lens, it provides an avenue to determine the kind of support a teacher in a particular circumstance needs to succeed and persist. It also could reduce stress, decrease teacher burnout, and increase teacher retention (Deci & Ryan, 2000; Skaalvik & Skaalvki, 2009).

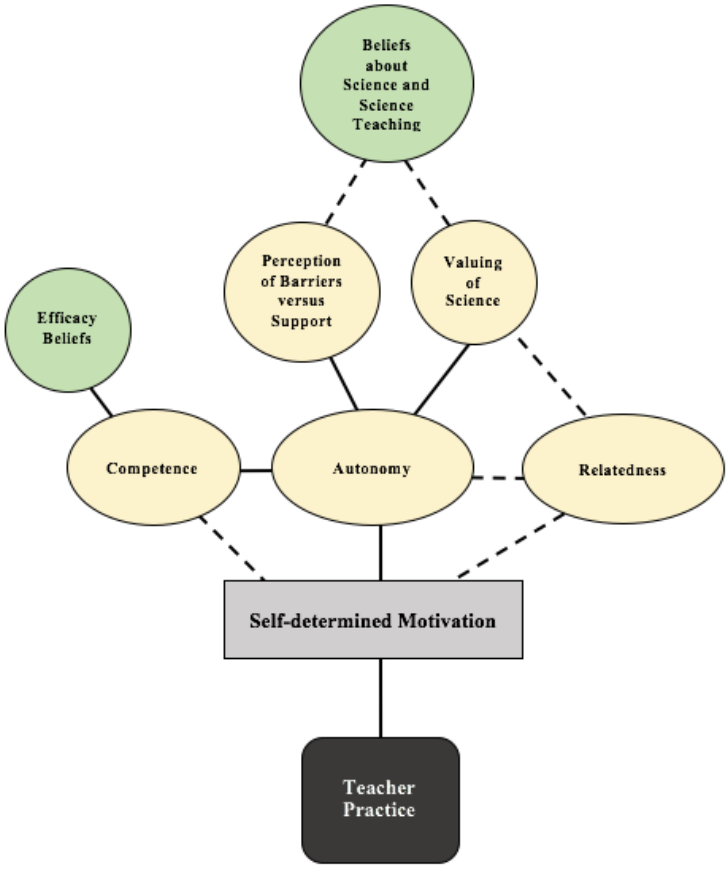
SDT as a Lens for Examining Science Teaching Beliefs and Practice

A major purpose for conducting this study was to determine if SDT could be used as a fresh lens to look at connections between teacher beliefs and practices. Although it has been determined that teacher beliefs undoubtedly inform their practice, the exact mechanism through which this occurs has not been agreed upon. This is due, in part, to conflicting results in the literature regarding the effects of teacher efficacy beliefs and science learning beliefs on their teaching practice (Mansour, 2009). Data in these studies show that teachers do not always teach in

ways that reflect their beliefs about science and science teaching. To date, SDT has not been utilized to look at teacher beliefs as they relate to instruction in context.

The data in this study were gathered with the goal of determining if the SDT needs perspective and the autonomy perceptions described in the OIT continuum could provide a way to examine the beliefs-practice inconsistency in science education literature. In Chapter 2, a diagram was provided showing the proposed connections between beliefs and practice from an SDT needs perspective. After analysis, the diagram was revised to show the connections that were found in the data (*Figure 5.2*). This diagram is not intended to be a conceptual model, but rather an illustration of connections seen and discussed from the data.

Figure 5.2 - Beliefs and Practice Connections from Data - SDT Perspective



As expected, a connection between the need for competence and autonomy was shown in the study (Deci & Ryan, 1985). There is a dotted line between these two ideas in the model because no direct connection was shown between competence and self-determined motivation in the data from this study. Faith provided an instance in which there was perceived competence with a low level of self-determination, so no direct link was demonstrated. The other teachers with low perceived competence also had low autonomy perceptions. Even though SDT proposes that all three needs must be met for intrinsic motivation, the OIT continuum suggests that the levels of competence and autonomy can vary and that competence does contribute to the overall picture of self-determination. The data provide evidence for the proposition set forth in cognitive evaluation theory (CET) that an individual can feel competent without necessarily feeling autonomous but cannot feel autonomous without competence (Ryan & Deci 2000). The autonomy connection in the diagram relates to self-determined motivation through the regulation levels in the OIT continuum. These connections are linked to the reasons for action rather than the specific goals they represent, which is the premise of SDT. The diagram indicates data-driven connections rather than predictions.

Although not explored in depth, the need for relatedness also showed connections with what research says about the importance of the teacher student relationship for motivating teachers to engage in effective teaching practices. The teachers in the study all expressed their desire to teach science because it has value for their students, no matter their own feelings for science (Baard, Deci, & Ryan, 2004; Crawford, 2007; Holzberger, Philipp, & Kunter, 2014). The relatedness connection to

self-determined motivation was incidental and does not have strong data support, so the connecting line in the diagram is dotted. A dotted line was added between valuing of science and relatedness because of the expressions of value of science for students as a part of the teacher student relationship. It, too, is a dotted line.

The above connections appeared in the proposed diagram in Chapter 2. Other elements were changed or added in the final diagram. Two factors from SDT are included as connections to autonomy. Valuing of science is connected to autonomy because perceived value is important for internalizing externally motivated behaviors and increasing autonomy levels. Barriers and support represent the external contextual factors and are also connected to autonomy perceptions. These two factors mediate between teacher beliefs and autonomy perception. The lines are dotted because they are new connections, although evidence from this study supports them. This is where the difference occurs between the beliefs/practice science education literature and the motivation perspective. The contextual factors are subsumed into the model rather than being peripheral to it. They seem to function as mediating cognitive factors that affect enacted behavior (Hutner & Markman, 2017). This has the potential to explain why beliefs about science and science learning do not always result in associated or expected classroom behaviors.

In this study, examining teacher perceptions and behaviors through their position within the OIT continuum provided a plausible and novel way to think about connections between beliefs and behaviors. Theoretical patterns and explanations for inconsistencies were found within the OIT structure. Since the continuum provides a comprehensive view of autonomous motivation that includes contextual factors, its

explanatory value is increased for complex contexts such as elementary teaching, especially when little direct association between beliefs and practice can be made. In a cognitive belief system where desired goals can be disconnected from core beliefs by mediating factors that are often contextual, a model that considers these contextual factors has the potential to clarify seeming inconsistencies between beliefs and practice (Hutner & Markman, 2016). The OIT continuum offers possible explanations for all or most of beliefs and practice connections examined in this group of teachers, thus indicating that it has the capacity to sort out connections between teacher beliefs and practices either on its own or as part of a more complex model.

Implications for Practice

The most obvious practical implication of this study is the need for additional support for elementary teachers trying to teach science in a system where science has lower priority than other content areas, despite its importance for teaching students about the world in which interact with other people and their environment. A strong finding from the study is the need for curriculum aligned to current science standards. Elementary teachers do not have the time, experience, or access to design a science curriculum from a potpourri of available resources. This problem is urgent but difficult because resources aligned to the new standards are in short supply, even though these standards are in effect in many states. In my experience, there are almost no curricula that are aligned to the 3-dimensional structure of the new standards, although some are better than others. Even if teachers have access to acceptable curricular materials, they still need professional development to help them implement

the curriculum and understand the underlying pedagogy behind the standards, which is new for many teachers.

In the absence of aligned curricula, professional development should at least fill in the gaps that exist in teacher understanding of the value in and pedagogy of 3-dimensional learning and instruction. Administrators and districts should also be included in professional development opportunities to help them understand the importance of science instruction that fosters critical thinking and the constructing of arguments from evidence that are the foundation of a literate society in the 21st century. The study also shows that the professional learning needs for teaching science are not a one-size-fits-all proposition for teachers. Supporting teacher autonomy for science teaching is tied to their individual beliefs and knowledge. The study shows that this varies widely. Careful consideration of teacher needs will allow the design of more targeted and relevant learning for teachers. This will, in turn, increase their motivation for participating in more professional development opportunities resulting in a culture of effective science instruction.

The study also has implications for preservice teacher education. Providing instruction that models and emphasizes the importance of student-centered science pedagogy may not be enough for new teachers to be able to enact it as practice in their future classroom. Preservice education programs might also consider providing their students with strategies for developing action goals that will help them utilize student-centered teaching within contexts that may provide barriers to the type of instruction they believe will benefit their students (Hutner & Markman, 2017).

Limitations

There are several limitations to this study because it is a convenience sample. The sample includes a relatively small number of schools in only one state, so it may not be possible to generalize the results to a larger population. The exploratory nature of the study makes this less of a problem than it might be otherwise, but it is still an issue for informing further research on a topic that has received very little study to date. Since the participants come from schools of varying sizes in various locations within the state diverse viewpoints and teaching practices are represented to the largest possible extent.

Some limitations exist regarding the quantitative sampling process in this study, again related to the fact that this is a convenience sample that relies on teacher self-report. There is a possibility that teachers may not have reported instructional time accurately because, despite privacy assurances, they were afraid their responses might negatively affect their employment or self-efficacy. Additionally, those that did not provide contact information for interviews may have answered in a different way from those who did agree to be contacted. This could result in a less representative sample for the qualitative aspect of the study and less opportunity for group comparison.

The participants were recruited from schools participating in professional development sessions that were mostly directed toward science and math. There is a good chance that these participants could have a more positive view of science instruction than the larger population because they may have sought out the professional development out of interest in the topic. This is somewhat discouraging given the low CPSIT average in the quantitative sample. Some of the participants

were recruited from professional development provided by the researcher. This could have resulted in interviewer bias from participants providing socially desirable responses that they think the interviewer wants to hear.

The OIT regulations have typically been studied using quantitative instrumentation. The qualitative approach is just now starting to be explored in this area. Some validity issues could occur with inductive interpretation of the levels of regulation in OIT. Since there are currently few instruments for measuring SDT constructs related to autonomy perceptions from the OIT continuum for teachers and none related to science teaching, the exploratory approach was taken to determine if there could be value in the construction of such an instrument. Care was taken to have interview transcripts and data analysis examined and triangulated by another researcher to avoid possible instances of misinterpretation.

Directions for Future Research

Since this is an exploratory study, there are several opportunities for future research using SDT paradigms to explore teacher beliefs and the practice of science instruction. It will be important to verify the results of the study in multiple ways. Notably, the examination of autonomous motivation for science teaching should be explored through valid and reliable instrumentation to find connections and verifiable correlations between belief constructs, SDT motivation constructs, and teacher practice.

Case studies might also provide an avenue for finding out more about the role of mediating contextual factors between teacher beliefs and science teaching. A serendipitous mini-case study occurred within this study involving four teachers with

the same curriculum in the same district. This provided an opportunity to explore a common curriculum as a source of support for science teaching and examine psychological or contextual factors which ensure or constrain its use. Since there is already a sizeable body of research on student autonomy support, this research strategy could be used with other contextual factors to determine more specifically what constitutes autonomy support for teachers.

The OIT perspective could be added to existing models of teacher beliefs and practice to determine if it increases the explanatory value of the model. There are other possibilities for studying the SDT perspective on motivation for teacher practice but before this can occur, the results of this small study need to be verified. The approach is promising but untested.

References

Adb-El-Khalick, F., & Lederman, N. G. (2000). Improving science teachers' conceptions of the nature of science: A critical review of the literature. *International Journal of Science Education, 22*(7), 665-701.

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50,* 179-211.

Alderfer, C. P. (1969). An empirical test of a new theory of human needs. *Organizational Behavior and Human Performance, 4,*142-175.

Allinder, R. M. (1994). The relationship between efficacy and the instructional practices of special education teachers and consultants. *Teacher Education and Special Education*, *17*, 86-95.

Ames, C. (1992). Classrooms: Goals, structures, and student motivation. *Journal of Educational Psychology, 84*, 261–271.

American Association for the Advancement of Science (AAAS). (1993). *Benchmarks for science literacy: A Project 2061 report*. New York: Oxford University Press.

Anderson, R. (2002). Reforming science teaching: What research says about inquiry. *Journal of Science Teacher Education, 13*(1), 1-12.

Appleton, K. (2007). Elementary science teaching. In S. Abell & N. Lederman (Eds.), *Handbook of research on science education,* (pp. 493-535). Mahwah, NJ: Lawrence Erlbaum Associates.

Assor, A. Kaplan, H., & Roth, G. (2002). Choice is good, but relevance is excellent: Autonomy-enhancing and suppressing teacher behaviors predicting students'

engagement in schoolwork. *British Journal of Educational Psychology, 72,* 261-278.

Atkinson, J., & Feather, N. (1966). *A theory of achievement motivation*. New York: Wiley and Sons.

Au, W. (2007). High stakes testing and curricular control: A qualitative metasynthesis. *Educational Researcher, 36*(5), 258-267.

Baard, P. P., Deci, E. L., & Ryan, R. M. (2004). Intrinsic need satisfaction: A motivational basis of performance and well-being in two workplace settings. *Journal of Applied Social Psychology, 34*(10), 2045-2068.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, *84*(2), 191-215.

Banilower, E. R., Smith, P. S., Weiss, I. R., Malzahn, K. A., Campbell, K. M., & Weis, A. M. (2013). *Report of the 2012 National Survey of Science and Mathematics Education.* Chapel Hill, NC: Horizon Research, Inc.

Baumeister, R., & Leary, M. (1995). The need to belong. Desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin*, 117, 497–529.

Benware, C., & Deci, E. L. (1984). Quality of learning with an active versus passive motivational set. *American Educational Research Journal, 21,* 755-765.

Bieg, S., Backes, S., & Mittag, W. (2011). The role of intrinsic motivation for teaching, teachers' care and autonomy support for students' self-determined motivation. *Journal for Educational Research Online, 3*(1), 122-140.

Black, A. E., & Deci, E. L. (2000). The effects of instructors' autonomy support and students' autonomous motivation on learning organic chemistry: A self-determination theory perspective. *Science Education, 84,*740–756.

Bransford, J. D., Brown, A. L. & Cocking, R. R. (Eds.). (2000). *How people learn: Brain, mind, experience, and school*. Washington, DC: National Academies Press.

Bransford, J. D. & Donovan, M. S. (2005). Scientific inquiry and how people learn. In M. S. Donovan & J. D. Bransford (Eds.), *How students learn: Science in the classroom*, (pp. 397-419). Washington DC: National Academies Press.

Bryan, L. A. & Abell, S. K. (1999). Development of professional knowledge in learning to teach elementary science. *Journal of research in Science teaching, 36*(2), 121-139.

Buehl, M. M., & Beck, J. S. (2014). The relationship between teachers' beliefs and teachers' practices. In H. Fives and M. Gregoire Gill (Eds.), *Handbook of Research on Teachers' Beliefs*. New York, NY: Routledge.

Buss, R. R. (2010). Efficacy for Teaching Elementary Science and Mathematics Compared to Other Content. *School Science and Mathematics*, *110*, 290–297. doi: 10.1111/j.1949-8594.2010.00037.x

Butler, R. (2014). What teachers want to achieve and why it matters: An achievement goal approach to teacher motivation. In P.W. Richardson, S.A. Karabenick, & H.M. Watt (Eds.), *Teacher motivation: Theory and Practice* (pp. 20-35). New York, NY: Routledge.

Bybee, R. W. (2014). The BSCS 5E Instructional Model: Personal Reflections and Contemporary Implications. *Science and Children*, *51*(8), 10-13.

Bybee, R., McCrae, B., & Laurie, R. (2009). PISA 2006: An assessment of scientific literacy. *Journal of Research in Science Teaching, 46*(8), 865-883.

Byers, A., & Fitzgerald, M. A. (2009). Networking for leadership, inquiry, and systemic thinking: A new approach to inquiry-based learning. *Journal of Science Education and Technology, 11*(1), 81-91.

Cady, J. A. & Rearden, K. (2007). Pre-service teachers' beliefs about knowledge, mathematics, and science. *School Science and Mathematics, 107*(6), 237-245.

Carey, K. (2008, September 17). The teacher autonomy paradox. *The American Prospect.* Retrieved from http://prospect.org/article/teacher-autonomy-paradox.

Charmaz, K. C. (2006). *Constructing grounded theory: A practical guide through qualitative analysis*. Thousand Oaks, CA: Sage.

Choi, S. & Ramsey, J. (2010). Constructing Elementary Teachers' Beliefs, Attitudes, and Practical Knowledge Through an Inquiry-Based Elementary Science Course

Ciani, K. D., Sheldon, K. M., Hilpert, J. C., & Easter, M. A. (2011). Antecedents and trajectories of achievement goals: A self-determination theory perspective. *British Journal of Educational Psychology*, *81*, 223–243.

Coladarci, T. (1992). Teachers' sense of efficacy and commitment to teaching. *Journal of Experimental Education, 60*, 323-337.

Collins, K. M. T., Onwuegbuzue, A. J., & Sutton, I. L. (2006). A model incorporating the rationale and purpose for conducting mixed methods research in special education and beyond. *Learning Disabilities: A Contemporary Journal, 4*, 67-100.

Corbin, J. & Strauss, A. (2008). *Basics of qualitative research (3rd ed.).* Thousand Oaks, CA: Sage.

Corcoran, T., Mosher, F. A., & Rogat, A. (2009). *Learning progressions in science: An evidence-based approach to reform*. Center on Continuous Instructional Improvement. Teachers College, Columbia University.

Cordova, D. I. & Lepper, M. R. (1994). Intrinsic motivation and the process of learning: Beneficial effects of contextualization, personalization, and choice. *Journal of Educational Psychology, 88*,(4). 715-730.

Crawford, B. (2007). Learning to teach science as inquiry in the rough and tumble of practice. *Journal of Research in Science Teaching,44*(4), 613-642.

Crawford, J. R. (2001). Teacher autonomy and accountability in charter schools. *Education and Urban Society, 33*(2), 186-200.

Creswell, J. W. (2003). *Research Design: Qualitative, Quantitative, and Mixed methods Approaches (2nd ed.).* Thousand Oaks, CA: Sage Publications.

Creswell, J. & Plano-Clark, V. (2007). *Designing and Conducting Mixed Methods Research*. Thousand Oaks, CA: Sage Publications.

Cronin-Jones, L. (1991). Science teacher beliefs and their influence on curriculum implementation: Two case studies. *Journal of Research in Science Teaching, 28*(3), 235-250.

Cuban, L. (2009). *Hugging the Middle: How Teachers Teach in an Era of Testing and Accountability.* New York, NY: Teachers College Press.

Culbert, S. A. (2011, March 6). Allow more autonomy. *The New York Times*. Retrieved from http://www.nytimes.com/roomfordebate/2011/03/27/how-to-raise-the-status-of-teachers/give-teachers-autonomy

Czerniak, C. M., & Lumpe, A. T. (1996). Relationship between teacher beliefs and science education reform. *Journal of Science Teacher Education, 7*(4), 247-266.

Darner, R. (2009). Self-determination theory as a guide to fostering environmental motivation. *The Journal of Environmental Education, 40*(2), 39-49.

Davis, E. A., Petish, D., & Smithey, J. (2006). Challenges new science teachers face. *Review of Educational Research, 76*(4), 607-651.

Davis, J., & Wilson, S. M. (2000). Principals' efforts to empower teachers: Effects on teacher motivation and job satisfaction and stress. *The Clearinghouse, 73*(6), 349-353.

de Charms, R. (1968). *Personal causation: The internal affective determinants of behavior*. New York: Academic Press.

Deci, E. L. (1971). Effects of externally mediated rewards on intrinsic motivation. *Journal of Personality and Social Psychology,* 18, 105–115.

Deci, E. L. (2009). Large scale school reform as viewed from the self-determination theory perspective. *Theory and Research in Education, 7,* 244-252.

Deci, E. L., Koestner, R., & Ryan, R. M. (2001). Extrinsic rewards and intrinsic motivation in education: Reconsidered once again. *Review of Educational Research, 71*(1), 1-27.

Deci, E. L., & Ryan, R. M. (Eds.). (2002). Handbook of self-determination research. Rochester, NY, US: University of Rochester Press.

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior.* New York: Plenum.

Deci, E. L., & Ryan, R. M. (1987). The support of autonomy and the control of behavior. *Journal of Personality and Social Psychology, 53,* 1024–1037.

Deci, E. L., & Ryan, R.M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry, 11*(4), 227-268.

Deci, E. L., & Ryan, R. M. (2002). Overview of self-determination theory: An organismic dialectical perspective. In E. L. Deci & R. M. Ryan (Eds.), Handbook of self-determination research (pp. 3-33). Rochester, NY: University of Rochester Press.

Deci, E. L., Ryan, R. M., & Williams, G. C. (1996). Need satisfaction and the self-regulation of learning. *Learning and Individual Differences,8*(3), 165-183.

Deci, E. L., Vallerand, R. J., Pelletier, L. G. & Ryan R. M. (1991). Motivation and education: The self-determination perspective. *Educational Psychologist, 26*(3&4), 325-346.

Dewey, J. (1933). *How We Think*. Lexington, MA: D.C. Heath.

DiCicco-Bloom, B., & Crabtree, B. F. (2006). The qualitative research interview. *Medical Education*, 40, 314-321.

Dorph, R., Shields, P., Tiffany-Morales, J., Hartry, A., McCaffrey, T. (2011). *High hopes – few opportunities: The status of elementary science education in California.* Sacramento, CA: The Center for the Future of Teaching and Learning at WestEd.

Duschl, R., & Wright, E. (1989). A case study of high school teachers' decision making models for planning and teaching science. *Journal of Research in Science Teaching, 26*(6), 467-501.

Dweck, C. S. (1986). Motivational processes affecting learning. American Psychologist, 41, 1040– 1048.

Ebert II, E. S., Ebert, C. & Bentley, M. L. (2013). *The educator's field guide: From organization to assessment*. Available from http://dx.doi.org/10.4135/9781452275154

Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology, 53,* 109–132.

Elliot, A. J., & Haracjiewicz, J.M. (1996). Approach and avoidance achievement goals and intrinsic motivation: A mediational analysis. *Journal of Personality and Psychology, 70*(3), 461-475.

Esach, H. (2003). Inquiry-events as a tool for changing science teaching efficacy belief of kindergarten and elementary school teachers. *Journal of Science Education and Technology 12*(4), 495-501.

Evans, B. (2011). Content knowledge, attitudes, and self-efficacy in the mathematics New York City Teaching Fellows Program (NYCTFP). *School Science and Mathematics, 111*(5), 225-235.

Evans, E. D., & Trimble, M. (1986). Perceived teaching problems, self-efficacy and commitment to teaching among preservice teachers. *Journal of Educational Research, 80*(2), 81-85.

Ezzy, D., (2002). *Qualitative analysis: Practice and innovation*. New fetter Lane, London: Routledge.

Fang, Z. (1996). A review of research on teacher beliefs and practices. *Educational Research, 38*(1), 47-65.

Felder, R. M., & Brent, R. (2009). Active learning: An introduction. *ASQ Higher Education Brief, 2*(4).

Fernet, C. (2012). Development and validation of the work role motivation scale for school principals. *Educational Administration Quarterly, 47*(20), 307-331.

Fleischman, H. L., Hopstock, P. J., Pelczar, M. P., & Shelley, B. E. (2010). *Highlights from PISA 2009: Performance of U.S. 15-year-old students in reading, mathematics, and science literacy in an international context* (NCES 2011-004). U.S. Department of Education, National Center for Education Statistics. Washington, DC: U.S. Government Printing Office.

Gabriel, R., Day, J. P., & Allington, R. (2011). Exemplary teacher voices on their own development. *Kappan,92*(8), 37-41.

Gagne´, M., & Deci, E. L. (2005). Self-determination theory and work motivation. *Journal of Organizational Behavior*, 26(4), 331–362.

Gagné, M., Forest, J., Gilbert, M., Aubé, C. Morin, E., & Malorni, A. (2010). The motivation at work scale, Validation evidence in two languages. *Educational and Psychological Measurement, 70*(4), 628-646.

Gall, M. D., Gall, J. P., & Borg, W. R. (2007). *Educational research: An introduction.* Boston, MA: Pearson Education.

Gess-Newsom, J., Southerland, S. A., Johnston, A., & Woodbury, S. (2003). Educational reform, personal practical theories, and dissatisfaction: The anatomy of change in college science teaching. *American Educational Research Journal, 40*(3), 731-767.

Gibson, S., & Dembo, M. (1984). Teacher efficacy: A construct validation. *Journal of Educational Psychology, 76*(4), 569-582.

Glaser, B. G. & Strauss, A. L. (1967). *The discovery of grounded theory: Strategies for qualitative research*. Chicago, IL: Aldine Publishing Company.

Gonzalez, H. B., & Kuenzi, J. J. (2012). Science, technology, engineering, and mathematics (STEM) education: A primer. Congressional Research Service, Library of Congress

Greene, J. C., Caracelli, V. J., & Graham, W. F. (1989). Toward a conceptual framework for mixed-method evaluation designs. *Educational Evaluation and Policy Analysis, 11,* 255-274.

Guay, F., Vallerand, R. J., & Blanchard, C. (2000). On the assessment of situational intrinsic and extrinsic motivation: The situational motivation scale. *Motivation and Emotion, 24*, (3), 176-213.

Guskey, T. R. (1988). Teacher efficacy, self-concept, and attitudes toward the implementation of instructional innovation. *Teaching and teachereducation, 4*(1), 63-69.

Haggar, M. S., & Chatzisarantis, N. (2011). Causality orientations moderate the undermining effect of rewards on intrinsic motivation. *Journal of Experimental Social Psychology, 47*, 485-489.

Hardré, P. L., & Reeve, J. (2003). A motivational model of rural students' intentions to persist in, versus drop out of high school. *Journal of Educational Psychology, 95*(2), 347-356.

Hawthorn, R .K. (1986). The professional teacher's dilemma: Balancing autonomy and obligation. *Educational Leadership*, *44*(2), 34-35.

Heider, F. (1958). *The psychology of interpersonal relations.* New York: Wiley.

Heyman, G. D., & Dweck, C. S. (1992). Achievement goals and intrinsic motivation: Their relation and their role in adaptive motivation. *Motivation and Emotion, 16,* 231-247.

Hodson, D. (1993). Philosphic stance of secondary school science teachers, curriculum experiences, and children's understanding of science: Some preliminary findings. *Interchange, 24*(1-2), 41-52.

Holzberger, D., Philipp, A., & Kunter, M. (2014). Predicting teachers' instructional behaviors: The interplay between self-efficacy and intrinsic needs. *Contemporary Educational Psychology, 39,* 100-111.

Hoy, A.W., & Spero, R.B. (2005). Changes in teacher efficacy during the early years of teaching: A comparison of four measures. *Teaching and Teacher Education, 21,* 343-356.

Hubbard, P., & Abell, S. (2005). Setting sail or missing the boat: Comparing the beliefs of preservice elementary teachers with and without an inquiry-based physics course. *Journal of Science Teacher Education, 16,* 5-25.

Hull, C. L. (1943). *Principles of behavior: An introduction to behavior theory*. New York: Appleton-Century-Crofts.

Hutner, T. L., & Markman, A. B. (2016). Proposing an operational definition of science teacher beliefs. *Journal of Science Teacher Education, 27*, 675-691.

Hutner, T. L. & Markman, A. B. (2017). Applying a goal-driven model of science teacher cognition to the resolution of two anomalies in research on the relationship between science teacher education and classroom practice. *Journal of Research in Science Teaching*. doi:10.1002/tea.21383

Ingersoll, R. (2003). *Who controls teachers' work? Power and accountability in American schools.* Cambridge, MA: Harvard University Press.

Johnson, R. B., & Onweugbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational Researcher, 33*(7), 14-26.

Johnson, R. B., Onwuegbuzie, A. & Turner, L. (2007) Toward a definition of mixed methods research. *Journal of Mixed Methods Research*, *1*(2), 112-133.

Jones, M. G. & Carter, G. (2007). Science teacher attitudes and beliefs. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research on science education,* (pp. 1067-1104). Mahwah, NJ: Lawrence Erlbaum Associates.

Jones, M. G., & Leagon, M. (2014). Science teacher attitudes and beliefs. In N.G. Lederman & S.K. Abell (Eds.), *Handbook of research on science education* (Vol. II, pp. 830–847). New York, NY: Routledge.

Joseph, J. (2010). *Does intention matter? Assessing the science teaching efficacy beliefs of pre-service teachers as compared to the general student population*. *Electronic Journal of Science Teaching, 14*(1). Retrieved from http://ejse.southwestern.edu.

Katz, I., & Assor, A. (2007). When choice matters and when it does not. *Educational Psychology Review, 19*, 429-442.

Keys, C. W., & Bryan, L. A. (2001). Co-constructing inquiry-based science with teachers: Essential research for lasting reform. *Journal of Research in Science Teaching, 38*(6), 631-645.

King, K., Shumow, L., & Lietz, S. (2001). Science education in an urban elementary school: Case studies of teacher beliefs and classroom practices. *Science Education, 85*(2), 89-110.

Klahr, D., & Li, J. (2005). Cognitive research and elementary sciencei: From the laboratory, to the classroom, and back. *Journal of Science Education and Technology, 14*(2), 217-238.

Knaggs, C. M., & Sondergeld, T. A. (2015). Science as a learner and as a teacher: Measuring science self-efficacy of preservice teachers. *School Science and Mathematics, 115*(3), 117-128.

Kocabas, I. (2009). The effects of sources of motivation on teachers' motivation levels. *Education, 129*(4), 724-733.

Koestner, R., Otis, N., Powers, T. A., Pelletier, L., & Gagnon, H. (2008). Autonomous motivation, controlled motivation, and goal progress. *Journal of Personality, 76*(5), 1201-1230.

Krajcik, J. (2015). Three dimensional instruction: Using a new type of learning in the classroom. *Science Scope, 39*(3), 16-18.

Land, S. M., & Hannafin, M. J. (2000). Student-centered learning environments: Foundations, assumptions, and implications. In D. Jonassen & S. Land (Eds.), *Theoretical foundations of learning environments,* (pp. 1-24). Mahwah, NJ: Lawrence Erlbaum Associates.

LeCompte, M. D. & Preissle, J. (1993). *Ethnography and qualitative design in educational research (2nd ed.)*. San Diego: Academic Press.

Lee, V. S. (2012). What is inquiry-guided learning?. *New Directions for Teaching & Learning*, *2012*(129), 5-14.

Lederman, N. G. (1999). Teachers' understanding of the nature of science and classroom practice: Factors that facilitate or impede the relationship. *Journal of Research in Science Teaching, 36*(8), 916-929.

Lederman, N. G. (2007). Nature of science: Past, present, and future. In S. Abell & N. Lederman (Eds.), *Handbook of research on science education,* (pp. 831-879). Mahwah, NJ: Lawrence Erlbaum Associates.

Lederman, N. G. (2014). Research on teaching and learning of nature of science. In N.G. Lederman & S.K. Abell (Eds.), *Handbook of research on science education* (Vol. II, pp. 600-620). New York, NY: Routledge.

Lepper, M. R. (1988). Motivational considerations in the study of instruction. *Cognition and Instruction, 5*(4), 289-309.

Madden, L., Beyers, J., & O'Brien, S. (2016). The importance of STEM education in the elementary grades: Learning from pre-service and novice teachers' perspectives. *Electronic Journal of Science Education, 20*(5). Retrieved from http://ejse.southwestern.edu.

Maehr, M. L. (1984). Meaning and motivation: Toward a theory of personal investment. In C. Ames & R. Ames (Eds.), *Research on motivation in education*, (pp. 115– 144). New York: Academic.

Maehr, M. L., & Sjogren, D.D. (1971). Atkinson's theory of achievement motivation: First step toward a theory of academic motivation? *Review of Educational Research, 41*(2), 143-161.

Maehr, M. L., & Zusho, A. (2009). Achievement goal theory: The past, present, and future. In K. R. Wentzel & A.Wigfield (Eds.), *Handbook of motivation at school* (pp.77–104). NewYork: Routledge.

Mansour, N. (2009). Science teachers' beliefs and practices: Issues, implications, and research agenda. *International Journal of Environmental and Science Education, 4*(1), 25-48.

Marshall, J., Horton, R., Igo, B., & Switzer, D. (2009). *International Journal of Science and Mathematics Education* (7), 575-596.

Marx, R. W. & Harris, C. J. (2006). No child left behind and science education: Opportunities, challenges, and risks. *The Elementary School Journal*, *106*(5), 467-478.

Maslow, A. H. (1943). A theory of human motivation. *Psychological Review*, 50(4), 370-96.

McLeod, J., Fisher, J. & Hoover, G. (2003) *The Key Elements of Classroom Management: Managing Time and Space, Student Behavior, and Instructional Strategies*. Alexandria, VA: ASCD.

Menon, D., & Sadler, T. D. (2016). Preservice elementary teachers' science self-efficacy beliefs and science content knowledge. *Journal of Science Teacher Education, 27*(6), 649-673.

Minner, D., Levy, A., & Century, J. (2010). Inquiry-based science instruction - what is it and does it matter? Results from a research synthesis years 1984 to 2002. *Journal of Research in Science Teaching, 47*(4), 474-496.

Morrison, J. A., Raab, F., & Ingram, D. (2009). Factors influencing elementary and secondary teachers' view on the nature of science. *Journal of Research in Science Teaching, 46*(4), 384-403.

Moulding, B., Bybee, R., & Paulsen, N. (2015). *A vision and plan for science teaching and learning: An educator's guide to a Framework for K-12 Science Education, Next Generation Science Standards, and state science standards.* Salt Lake City, UT: Essential Teaching and Learning Publications.

Murphy, M. (2014). *Orchestrating School Change: Transforming Your Leadership*. Huntington Beach, CA: Shell Educational Publishing.

National Research Council (NRC). (1996). *National science education standards*. Washington, DC: National Academy Press.

National Research Council (NRC). (2007). *Taking Science to School: Learning and Teaching Science in Grades K-8.* Committee on Science Learning, Kindergarten Through Eighth Grade. Duschl, R. A., Schweingruber, H. A, & Shouse, A. W. (Eds.). Board on Science Education, Center for Education. Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

National Research Council (NRC). (2011). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas.* Committee on a Conceptual Framework for New K-12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

National Science Teachers Association. (2004). NSTA position statement: Scientific inquiry. Retrieved March 29, 2011 (http://www.nsta.org/pdfs/PositionStatement_ScientificInquiry .pdf).

National Science Board. (2014). *Science and Engineering Indicators 2014*. Arlington VA: National Science Foundation (NSB 14-01).

National Science Board. (2015). *Revisiting the STEM workforce: A Companion to Science and Engineering Indicators 2014*, Arlington, VA: National Science Foundation (NSB-2015-10).

Nespor, J. (1987). The role of beliefs in the practice of teaching. *Journal of Curriculum Studies, 19*, 317-328.

NGSS Lead States. (2013). *Next generation science standards: For states, by state*s. Washington, DC: The National Academies Press.

NGSS Lead States. (2013a). Appendix H. *Next generation science standards: For states, by state*s. Washington, DC: The National Academies Press. Retrieved March, 28, 2017 http://www.nextgenscience.org/sites/default/files/resource/files/Appendix%20H%20-%20The%20Nature%20of%20Science%20in%20the%20Next%20Generation%20Science%20Standards%204.15.13.pdf

Nicholls, J. G. (1984). Achievement motivation: Conceptions of ability, subjective experience, task choice, and performance. *Psychological Review*, *91*(3), 328-346.

Niemiec, C. P., & Ryan, R. M. (2009). Autonomy, competence, and relatedness in the classroom. *Theory and Research in Education, 7*(2), 133-144.

Onweugbuzie, A. J., & Collins, K. M. (2007). A typology of mixed methods sampling designs in social science research. *The Qualitative Report, 12*(2), 281-316.

Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research, 62*(3), 307-332.

Palmer, D. (2002). Factors contributing to attitude exchange amongst preservice elementary teachers. *Science Education, 86*(1), 122-138.

Palmer, D. (2011), Sources of efficacy information in an inservice program for elementary teachers. *Science Education, 95*, 577–600.

Parker (nee Richardson), G. (2015). Teachers' autonomy. *Research in Education*, *93*(1), 19-33. doi:10.7227/RIE.0008

Patton, M. Q. (1990). *Qualitative Evaluation and Research Methods* (2nd ed.). Newbury Park, CA: Sage.

Patton, M. Q. (2002). *Qualitative Research and Evaluation Methods*. Thousand Oaks, CA: Sage Publications.

Pearson, L. C., & Hall, B. W. (1993). Initial construct validation of the teaching autonomy scale. *Journal of Educational Research, 86*(3), 172-178.

Pearson, L. C., & Moomaw, W. (2005). The relationship between autonomy and stress, work satisfaction, empowerment, and professionalism. *Educational Research Quarterly, 29*(1), 37-53.

Pelletier, L. G., Seguin-Levesque, C., & Legault, L. (2002). Pressure from above and pressure from below as determinants of teachers' motivation and teaching behaviors. *Journal of Educational Psychology, 94*(1), 186-196.

Piaget, J. (1936). *Origins of intelligence in the child.* London: Routledge & Kegan Paul.

Pintrich, P. R. (2000). The role of goal orientation in self-regulated learning. In M. Boekaerts, & P. R. Zeidner (Eds.), *Handbook of self-regulation* , (pp. 451-502). San Diego, CA, US: Academic Press.

Pintrich, P. R. (2012). An achievement goal perspective on issues in motivation terminology, theory, and research. *Contemporary Educational Psychology, 25*, 92-104.

Ramey-Gassert, L., Shroyer, M. G., & Staver, J. R. (1996). A qualitative study of factors influencing science teaching self-efficacy of elementary level teachers. *Science Education, 80*(3), 283-315.

Pollak, V. L. (1993). The spirit of science. *Journal of Science Education and Technology, 2*(4), 513-519.

Reeve, J. (2008). *Understanding motivation and emotion (5th ed.)*. Hoboken, NJ: Wiley.

Reeve, J. (2012). A self-determination theory perspective on student engagement. In Christenson, S.L., Reschly, A.L., & Wylie, C. (Eds.), *Handbook of Research on Student Engagement* (pp. 149-172). New York: Springer.

Reeve, J., Deci, E. L., & Ryan, R. M. (2004). Self-determination theory: A dialectical framework for understanding socio-cultural influences on student motivation. In S. Van Etten & M. Pressley (Eds.), *Big theories revisited* (pp. 31–60). Greenwich, CT: Information Age Press.

Reeve, J., Jang, H., Carrell, D., Barch, J., & Jeon, S. (2004). Enhancing high school students' engagement by increasing their teachers' autonomy support. *Motivation and Emotion, 28*, 147–169.

Reeve, J., Nix, G., & Hamm, D. (2003). *Journal of Educational Psychology, 95*(2), 375-392.

Roehrig, G. H., & Kruse, R. A. (2005). The role of teachers' beliefs and knowledge in the adoption of a reform-based curriculum. *School Science and Mathematics*, *105*(8), 412–422.

Roehrig, G. H., & Kruse, R. A. (2010). The role of teachers' beliefs and knowledge in the adoption of a reform-based curriculum. *School Science and Mathematics, 105*(8), 412-422.

Ross, J., & Bruce, C. (2010). Professional development effects on teacher efficacy: Results of randomized field trial. *The Journal of Educational Research,101*(1), 50-60.

Roth, K. J. (2014). Elementary science teaching. In N.G. Lederman & S.K. Abell (Eds.), *Handbook of research on science education* (Vol. II, pp. 361-393). New York, NY: Routledge.

Roth, G., Assor, A., Kanat-Maymon, Y., & Kaplan, H. (2007). Autonomous motivation for teaching; How self-determined teaching may lead to self-determined learning. *Journal of Educational Psychology, 99*(4). 761-774.

Rotter, J. B. (1954). *Social learning and clinical psychology*. NY: Prentice-Hall.

Rotter, J. B. (1966). Generalized expectancies for internal versus external control of reinforcement. *Psychological Monographs***,** 80 (1, Whole No. 609).

Russell, T., & Martin, A. K. (2014). Learning to teach science. In N.G. Lederman & S.K. Abell (Eds.), *Handbook of research on science education* (Vol. II, pp. 871–888). New York, NY: Routledge.

Ryan, R. M., & Connell, J. P. (1989). Perceived locus of causality and internalization: Examining reasons for acting in two domains. *Journal of Personality and Social Psychology, 57*(5), 749-761.

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, *55*(1), 68-78.

Ryan, R. M., & Deci, E.L. (2000a). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology, 25***,** 54–67.

Ryan, R. M., Rigby, S. & King, K. (1993). Two types of religious internalization and their relations to religious orientations and mental health. *Journal of Personality and Social Psychology,65*(3), 586-596.

Ryan, R. M., & Sapp, A. (2005). Considering the impact of test-based reforms: A self-determination theory perspective on high-stakes testing and student motivation and performance. *Unterrichwissenschaft, 33*, (2), 143-159.

Sadri, G., & Bowen, C .R. (2011). Meeting employee requirements: Maslow's hierarchy of needs is still a reliable guide to motivating staff. *Industrial Engineer*, 43(10), 44-48.

Samuelowicz, K., & Bain, J.D. (1992). Conceptions of teaching held by academic teachers. *Higher Education, 24*, 93-111.

Samuelowicz, K., & Bain, J. (2001). Revisiting Academics' Beliefs about Teaching and Learning. *Higher Education, 41*(3), 299-325.

Savasci, F., & Berlin, D .F. (2012). Teacher beliefs and classroom practice related to constructivism in different school settings. *Journal of Science Teacher Education,23*(1), 65-86.

Shank, G. D. (2002). *Qualitative research: A personal skills approach*. Columbus, Ohio: Merrill Prentice Hall.

Sheldon, K. M., & Hilpert, J. C. (2012). The balanced measure of psychological needs scale: An alternative domain general measure of need satisfaction. *Motivation and Emotion,* DOI 10.1007/s11031-012-9279-4.

Shim, M. K., Young, B. J., & Paolucci, J. (2010). Elementary teachers' views on the nature of scientific knowledge: A comparison of inservice and preservice teachers approach. *Electronic Journal of Science Education, 14*(1). Retrieved from http://ejse.southwestern.edu

Shriberg, D., & Shriberg, A. B. (2006). High-Stakes Testing and Dropout Rates. *Dissent*, *53*(4), 76-80.

Skaalvik, E. M., & Skaalvik, S. (2009). Does school context matter? Relations with teacher burnout and job satisfaction. *Teaching and Teacher Education, 25*, 518–524.

Song, L., Hannafin, M., & Hill, J. R. (2007). Reconciling beliefs and practices in teaching and learning. *Education Technology Research Development, 55,* 27-50.

Speer, N. (2005). Issues of methods and theory in the study of mathematics teachers' professed and attributed beliefs. *Educational Studies in Mathematics, 58*(3), 361-391.

Spence, K. W. (1958). A theory of emotionally based drive (D) and its relation to performance in simple learning situations. *American Psychologist*, *13*(4), 131-141.

Stefanou, C. R., Perencevich, K. C., DiCinto, M., & Turner, J.C. (2004). Supporting autonomy in the classroom Ways teachers encourage student decision making and ownership. *Educational Psychologist, 39*(2), 97-110.

Stephan, Y., Boiché, J., & LeScanff, C. 2010. Motivation and physical activity behaviors among older women: A self-determination perspective. *Psychology of Women Quarterly, 34,* 339-348.

Tashakkori, A., & Teddlie, C. (1998). *Mixed methodology: Combining qualitative and quantitative approaches.* Thousand Oaks, CA: Sage.

Tilgner, P. J. (1990). Avoiding science in the elementary school. *Science Education, 74*(4), 421-431.

Trépanier, S., Fernet, C., & Austin, S. (2013). The moderating role of autonomous motivation in the job demands-strain relation: A two sample study. *Motivation and Emotion, 37*(1), 93-105.

Trumbull, D., Scarano, B., & Bonney, R. (2006). Relations among two teachers' practices and beliefs, conceptualizations of the nature of science, and their implementation of student independent inquiry projects. *International Journal of Science Education, 28*(14), 1717-1750.

Trygstad, P., Smith, P., Banilower, E., & Nelson, M. (2013). The status of elementary science education: Are we ready for the Next Generation Science Standards? *Horizon Research, Inc. Supported by a National Science Foundation grant, DUE-0928177.*

Tschannen-Moran, M. & Hoy, A. W. (2001). Teacher efficacy: Capturing an elusive construct. *Teaching and Teacher Education, 17,* 783-805.

Tschannen-Moran, M., Woolfolk Hoy, A., & Hoy, W. (1998). Teacher efficacy: Its meaning and measure. *Review of Educational Research*, *68*, 202–248.

Turner, J., Meyer, D. K., & Christensen, A. (2009). Teachers' beliefs about student learning and motivation. In L.J. Saha, A.G. Dworkin (eds.), International Handbook of Research on Teachers and Teaching, 361–371.

United States Census Bureau (USCB). (2016). Quick facts – Oklahoma. *Race and Hispanic origin.* Retrieved online from: http://www.census.gov/quickfacts/table/PST045215/40,00

U.S. Department of Education. Institute of Education Sciences, National Center for Education Statistics (NCES). (2011). Retrieved online from: https://nces.ed.gov/surveys/sass/tables/sass1112_2013314_t1s_002.asp

van Driel, J. H., Beijaard, D., & Verloop, N. (2001). Professional development and reform in science education: *The role of teachers' practical knowledge. Journal of Research in Science Teaching, 38*(2), 137-158.

Vansteenkiste, M., Lens, W., & Deci, E. L. (2006). Intrinsic versus extrinsic goal contents in self-determination theory: Another look at the quality of academic motivation. *Educational Psychologist, 41*(1), 19-31.

Vansteenkiste, M., & Ryan, R. M. (2013). On psychological growth and vulnerability: Basic psychological need satisfaction and need frustration as a unifying principle. *Journal of Psychotherapy Integration,* 23(3), 263-280.

Vansteenkiste, M., Sierens, E., Soenens, B., Luyckx, K., & Lens, W. (2009). Motivational profiles from a self-determination perspective: The quality of motivation matters. *Journal of Educational Psychology, 101*(3), 671-688.

Venville, G., Wallace, J., Rennie, L., & Malone, J. (2002). Curriculum integration: Eroding the high ground of science as a school subject. *Studies in Science Education, 37,* 43-83.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Wahba, M. A., & Bridwell, L. G. (1976). Maslow reconsidered: A review of the research on the need hierarchy theory. *Organizational Behavior and Human Performance, 15*, 212-24.

Wallace, C., & Kang, N. (2004). An investigation of experienced secondary science teachers' beliefs about inquiry: An examination of competing belief sets. *Journal of Research in Science Teaching, 41*(9), 936-960.

Waters-Adams, S. (2006). The relationship between understanding of the nature of science and practice: The influence of teachers' beliefs about education, teaching, and learning. *International Journal of Science education, 28*(8), 919-944.

Wee, B., Shepardson, D., Fast, J., & Harbor, J. (2007). Teaching and learning about inquiry: Insights and challenges in professional development. *Journal of Science Teacher Education,* 18, 63-89.

Wenner, G. (1995). Science knowledge and efficacy beliefs among preservice elementary teachers: A follow-up study. *Journal of Science Education and Technology*, *4*(4), 307-315.

Wenner, G. (2001). Science and mathematics efficacy beliefs held by practicing and prospective teachers: A 5-year perspective *Journal of Science Education and Technology, 10*(2), 181-187.

Wei, R. C., Darling-Hammond, L., Andree, A., Richardson, N., & Orphanos, S. (2009). *Professional learning in the learning profession: A status report on teacher development in the United States and abroad*. Dallas, TX: National Staff Development Council.

Weiner, B. (1986). An *attributional theory of motivation and emotion*. New York: Springer-Verlag.

Wiener, B. (1990). History of motivational research in education. *Journal of Educational Psychology, 82*(4), 616-622.

White, R. W. (1959). Motivation reconsidered: The concept of competence. *Psychological Review*, 66, 297-333.

Wilches, J. U. (2007). Teacher autonomy: A critical review of the research and concept beyond applied linguistics. Ikala Revista de Lenguaje y Cultura, *12*(8), 245-275.

Wilson, C. D, Taylor, J. A., Kowalski, S. M., & Carter, J. (2010). The relative effects and equity of inquiry-based and commonplace science teaching on students' knowledge, reasoning, and argumentation. *Journal of Research in Science Teaching, 47*(3), 276-301.

Windschitl, M. (2002). Inquiry projects in science teacher education: What can investigative experiences reveal about teacher thinking and eventual classroom practice? *Science Education, 87*, 112-143.

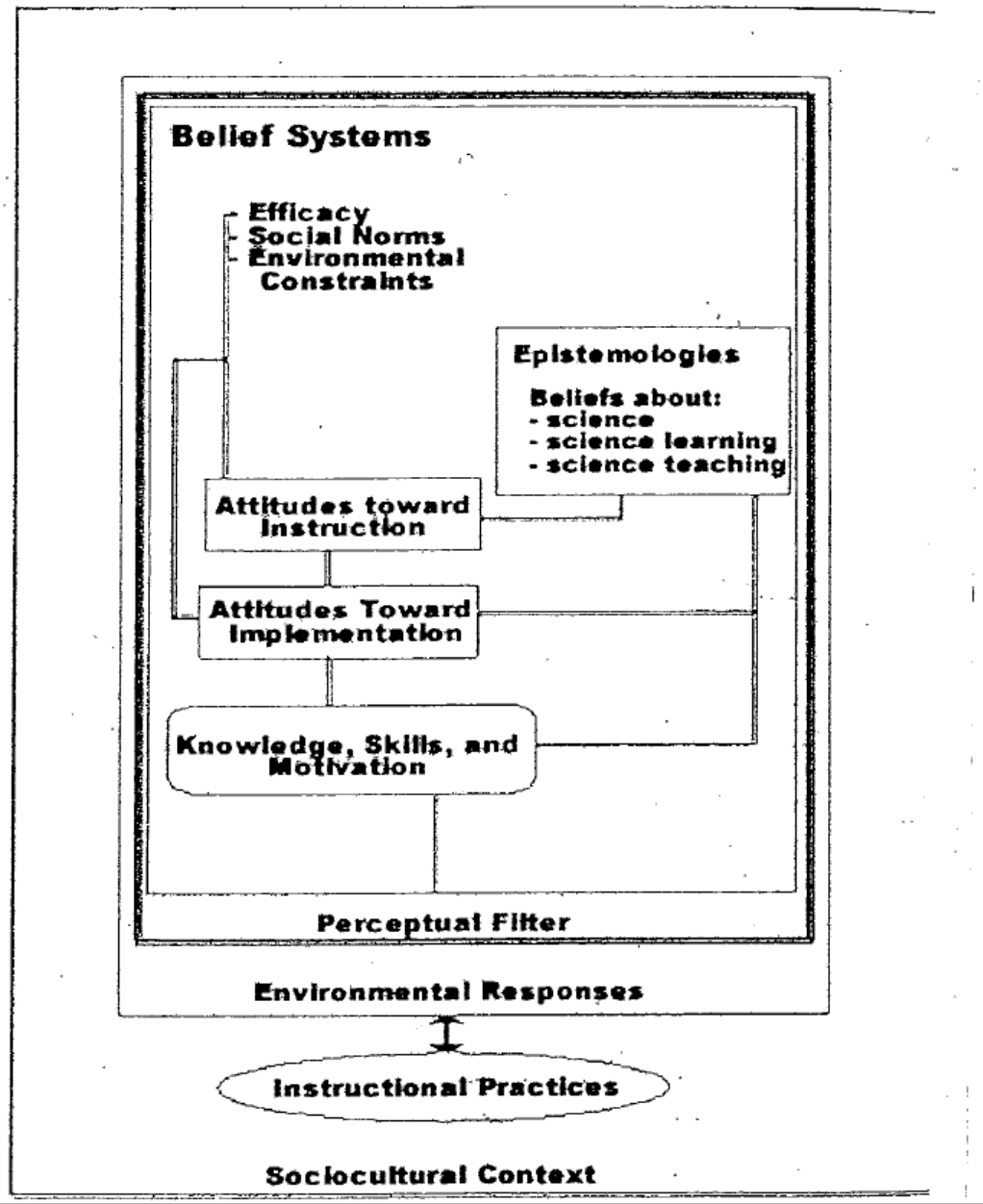
The World Bank: United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics. (2016). *Primary education, teachers, %.* Retrieved online from: http://data.worldbank.org/indicator/SE.PRM.TCHR.FE.ZS

Young, M. R. (2005). The motivational effects of the classroom environment in facilitating self-regulated learning. *Journal of Marketing Education, 27*(1), 25-40.

Appendix A

Sociocultural Model of Embedded Belief Systems

Jones & Carter (2007)



Appendix B
Survey Items

Teaching Demographics:

1. Which of these most closely describes your school?
   urban, suburban, rural

2. What grade(s) do you **currently** teach? Circle all that apply.

   K – 1st – 2nd – 3rd – 4th – 5th – 6th

3. Which of the following content areas are you required to teach to your **current** students? Circle all that apply.
   A. Language Arts
   B. Reading
   C. Mathematics
   D. Social Studies
   E. Science

4. If there is a content area in the question above that was not checked, please describe the reason it was not checked.

5. How many students do you currently teach? _____

6. How many years of teaching experience do you have?
   A. 0 – 2 years
   B. 3 – 5 years
   C. 6 – 10 years
   D. 11 – 20 years
   E. More than 20 years

7. What is your gender? M F

8. Have you ever taken a college course in elementary science teaching methods?
   A. Yes
   B. No

Science Teaching Practice

9. Which of the following describes the way your science instruction is scheduled during the school year?
   A. I teach science throughout the school year
   B. I teach science during only one semester of the school year
   C. I teach science during only one quarter of the school year

D. I never teach science
E. Other (please describe)

10. Which of the following most closely describes your pattern of teaching science during the time of the school year you teach science?
    A. I teach science 4-5 times a week
    B. I teach science 2-3 times a week
    C. I teach science once a week
    D. I teach science about 2 times a month
    E. I teach science about once a month
    F. I never teach science

11. On the days you teach science, about how long do you spend teaching science with your students?
    A. About 15 minutes
    B. About 30 minutes
    C. About 45 minutes
    D. About 60 minutes
    E. About 75 minutes
    F. About 90 minutes
    G. Longer than 90 minutes
    H. I never teach science

12. Not counting lunch, recess, or planning period(s), how many hours a day do you spend teaching your students all subjects? _____

13. Taking the entire school year into consideration and all of the subjects (reading, writing, math, etc.) you are required to teach, estimate the **approximate** amount of your teaching time that is spent doing science instruction with your students.
    1. 0%
    2. About 5%
    3. About 10%
    4. About 15%
    5. About 20%
    6. About 25%
    7. About 30%
    8. About 35%
    9. About 40%
    10. About 45%
    11. About 50%
    12. More than 50%

14. Which of the following is your **primary** method of providing science instruction in your classroom?
    A. Science textbook
    B. District-made or purchased curriculum (teacher's manual with resources)
    C. Teacher-created curriculum (varied resources selected by the teacher)
    D. Science kits (FOSS, Delta Science Modules, SCIS, STC, etc.)
    E. Other (please specify)
    F. I never teach science

15. If there are other methods you use for science instruction **in addition** to your primary method, please indicate below by checking those that apply?
    A. No other methods used
    B. Textbook readings
    C. Hands-on science activities
    D. Laboratory activities
    E. Science kits
    F. Teacher-created activities
    G. Lessons from on-line sources
    H. Lessons from science teaching resource books
    I. Other (please specify)

Appendix C
Interview Protocol

General Background Information

1. **How long have you been teaching?**
2. **In what areas are you certified to teach?**
3. **What made you decide to become a teacher?**
4. **What is your educational background?**
5. **What type of preparation did you receive in your preservice education for teaching science?**
    a. If you had a science methods class, please describe the type of instruction you received from it. What types of teaching methods were presented and modeled?
    b. What types of science courses did you take in college?

Teaching Practice

6. **Please describe your current teaching assignment.**
    a. What grade level do you currently teach?
    b. What is a typical instructional day/week like for you?
    c. What content areas are you specifically responsible for teaching?
    d. How do you organize your time and your students to make sure you get everything done that you are supposed to?
7. **How and where does science fit in with your instructional routine?**
    a. How often do you teach science?
    b. How long is your science teaching time generally?
    c. Describe any ways that you integrate science into other subjects.
    d. How do you go about prioritizing science in the larger scheme of all of the concepts you must teach your students?
8. **What type of curriculum do you use to meet the science objectives you are required to teach and how do you deliver it to the students?**
    a. Do you have a set science curriculum that you can follow for science? Do you follow it? Is this curriculum required by your school or district? Describe the types of things students are asked to do with this curriculum.
    b. If you don't have a set science curriculum, how do you decide what you will do with your students to meet the science objectives?
    c. What types of activities do you have your students engage in when they are learning science?
        i. Do you use a textbook and/or worksheets to teach science?
        ii. What types of hands-on activities do you use with students in science?
        iii. How often do you do the following:
            1. Have students make scientific observations
            2. Have student investigate scientific questions

3. *Have students work in groups on scientific problems*
4. *Have students collect, record, and analyze data*
5. *Create and/or use models to explain scientific ideas*

d. *What classroom resources do you have or use for teaching science?*
   i. *How often do you have to provide materials to teach science to your students? Is this true for other subject areas as well?*

e. *How do your students respond to the science instruction they receive in your class?*

f. *Describe a recent science lesson you did with your students that is typical of the type of science lessons you usually do with your students.*

Autonomous Motivation for Teaching

9. *Locus of Causality* – To what extent do you feel that you have influence and control over your science teaching decisions or do you feel they are imposed on you?

a. *How important do you think it is for elementary students to learn science?*
   i. *Do elementary students need to learn science in order to be successful later in life?*
   ii. *Where does science rank on the list of things students need to be successful?*

b. *Does your administration encourage/force you to teach science?*

c. *Are you evaluated on your science teaching? How do you feel about this?*

d. *Do you ever think that you might be teaching science too often/too little? If you do, what factors enter into that feeling?*

10. *Locus of Causality* - Is science a subject that you are comfortable teaching to your students? Elaborate on why or why not.

a. *Is science a subject that you yourself are interested in or enjoy?*

b. *Do you like to teach science?*

c. *Do you feel that you understand enough about science yourself to effectively teach it to your students?*

d. *Do you feel your teacher preparation program prepared you to teach science?*

e. *Do you feel confident that your teaching provides students with what they need to master the required science objectives and learn science effectively?*

f. *How do you stay current with what you need to teach science to your students?*

11. *Volition* - How much freedom do you feel you have to make decisions about how you teach science? Is this the same or different for other subjects as well?

a. *How much say does administration have over how you teach science?*

b. *Do you feel pressure to improve science instruction in the current push for education reform? Why do you feel this way?*
c. *How do you feel the new Common Core standards (Oklahoma Academic Standards) affect elementary teachers with regard to science?*
    i. *Does accountability change the level of importance of science instruction in any way? Why do you think this is so?*
d. *Does your administration ever pressure/request you to teach science more, less, or in a different way?*
e. *Do students or parents ever pressure/request you to teach science more, less, or in a different way?*
f. *Do you feel as though you teach science in a way you really want to or do you feel as though you are forced to teach in a way that goes against your teaching philosophy?*

Autonomy Support for Science Teaching

12. What kind of support do you receive for teaching science?

a. *Administrative support*
    i. *Does your principal find ways to help you fit science into your day?*
    ii. *Does your principal provide positive or constructive feedback in your efforts to teach science?*
b. *Collegial support*
    i. *Do you and your colleagues collaborate on doing science instruction?*
c. *Parent support*
    i. *Do parents provide you with positive or negative feedback on your efforts to teach science?*
d. *Other support*

Teacher Orientation to Student Autonomy Support

13. If you were asked for a definition of science as a discipline, what would you say? (There is no right or wrong answer for this. It is more of a personal perception or opinion.)

14. What do you think is the best way for students to learn science?

a. *What do you think effective science teaching looks like in elementary school?*
b. *Do you think that elementary students should be taught in a different way than students in middle and high school? We are not talking about the content they learn but about the way the content is taught.*

c. *Do you think elementary students are too young to learn major science concepts such as properties of matter, biological diversity, or conservation of energy?*

15. What types of choices do you provide your students in their learning of science?

a. *Do you allow them to choose who they work with, create rules and procedures for their learning, address questions they have generated on their own, choose topics, materials and/or presentation formats for projects, or make decisions about what and how they will learn?*

16. In what ways do you have students find solutions to problems and share the solutions they come up with?

a. *What types of problem-solving do your students engage in during science or science-related instruction?*
b. *Do you allow students to discuss and/or generate multiple or diverse strategies for problem solving?*
c. *Do you provide students with open-ended problems or investigations that may have more than one solution?*
d. *In what ways do you ask students to present justifications to their solutions and how do you assess this?*

17. How do you provide formal and informal feedback to your students about their learning?

a. *What type of feedback do you provide students and at what point in the instructional sequence is it provided?*
b. *What type of grading do you use for your students in science? Is this the same as it is in other content areas?*

Other Information

18. Is there anything else you would like me to know that we haven't discussed about your experience teaching science in your current teaching assignment or about your feelings and choices in regard to teaching science?

Appendix D
Subscales from Autonomous Motivation for Teaching Scale (Roth, Assor, Kanat-Maymon, and Kaplan, 2007)

Subscales Assessing Four Types of Motivation for Teaching

External Motivation

1. When I devote time to individual talks with students, I do so because I want the parents to appreciate my knowledge and familiarity with their children.

2. When I try to find interesting subjects and new ways of teaching, I do so because I want the parents to be satisfied so they won't complain.

3. When I invest effort in my work as a teacher, I do so because I do not want the principal to follow my work too closely.

4. When I invest effort in my work as a teacher, I do so in order to prevent disruptions and discipline problems during the lessons.

Introjected Motivation

5. When I try to find interesting subjects and new ways of teaching, I do so because I think it is a shame to keep on teaching in the same way all the time.

6. When I invest effort in my work as a teacher, I do so because if I do not invest enough I would feel ashamed of myself.

7. When I invest effort in my work as a teacher, I do so because otherwise I would feel guilty.

8. When I devote time to individual talks with students, I do so because it makes me feel proud to do this.

Identified Motivation

9. When I try to find interesting subjects and new ways of teaching, I do so because it is important for me to keep up with innovations in teaching.

10. When I devote time to individual talks with students, I do so because I can learn from them what happens in the classroom

11. When I invest effort in my work as a teacher, I do so because it is important for me to make children feel that I care about them.

12. When I invest effort in my work as a teacher, I do so because it is important for me to feel that I help people.

Intrinsic Motivation

13. When I try to find interesting subjects and new ways of teaching, I do so because it is fun to create new things.

14. When I invest effort in my work as a teacher, I do so because I enjoy finding unique solutions for various students.

15. When I invest effort in my work as a teacher, I do so because I enjoy creating connections with people.

16. When I devote time to individual talks with students, I do so because I like being in touch with children and adolescents.

Received February 5, 2007
Revision received July 26, 2007
Accepted July 30, 2007 ■

Appendix E

Autonomy Supportive Instructional Behavior Items
(Bieg, Backes, & Mittag, 2011)

Items for instructional behavior as rated by teachers and students

Teachers' self-reports	Students' ratings
Autonomy	
Students can often decide between various topics in my course.	We can often decide between various topics in this course.
Students can often decide in my class if they want to work alone or in groups.	We can often decide in class if we want to work alone or in groups.
Students can often decide in my class the way they work on a topic, such as with a book, video, group discussion, teacher lecture, etc.	We often decide in this course the way we work on topics, such as with a book, video, group discussion, teacher lecture, etc.
Students can often decide in my class when and how long they work on a certain task.	We can often decide in class when and how long we work on a task.
Students can often choose between different/various difficult tasks in my class.	We can often choose between different/ various tasks in this course.
In my class, students can often determine where they want to work on a task, such as in the classroom, another room, or outside the school.	
Teachers' Care	
If a student has a personal question, I respond to it in class.	Our teacher tries to fulfill our wishes as far as possible.
I discuss topics with students who missed the class discussion.	Our teacher takes care of the problems of the students.
My personal relationship to my students is more important than rapidly teaching topics.	Our teacher feels up to talk with us mostly, if there is something we do not like.
There is always enough time in class for personal and social matters.	If we want to discuss something with our teacher, he will have time for us.
I help every student who has got difficulties with his/her work.	Our teacher helps us like a friend.

Appendix F
Features of Autonomy Support
(Stefanou, Perencevich, DiCinto, & Turner, 2004)

Strategies Associated With the Different Features of Autonomy Support

Organizational Autonomy Support	*Procedural Autonomy Support*	*Cognitive Autonomy Support*
Students are given opportunities to:	Students are given opportunities to:	Students are given opportunities to:
Choose group members	Choose materials to use in class projects	Discuss multiple approaches and strategies
Choose evaluation procedure	Choose the way competence will be demonstrated	Find multiple solutions to problems
Take responsibility of due dates for assignments	Display work in an individual manner	Justify solutions for the purpose of sharing expertise
Participate in creating and implementing classroom rules	Discuss their wants	Have ample time for decision making
Choose seating arrangement	Handle materials	Be independent problem solvers with scaffolding
		Re-evaluate errors
		Receive informational feedback
		Formulate personal goals or realign task to correspond with interest
		Debate ideas freely
		Have less teacher talk time; more teacher listening time
		Ask questions