Elementary teachers' perceptions of science teaching constraints and affordances and their influence on science teaching self-efficacy and beliefs

by

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B.S., Emporia State University, 2014
M.S., Emporia State University, 2018

AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

DOCTOR OF PHILOSOPHY

Department of Curriculum and Instruction
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Abstract

This study aimed to explore possible correlations between elementary inservice teachers' (n=138) perceptions of science teaching constraints and affordances as well as their demographic information and science teaching self-efficacy and beliefs through the use of inferential statistics (Field, 2018; Riggs & Enochs, 1990). It also sought to explore teachers' perceptions of events and policies and the effects they had on their science instruction, including the impact of COVID-19 responses through open-ended survey questions and qualitative data analysis (Saldaña, 2021).

Due to philosophical, material, and logistical constraints placed on elementary teachers, science instruction is often limited in the elementary grade levels (Banilower, 2019; Banilower et al., 2018; Smith, 2020). Upon entrance into elementary classrooms, teachers often feel ill equipped to address the standards for a variety of reasons (Zinger et al., 2020). Reports have shown that these constraints and affordances placed on teachers have increased since the onset of the COVID-19 pandemic (Berger et al., 2022). This online survey research used a modified tailored-design method distributed to inservice elementary teachers through public elementary school principal contact information in a state in the Midwest (Dillman et al., 2014). This mixed-method, non-experimental exploratory research analyzed inservice elementary teachers' perceptions of their own science teaching constraints and affordances along with their science teaching self-efficacy and beliefs through the STEBI-A to explore possible correlations between the two (Riggs & Enochs, 1990). The science teaching constraints and affordances used in this research include the amount of time elementary teachers have to teach science, their district and school lesson planning initiatives, the depth of the Next Generation Science Standards (NGSS), the physical materials they have access to, their adopted science curriculum, the facilities they have access to, their perceptions of professional development, and their perceptions of their

Professional Learning Community (PLC). Secondarily, this research explored correlations between demographic information reported by teachers and the components of the STEBI-A. Lastly, open-ended written response items were also included to explore how teachers to describe how certain events or policies, including responses to the COVID-19 pandemic, have impacted their science instruction.

For the quantitative analysis, exploratory MANOVA were used in analyzing the survey data to isolate correlations between both Science Teaching Outcome Expectancy (STOE) and Personal Science Teaching Self-Efficacy (PSTE) as they relate to science teaching constraints and affordances as well as demographic variables (Field, 2018). For the qualitative response analysis, two cycles of coding written responses were used in showcasing patterns and themes in the teachers' experiences of both general events and policy changes as well as those related specifically to COVID-19 (Saldaña, 2021).

Relationships between science teaching constraints and affordances and elementary inservice teachers' STOE and PSTE were shown in the research, including relationships with teachers' perceptions of the NGSS, physical materials, adopted curriculum, professional development, and PLCs as well as their experience in the classroom and type of curriculum. In the qualitative analysis, themes about time, materials, professional development, and other factors were shown to be a result of the results of general school and district policy as well as COVID-19 policy. Discussions of the results include applications for teacher inservice, elementary school building scheduling and initiatives, facilities, materials, curriculum, as well as general teacher support.

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"Thus says the LORD: "Let not the wise man boast in his wisdom, let not the mighty man boast in his might, let not the rich man boast in his riches, but let him who boasts boast in this, that he understands and knows me, that I am the LORD who practices steadfast love, justice, and righteousness in the earth, for in these things I delight, declares the LORD."
-Jeremiah 9:23-24, ESV

I know that everything I have has been given to me. This degree being completed is a complete gift of grace from my God and Father. To him belongs all glory, honor, and praise. I acknowledge that God not only ordains the ends, but also the means to those ends, so I would like to acknowledge the ways he has provided for me through the people he has surrounded me with.

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Dedication

This dissertation is dedicated to all the elementary educators who are teaching science in the best ways they know how, given the limitations and constraints they face daily. Your work to instill wonder and awe in young students may not always be seen but is extremely valuable.

Chapter 1 - Introduction

Overview

Since the onset of No Child Left Behind and the continuation of high stakes testing with the Every Student Succeeds Act, there seems to be an overarching emphasis on the instruction of mathematics, reading and writing over and above that of other subject areas across grade levels (Banilower et al., 2019; Griffith & Scharmann, 2008). Nowhere is this emphasis seen more prevalently than in the average elementary classroom (Plumley, 2019). In one sense, it's understandable that these formative years in a child's life are used to impact their knowledge of mathematics and reading which, if left unaddressed, snowball into greater problems as students move through the subsequent grade levels (Ten Braak et al., 2022). Perhaps this is the result of the emphasis of standardized testing of math and reading for K-12 students, or perhaps it is our society's emphasis on these subjects as the cores, or building blocks of student understanding which leads to this neglect of science and social studies. Whatever the reasons may be for the neglect of science instruction at the elementary level, there is indeed a gap (Milner et al., 2012; Plumley, 2019). According to Plumley (2019) and the National Survey of Science and Mathematics Education (NSSME+),

> Only 18 percent of primary grades classes and 26 percent of intermediate grades classes receive science instruction all or most days every week of the school year. The large majority of elementary classes receive science instruction only a few days a week or during some, but not all, weeks of the year. (Banilower et al., 2018, p. 15)

In a similar vein, Plumley (2019) analyzed the number of minutes on average that self-contained elementary teachers spend on science instruction in their classrooms. In self-contained classrooms in grades Kindergarten through sixth grade, an average of 20 minutes is spent on science instruction compared to 87 and 58 minutes in reading and math, respectively (Plumley, 2019). Another observation from Plumley (2019) show the neglect of science instruction at the elementary level is seen in that more than half of all elementary classes surveyed about their science resources or textbooks stated that their resources were adopted prior to 2012. This makes a difference in instructional practices and the outlook on science education reform because the resources adopted before 2012 were prior to the main change in initiatives within science education with the adoption and implementation of the Next Generation Science Standards by some of the United States (National Research Council, 2012, NGSS Lead States, 2013).

Not only is there neglect of science at the elementary level, but it seems to be happening at the undergraduate teacher preparation level also. It has been shown that preservice science teaching experiences impact the science teaching self-efficacy of preservice elementary teachers (Menon, 2020), and Cantrell et al. (2003) have shown that extended and early experiences for preservice teachers to facilitate science learning for colleagues as well as school-aged students helps to develop comfortability and self-efficacy with science instruction. Preservice teachers who are put in the position of students for the purpose of participating in science instruction, and who develop a community that is safe for experimentation and growth is shown to be extremely beneficial for both the preservice teachers, as well as their future students (Cantrell et al., 2003). It seems, however, that these experiences aren't happening for elementary preservice teachers regularly (Dabney et al., 2020). For instance, Dabney et al. (2020) have shown that the prerequisite science coursework in preservice elementary education programs was, "primarily lecture based," and reminded the preservice educators of the type of instruction they received in the classroom as the focus was placed on high-stakes testing (p. 96). Participants responded that they felt the coursework wasn't sufficient and that the philosophy of instruction they experienced was different than that which had been taught to them in science methods courses (Dabney et al., 2020). These experiences implicitly and explicitly impact the outlook of preservice teachers on their philosophy of science education and follow them through their inservice science teaching experiences as well (Cantrell et al., 2003; Diamond et al., 2013).

With this current state of elementary school structures as well as elementary education teacher preparation programs, it's no wonder when inservice elementary teachers are confronted with a framework as deep and complex as the NGSS they often feel inadequate to teach them in their entirety (Zinger et al., 2020).

A Brief History of Reform-Based Science Education

This present mindset of elementary science education is prevailing against decades-old efforts to reform the way teachers and learners interact with the curriculum of science at this level. Historical events and crises have shaped the way science education is treated at the national level (Yager, 2000). In the 50's the government's response to the space race with Russia determined the focus of the science curriculum (Yager, 2000). In the 1960's and 70's, social and political unrest and activism influenced the efforts of reform (Yager, 2000). And in the 80's, 90's, and early 2000's, the emphasis shifted to a more individualistic, place and problem-based philosophy and outlook (Ames, 2014; Yager, 2000). In 2011, the need was seen for efforts to be given to shift the mindset of how science should be taught in K-12 education, so the National Research Council created their Framework for K-12 Science Education (2012). Due to the federalist nature of the United States constitution, the facilitation of education is a responsibility which is designated to the states, so the National Research Council had to lobby for the adoption of the NGSS at the state level. So far only 20 states and the District of Colombia have adopted the NGSS in their entirety, and 24 states have standards that are consistent with the National Research Council (2012) framework.

Rationale

Since the adoption of the NGSS by most states in 2013 and 2014 as standards for their core science curriculum, there has been a shift in the way K-12 science instruction is viewed (NGSS Lead States, 2013). Each NGSS standard is extremely complex, having a "three-dimensional" design, so that in each standard students who are being taught must complete tasks that scientists complete, or the Science and Engineering Practices (SEPs), understand topics that scientists understand, the Disciplinary Core Ideas (DCIs), and make connections across the curriculum, or understand Crosscutting Concepts (CCCs) (NGSS Lead States, 2013). These three-dimensional categories make the science curriculum emphasize in-depth and hands-on approaches to the topic of science instead of the memorization of facts alone (NGSS Lead States, 2013).

Not only does the depth of the standards impact teacher perceptions of science teaching, but there are also other constraints described in the current research as well. Studies have shown that teachers transitioning to this deeper philosophical approach to science instruction either meet resistance or are propelled by structures and procedures they have in place (Bradbury & Wilson, 2020; Bybee, 2014; Johnson & Dabney, 2018; Zinger et al., 2020). This research refers to these factors that science teachers experience as "science teaching constraints and affordances." The first relevant science teaching constraint is the time teachers are allotted to teach the content (Johnson & Dabney, 2018; Zinger et al., 2020). Teachers also often feel constrained by the requirements that the systems, or lesson plan initiatives, they are subjected to place on the time spent in differentiated and whole group math and reading instruction (Johnson & Dabney, 2018; Zinger et al., 2020). Due to their feelings that time to teach science is limited, inservice elementary teachers often feel that they can't reach the depth of learning that the NGSS requires (Zinger et al., 2020). There also seems to be a perception of the lack of materials to teach the requirements of the standards influences instruction as well (Johnson & Dabney, 2018). Science teachers also often feel like they had insufficient resources to teach the NGSS adequately (Banilower 2019; Banilower et al., 2018, Zinger et al., 2020). Teachers often feel that they lack the facilities they need to implement science-specific labs and activities that they can't do in their classrooms (Banilower et al., 2018). Lastly, elementary teachers have been shown to be dependent upon the professional development they receive as well as the professional learning communities (PLCs) they are a part of in their particular contexts (Catalano et al., 2019; Johnson & Dabney, 2018; Zinger et al., 2020). All of these science-teaching related constraints and affordances may impact the self-efficacy of the elementary teacher regarding the content knowledge required to lead or facilitate the instructional process and also how inservice elementary teachers perceive science instruction in their spheres of influence.

Statement of the Problem

Due to the philosophical shifts associated with the adoption and implementation of the NGSS versus the practices that average elementary teachers utilize within their classrooms, the structures and systems that elementary teachers are subjected to, as well as other science teaching constraints and affordances their respective districts and schools allow, this research aims to consider if inservice elementary teachers' perceptions of these constraints and affordances impact their science teaching self-efficacy. Since it has been shown that self-efficacy scores are related to aptitude and comfortability of teaching science (Menon & Sadler, 2018) and it can be shown that changes to science teaching constraints and affordances at the building, district, or state-level impact these self-efficacy scores (Zinger et al., 2020), then it would necessitate change to the systems in order to better accommodate elementary teachers in their work to implement the NGSS for the good of their students' science learning.

While studies have been completed researching the constraints and affordances of general science teaching practice, there is a gap in the literature exploring if and how the science teaching constraints and affordances that elementary inservice teachers are subject to impact their perceived science teaching self-efficacy, and if there are specific events, policies, or changes that impact their interpretations of successful science teaching, including recent COVID-19 responses and changes to policies.

Research Purpose

The purpose of this research was to explore the possible effects that science teaching constraints and affordances have on the perceived self-efficacy of elementary teachers as they implement science instruction. This study utilized non-experimental, tailored-design survey methods, and quantitative data analysis to determine if there were any statistically significant correlations or relationships between the science teaching constraints and affordances and elementary inservice teachers' science teaching self-efficacy scores (Dillman, et al., 2014; Field, 2017). This research also utilized open-ended written responses regarding elementary inservice teachers' perceptions of events and policies on their science instruction and analyzed those with two-cycle qualitative data analysis (Saldaña, 2021). This research has extended the current body of literature in a variety of ways:

1. There seems to be a gap in the literature regarding the relationship of the science teaching constraints and affordances of inservice teachers and their impact on science teaching self-efficacy.
2. More specifically, this research more clearly defines the relationship between science teaching constraints and affordances for elementary teachers as distinct from all K-12 teachers of science.
3. The current body of research contains qualitative analysis over science teaching constraints and affordances but doesn't shed light on the influence similar constructs have on the science teaching self-efficacy of elementary inservice teachers.

4. This research also aims to explore the relationship of policy decisions, trainings, events, and specifically those related to the COVID-19 pandemic response, on the science teaching at the elementary level.

Research Questions

The research questions in this study aimed to analyze the relationship between elementary teachers' perceptions of the science teaching constraints and affordances that they are subject to as a potential influencer of their science teaching self-efficacy beliefs. The independent variables for this study were the teachers' perceptions of science teaching constraints and affordances listed in the survey instrument, and the dependent variables were the responses to the questions over self-efficacy when teaching science. On a personal note, this researcher works with preservice teachers and their mentors in a Professional Development School (PDS) in the Midwest and has had conversations with both preservice and inservice teachers about their science instruction, and many times inservice and preservice teachers justify certain pedagogical choices when it comes to science because of the perceived science teaching constraints and affordances they experience, so I was very interested to see if these science teaching constraints and affordances impact their science teaching self-efficacy and beliefs. The research questions for this exploratory study were:

1. Are there any statistically significant correlations between inservice elementary teacher perceptions of science teaching constraints and affordances and their score on the science teaching efficacy and belief instrument (STEBI-A)?
2. If any, what other statistically significant correlations can be made between demographic information and inservice elementary teachers' science teaching self-efficacy?
3. How do inservice elementary teachers describe the impact of policies, training or events like the COVID-19 pandemic on their science instruction?

Theoretical Framework

Before discussing the study design, it is imperative to define terms and understand the theoretical nature of the constructs the researcher would be measuring. These include the justification of self-efficacy psychometrics, as well as defining and operationalizing science teaching constraints and affordances. Secondarily, due to the research questions, there is a need to define the terms that are used within this exploratory research. Definitions and theoretical foundations of age, gender, grade level taught, subjects taught, years of experience, educational level of the inservice teacher, community population of the school, daily time to teach science, and the amount of professional development provided to inservice elementary teachers are all considered.

Operational Definitions

1. *Elementary Education:* instruction that takes place in a K-6 classroom from a licensed elementary teacher (File, N. & Gullo, F, 2002).
2. *Elementary Inservice Teacher:* a licensed teacher who teaches multiple subjects, including science, math, social studies, and reading/English Language Arts (ELA) to diverse groups of learners (Nowicki et al., 2013).
3. *Science Teaching Self-Efficacy:* the general feeling of preparedness and effectiveness that inservice or preservice teachers experience while teaching the subject of science (Bandura, 1986; Riggs & Enochs, 1990). This includes two constructs: science teaching outcome expectancy (STOE) which characterize how science teachers can influence the result of learning, and personal science teaching efficacy (PSTE), or how effective science teachers perceive themselves to be at teaching science (Riggs & Enochs, 1991).
4. *Science Teaching Constraints and Affordances:* building, district, state, or national factors which influence the teaching and learning process (Zinger et al., 2020).

Elementary Education and Inservice Teachers

According to the United States Bureau of Labor Statistics, an elementary teacher is someone who “instruct[s] young students in basic subjects, such as math and reading, in order to prepare them for middle school” (2022). In general, students at the elementary level experience instruction from one teacher that instructs them in multiple subjects over the course of each day (Banilower, 2019; Banilower et al., 2018). Although there are some schools that have specialized teachers for specific content areas, the majority of elementary teachers teach multiple subjects to one group of students (Banilower, 2019; Banilower et al., 2018).

When discussing the sample population, File & Gullo (2002) make a distinction between types of early education teachers. In their writings, they describe the philosophical and theoretical distinctions between elementary education teachers and early childhood teachers, along with the paradigms and goals of their respective roles (File & Gullo, 2002). They state, “The child-directed and play-oriented methods that have predominated in [Early Childhood programs] stand in contrast to the traditionally heavier reliance in [elementary education] on teacher-direction, discrete content areas, and large-group instruction” (File & Gullo, 2002, p. 127). This population is also separated from the middle-school population of teachers that teach one subject to many groups of students throughout a given day.

In general, elementary inservice teachers are equipped through their respective undergraduate or graduate programs to plan, facilitate, and assess instruction in all the core content areas. This study is aimed specifically at elementary inservice teachers with a self-contained class that experiences instruction in all subject areas.

Science Teaching Self-Efficacy

Self-efficacy theory was developed by Bandura (1977; 1986) and measures the perception of a participant’s views of their own performance in a given area or construct.

Bandura (1977; 1986) builds in two components to his self-efficacy theory which are also found in more recent self-efficacy instruments: personal efficacy beliefs, and outcome expectancy. Personal efficacy beliefs measure the individual's beliefs about their internal ability to complete a given task or to complete an activity, and outcome expectancy measures the individual's view of the quality of outcome they anticipate based upon their strivings (Bandura, 1986).

Riggs (1988) and Riggs & Enochs (1990) built their survey instrument, the Science Teaching Efficacy and Belief Instrument (STEBI-A) using these components of Bandura's self-efficacy theory but applied to the science teaching of inservice teachers. Components in Riggs & Enochs (1990) survey include science teaching outcome expectancies (STOE), and personal science teaching efficacy (PSTE). This study aims to consider if and how elementary inservice teachers' views of their own science teaching are affected by their perceptions of science teaching constraints and affordances.

Science Teaching Constraints and Affordances

There are many factors that influence teachers' decisions when it comes to curriculum and instruction. This study considered how these science teaching constraints and affordances impact the science teaching efficacy and beliefs of elementary inservice teachers. There are certain factors that elementary teachers experience that other categories of teachers do not. The science teaching constraints and affordances measured in this study were: 1) the amount of time elementary teachers have for science (Banilower et al., 2018; Teig et al., 2019), 2) lesson planning initiatives used by the district (Zinger et al., 2020), 3) the depth of the standards themselves (NGSS Lead States, 2012; Ramey-Gassert et al., 1996), 4) the physical materials needed to teach science (Banilower et al, 2018; Zinger et al., 2020), 5) the adopted curriculum (Banilower et al., 2018), 6) the physical space/facilities teachers have access to (Zinger et al., 2020), 7) the science-specific professional development (Granger et al., 2020), 8) and professional learning communities or communities of practice (Dogan et al., 2016). These constraints and affordances were chosen because they are systemic to, or outside the control of, inservice elementary teachers. In this study, teachers responded with their perceptions of these constraints and affordances in their individual contexts.

Demographic Information and Exploratory Factors

Along with inservice elementary teachers' perceptions of science teaching constraints and affordances, this study also collected exploratory demographic information about the participants to see if there were any relationships from this information to science teaching self-efficacy to determine possible patterns of influence. There were eleven predictor or exploratory variables that were collected.

The first factor that was considered as a demographic predictor variable is the age of the teacher. This study will collect the age of the elementary teacher in order to see if there is a difference in the self-efficacy of the teacher as it relates to the age of the teacher.

The second factor that will be considered as a demographic/exploratory factor is the gender of the inservice elementary teacher. Yang & Wang (2019) showed that there is a gap in science teaching self-efficacy scores based on gender, so this study will aim to consider the relationships mentioned in their research.

Third, this research will measure the years of experience inservice elementary teachers have in the classroom. Although it has been shown that experience doesn't necessarily relate to science teaching self-efficacy (Menon, 2020, Podolsky et al., 2019), this study is exploring whether there are any correlations within this sample.

The fourth demographic that this research will measure is that of the educational level of the inservice elementary teachers that respond. It has been noted that the educational level of science teachers impacts their science teaching self-efficacy (Yang & Wang, 2019), so this research sought to analyze the education levels of its respondents in order to determine if it impacts the results of STOE and PSTE in respondents.

The fifth exploratory factor that is considered in this research is that of the age-level of the students that are being taught. The NGSS is an ever-deepening and expanding set of standards that changes with regard to its complexity as students get older, so this research aims to consider whether the age-group or grade-level of the students being taught impacts the inservice elementary teacher's science teaching self-efficacy (NGSS Lead States, 2013).

The sixth variable that will be collected in this research is the number of sections that teachers have in their school context. Research has shown that Communities of Practice (CoPs) and Professional Learning Communities (PLCs) impact inservice teachers and their practice because they offer support, encouragement, modeling, and mentorship (Kelley et al., 2020). This research is interested in looking at the number of sections at a school and seeing if they impact perceived science teaching self-efficacy among inservice elementary teachers.

Seventh, the next factor considered are the subjects that inservice elementary teachers are required to teach. Increasingly, elementary classrooms are moving from a self-contained structure to a more specialized model, where teachers are responsible to teach multiple groups of students one or two subjects instead of all four of the traditional subject areas of math, reading/English language arts, science, and social studies (Smith & Craven, 2018). Due to the nature of the research question, this variable will be constant among all data collected because the sample population in question teach all content areas to one group of students.

The eighth demographic that was collected in this research was the population of the community in which the inservice elementary teachers work. Reagan et al. (2019) have shown that rural schools face different constraints than that of urban or sub-urban communities, and thus the instruction in those areas is planned and delivered differently than it would be in places that are urban (Johnson et al., 2019), so this research sought to explore the influence of location on self-efficacy of teachers.

The ninth variable collected in this analysis of the teacher's context is the amount of time elementary inservice teachers have to teach science each day. Banilower et al. (2018) show that daily science instruction time varies but is limited in most elementary classrooms to fractions of the time spent on other subjects. This construct is being measured to analyze if there is any relationship between self-efficacy and the amount of time spent on direct science instruction.

Tenth, this research asks teachers to identify curricular resources that are adopted by their school. Whether schools have an adopted book or an initiative-based curriculum such as Project Based Learning (PBL), emphases on testing subjects by grade-level, or other initiatives. These curricular choices and their implementation can have large effects on the achievement of students and on the self-efficacy of inservice teachers (Samsudin et al., 2020; Saputro et al., 2020). According to NSSME+, the materials elementary inservice teachers are required to use are often outdated, insufficient, or lacking the diversity needed to meet the needs of students (Banilower et al., 2018). For instance, elementary inservice teachers are likely to skip over instructional activities within their designated curriculum due to lack of time, resources, materials, space, and because they don't meet the requirements of the pacing guides set at the district-level (Banilower et al., 2018).

The eleventh variable collected in this research is that of the amount of professional development hours that are spent specifically on science-related topics. Seneviratne et al. (2019) have shown that consistent and reform-based professional development positively impacts both inservice and preservice teachers' self-efficacy when it comes to teaching science. This study aims to collect basic data on how frequently these inservice teachers had science-specific professional development.

Overall, these demographic and exploratory factors are collected in addition to the teachers' perceptions of their science teaching constraints and affordances and will be used to give context to the responses in that section in further discussion and application.

Design of the Study

Methods

The design of this study was survey research, using the tailored-design method (Dillman, et al., 2014). K-6 inservice teachers were recruited through open access contact information for principals of public elementary schools in a state in the Midwest (n=708). The survey and research explanation along with a message to forward the survey on to their teachers, if it was appropriate for them to do so. In the survey instrument itself, participants note their status as a licensed teacher or working on licensure. Participants were recruited via email through their principals over the course of three weeks. The researcher used public records to contact school principals in a state in the Midwest and sent out requests for the principals to forward the survey on to their K-6 public school teachers. Requests for principals to forward the survey for teachers to complete were sent three times over the course of the three weeks, and an incentive of a drawing for five $20 gift cards allocated randomly were used to increase participation (Cobanoglu, & Cobanoglu, 2003). In each correspondence, the researcher updated the principals on the number of teachers that had responded to the survey in total, as well as communication to forward the message on to their staff, as listed in Appendix C, D, and E. Within each correspondence, there was a link to the survey that teachers could access through clicking on the link. Over the course of the three weeks, there were a total of 227 responses.

The content of the Qualtrics survey itself included four sections. The first section was an explanation of the study and a presentation of the goal of the study along with permission from the participant for their given information to be used for the study and their designation of whether they would like to be sent the results and also if they would like to be considered for a drawing for one of the gift cards. The second section of the survey was a collection of demographic information and clarifying questions about the nature of the classroom the participant teaches in so they can be sorted and qualified or disqualified from the sample population of practicing elementary self-contained teachers. The third section of the survey asked about the teachers' perceptions of science teaching constraints and affordances, including access to materials, curriculum, space, time, and other resources. In this section, they marked their agreement or disagreement using a 5-point Likert scale over eight science teaching constraints and affordances. In this section, teachers were also asked to respond to two open-ended questions, one relating to the policy changes or events that have most impacted their science teaching in general, and second about the impacts specifically of COVID policy on their perception of science teaching. The fourth and last section of the survey was a use of Riggs & Enochs' (1990) Science Teaching Efficacy Belief Instrument (STEBI-A) for inservice teachers. This section of the survey uses a 5-point Likert scale to measure the Science Teaching Outcome Expectancy (STOE) and the Personal Science Teaching Efficacy (PSTE) (Riggs & Enochs, 1990; Slater et al., 2021). The researcher obtained permission from Riggs (1990) to use the STEBI-A within the confines of this research prior to the creation and dissemination of the survey instrument.

Data Analysis

The online survey used Qualtrics for participants to complete the survey, and the Qualtrics server served as the location where all the raw data that was collected was kept throughout the study. Data was then transferred to a password-protected personal computer with Microsoft Excel where the researcher anonymized and filtered the data to fit the research question. Using SPSS, the negative survey items had scores reverse-coded to fit the nature of the hypothesis. After data collection, reorganization, and recoding was completed, the researcher then used SPSS statistical software to complete a multivariate analysis of variance (MANOVA) to determine if there were any statistically significant correlations between the multiple independent variables and the multiple measured dependent variables. This research also utilized exploratory MANOVA to explore possible correlations between demographic information and the constructs of the STEBI-A (Field, 2018; Riggs & Enochs, 1990).

Open-ended qualitative responses were coded using Saldaña's (2021) two-cycle method of coding. The first cycle of coding was completed through the lens of "In-Vivo" coding or verbatim coding (Saldaña, 2021). According to Saldaña (2021), in vivo coding "refers to a word or short phrase from the actual language found in the qualitative record" (p. 137). The second cycle of coding that was used in the data analysis process was Saldaña's (2021) "Theoretical Coding" (pp. 314-319). Saldaña (2021) refers to this type of coding as "conceptual coding" based in the underlying assumptions or theories found in the research. In this coding process, the themes and categories developed in the first cycle of coding are further refined into categories and subcategories which are based on the theories underlying the study (Saldaña, 2021). In this sense, the research questions established the underlying theories used, and the qualitative responses of the participants highlight the experiences they have concerning this concept.

Limitations and Delimitations of the Study

There are a few limitations and delimitations of this study. This research was conducted as a part of the requirements of a doctoral dissertation. Survey research is limited by its nature to the self-reporting of the respondents. There are questions about the correlations from self-efficacy scores and the actual teaching practices of elementary science teachers, the sampling procedures also have limitations, and data analysis in an exploratory study should also be understood.

First, there are questions and considerations with regards to the correlations between actual teaching practices and the scores of self-efficacy. In their study, Kruse et al. (2021) reported that there are instances where the actual teaching practices of science teachers don't necessarily correlate with the self-efficacy scores. This study was completed with preservice teachers, so the populations are different. Given the findings in their study, though, it would be prudent to look at the data collected from this study as teacher perceptions, and not actual practice (Kruse et al., 2021). This means that there could be a benefit to seeing if the self-efficacy scores could correlate with a particular practice within the classroom instruction of inservice elementary teachers. In this survey research, it was assumed that teachers were able to accurately represent their perceptions through the use of the survey instrument.

Secondly, this survey research and the sampling process both have their limitations. Survey research more broadly has some limitations. Coughlan et al. (2009) mention that some historical problems with survey research have been that they are generally not effective at getting the sample population to participate. In this way, the biggest problem to overcome with sample populations targeted for survey research is non-response error (Coughlan et al., 2009). In order to overcome this, the researcher is using readily available public access to the sample population as well as an incentive to persuade respondents to complete the survey instrument (Coughlan et al., 2009). Multiple contacts over the course of the dissemination of the survey instrument have also been proven to help with non-response error (Coughlan et al., 2009). Personalizing contact to the individuals in the sample population has also been shown to decrease the prevalence of non-response error, though for this research such targeted communication wasn't utilized (Coughlan et al., 2009). This research dealt with obstacles in sampling that limited the ability to reach the sample population, namely that communication to the sample population occurred through the medium of building principals. Regarding this, there is no way to know which administrators forwarded the email to prospective participants, or just forgotten in the busyness of work.

The sample-gathering procedure is a self-report system. This means that the researcher is unable to ensure all participants are being honest about their demographic or predictor-variable completion. This possibility was offset by the targeted communication done between the researcher and the participant population. Second, the perceptions of teachers' available resources and the resources available to them also might not be a direct correlation. For instance, the teachers who have low markings for availability of resources may mark the response low because of a true lack of resources, or they may not be aware of the types of resources are available to them from their school or district. These responses also don't consider that most elementary science standards in the NGSS can be accomplished using outdoor and common resources. This means that the more adaptable and fluid teachers are with their content knowledge, the more everyday items seem more like explicit science resources. In the future, it would be wise to consider differentiation between curriculum-explicit resources and everyday items that can be used for science. Similar arguments could be made for professional development and in-person training. Oftentimes teachers have funds and resources available that could be used to learn or impact science instruction but might not be accessed by them for the purpose of science instruction. Regarding this sample, however, it can be assumed that teachers have no reason to falsify their perceptions of the science teaching constraints and affordances.

With regard to data analysis, there are limitations to this study. Given the nature of this study as an exploratory one, there were many statistical tests that the data was put through as it relates to MANOVA and MANCOVA. Due to this, the level of Type-I error increases with every statistical test. Although the significance of the relationships between variables is explicit, there may be constructs that should be more specifically targeted, after analysis of the data was completed. This study is not an exhaustive list of all science teaching factors that influence a teacher's pedagogical choices, but patterns can be drawn from the data collected about those factors and their influence on self-efficacy for this sample population.

Organization of the Study

This chapter has given an overview of the study through briefly explaining the background, research purpose, research questions, limitations and delimitations, a definition of terms as well as a brief overview of the constructs present within the study. A large enough sample of elementary inservice teachers agreed to participate in this study to explore possible correlations between the teachers' self-efficacy and beliefs regarding science instruction and the science teaching factors that influence them daily.

Chapter 2 includes an explanation of and connection to current literature regarding the constructs used in this study, as well as the background of the survey instruments used. The theoretical framework of the study is also discussed in detail.

Chapter 3 describes the methodology of this research study organized by the research design, participants, an explanation of the instrument used, and the procedures taken including quantitative and qualitative analysis. The origin of the survey instrument is also discussed as well as rationale for how the survey instruments were blended to gather data for this new study.

Chapter 4 presents the findings of this study based on the data analysis of the exploratory MANOVA and presentation of qualitative codes. The findings from the statistical analyses are discussed and presented to answer the research questions of the study.

Chapter 5 communicates the findings of the study, and places them in the current context of science education at the elementary level. In this chapter implications of the research on classroom pedagogy, building and district policy, and state and federal policy are presented.

Science teaching constraints are in place for a reason, and if they hinder teachers' planning and presentation of science curriculum, they should be analyzed for change.

Chapter 2 - Literature Review

Overview

Since the USSR successfully launched the first satellite into space in 1957, there have been large governmental and non-governmental forces influencing and directing the implementation of science education because the welfare of the United States was said to rest upon our collective successes in the fields of mathematics and science (Yager, 2000). In the 1950's and 60's the emphasis was more on individual mastery of the content knowledge in each of the science disciplines as removed from technology and engineering (Yager, 2000). In the 1970's, there was a shift away from this focus, and onto a societal and career-driven focus that tries to create problem-solvers that can aid the ills of a broken nation (Yager, 2000). As time moved on, the focus shifted to a richer, more student-centered view of science education that increases the emphasis on question-asking and answering that is directed by the student and applied to real-world problems and phenomena (Yager, 2000). Specifically, in the 1996 efforts for science education reform, the re-introduction of technology as a critical and intertwined component within the framework was illuminated (Ames, 2014; National Research Council, 1996; Yager, 2000). This emphasis on science and technology literacy as well as place-based science instruction continued for a decade and a half before the efforts for reform continued through the development of the National Research Council's *A Framework for K-12 Science Education* (2012) whichset the stage for the development and push for states in the United States of America to adopt the NGSS. Since the creation and push for the implementation of the NGSS in 2013, so far only 20 states and the District of Colombia have adopted them in their entirety, and 24 states have standards that are consistent with the National Research Council (2012) framework, or NGSS-similar standards.

The adoption of the NGSS in 2013 marked a shift in science education at every level (NGSS Lead States, 2013). The NGSS are complex to teach, each being composed of DCIs, CCCs, and SEPs (NGSS Lead States, 2013). The emphasis on science education since their adoption has shifted from a comprehension-based standard to a performance-based standard. The standards are adequately named performance expectations (PE) and are extremely student-centered (NGSS Lead States, 2013). The philosophy of the NGSS takes the mastery and delivery of content information from the teacher and places the impetus for learning on the student to use the information gained through inquiry to create, analyze, and describe solutions to problems or explanations of phenomena (National Research Council, 2012).

The PEs are conceptually deep, each challenging students and teachers alike to think, plan, and act like scientists. An example PE is listed in Figure 1. In the listed PE students are to independently prove that the speed of an object is related to the energy of that object. In a traditional science lesson, elementary teachers might just use the thirty minutes they have every-other day to teach students what energy is, and how it relates to speed, and at the end of the unit students might be able to do something fun to show what they learned. With the reform-based standards, teachers are encouraged to empower students to become scientists, use demonstrations, data collection, and observation to collect evidence that they then use to construct an explanation relating speed to energy. In a classroom where time is of the essence and topics aren't interconnected, thirty minutes every-other day seems to take this engaging PE and transform it into a burden that seems overwhelming (Smith, 2020).

Figure 2.1

Example NGSS Performance Expectation

Students who demonstrate understanding can:

4-PS3-1. **Use evidence to construct an explanation relating the speed of an object to the energy of that object.** [*Assessment Boundary: Assessment does not include quantitative measures of changes in the speed of an object or on any precise or quantitative definition of energy.*

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. • Use evidence (e.g., measurements, observations, patterns) to construct an explanation.	**PS3.A: Definitions of Energy** • The faster a given object is moving, the more energy it possesses.	**Energy and Matter** • Energy can be transferred in various ways and between objects.

NGSS Lead States, 2013, 4-PS3-1.

Background on Elementary Science Teaching Initiatives

Not only are the standards complex, so is the nature of science instruction at the elementary level. With many initiatives vying for the attention of teachers, it is important to consider three of the leading trends in science education: Science, Technology, Engineering and Mathematics (STEM), Inquiry-Based Learning, and Project-Based Learning (PBL).

As states increasingly push elementary teachers to increase math and reading scores on standardized tests, there seems to be associated pressure to integrate STEM and STREAM (including Reading and the Arts) initiatives into science education. In 2021, a total of $580 million was used to help schools and other organizations integrate this initiative from kindergarten classrooms to post-secondary classrooms (U.S. Department of Education, 2021). To elementary school teachers, these topics can seem like extra additions to the already very full daily schedule. Furthermore, with these additions teachers can view their understanding of science as insufficient, especially for activities like designing, coding, or experimenting, which are some ways that students can achieve the PEs in the NGSS (NGSS Lead States, 2013). The basis for this push for STEM and STREAM is based on research that integrated science concepts are easier for students to make connections between. The same phenomenon is seen, as Deniz and Akerson (2013) have shown, when teachers make connections from favorable content areas, such as math or language arts, their connections to science increase and their science content knowledge increases. This phenomenon is one of the reasons why STEM and STREAM are gaining a foothold in science education at the elementary level.

Another trend impacting elementary science education is that of guided and independent inquiry; or viewing science instruction as a way to direct students to asking and answering their own questions (Cook and Ewbank, 2019). This inquiry process includes a restructuring of science classes to facilitate question-asking in response to scientific phenomenon, or natural, observable events, using practices that scientists use to collect and analyze data, and review the data and draw conclusions (Cook and Ewbank, 2019). This is the type of framework that the NGSS is based upon (National Research Council, 2012). Lee et al. (2016) also show that when teachers themselves are participants in an inquiry-driven classroom structure, their content knowledge grows, but the constraints of professional development seminars are often slightly different than that of the everyday elementary classroom structure. When viewing this inquiry-based practice as well as different constraints placed on elementary teachers, restructuring classroom dynamics to fit this planning-intensive model may be met with frustration. The NGSS endorsed model of science teaching emphasizes student-driven construction of scientific principles from observable events which is an application of constructivist-style pedagogy, and similar to this inquiry-driven method of instruction (NGSS Lead States, 2013; National Research Council, 2012).

The last major trend in science education that impacts elementary science classrooms across the United States is that of an emphasis on social activism and community engagement through Project-Based Learning (PBL) and Citizen Science (Ferrero et al, 2021). Scott (2016) mentions that activities outside of the classroom can increase the involvement and content knowledge of students and gives them motivation to pursue fields of science later in life. Carrier et al. (2013) also show that experiential, hands-on learning experiences allow students to interact with the content in ways that they wouldn't otherwise in the classroom context. Citizen science uses the fieldwork of students to be shared with researchers in different science fields (Scott, 2016). PBL, in a like-minded way, allows teachers and students to participate in solving a problem, or create a project that helps their school, community, state, or nation (Almulla, 2020).

With the onset of COVID-19, however, elementary teachers have found themselves trying to supplement the supposed learning loss of the COVID-19 pandemic, a result of school closures and virtual classes (Skar, 2023; Kuhfeld et al., 2020). Data has suggested that reading and fluency skills in elementary students were one of the results of these closures (Starling-Alves et al., 2023). Research also suggests that reading and fluency skills weren't the only student dispositions to be impacted. Halloran et al. (2023) suggest that elementary performance on exams in virtually every content area was significantly impacted by school closures in most states in the United States during the COVID-19 pandemic of 2020 to 2022. So, as local school districts are often increasing the initiatives that elementary teachers are often required to follow, the pressure for them to remediate mathematical and reading/ELA skills for students is increasing, placing elementary inservice teachers in between a rock and a hard place when it comes to preparing instruction that meets the rigor and relevance of the NGSS (Zinger et al., 2020).

Theoretical Framework

Science Teaching Constraints and affordances:

Currently there is a research gap in the field of science education that operationalizes the circumstances surrounding inservice elementary science teachers as science teaching constraints and affordances. This research chose to refer to categories of conditions which teachers are subjected to as science teaching constraints and affordances for several reasons. Teachers' time, initiatives, standards, materials, curriculum, professional development, and PLCs are directly influenced by factors outside of their control (Zinger et al., 2020). For example, their building, district, state, and national initiatives impact their daily instruction, but teachers often don't have a choice in their implementation (Banilower et al., 2018; Smith, 2020). Since these factors, whether viewed positively or negatively, impact the daily routines, planning, instruction, and assessment of teachers, this research has labeled them science teaching constraints and affordances. While research has been completed which labels these factors constraints and affordances for science teachers (Johnson & Dabney, 2018; Zinger et al., 2020), some of the factors defined in this research can be controlled by the teachers themselves, like classroom culture, teacher-student relationships, and to a certain extent, the teacher's content knowledge prior to science teaching, and therefore aren't dependent upon policy, adoption of curriculum or any other force outside of the control of the classroom teacher.

This study aims to isolate if inservice elementary teachers' perceptions of their time to teach science, their adopted lesson planning initiatives, the depth and rigor of the NGSS, the availability of physical materials, their adopted curriculum, the space and facilities they have access to, the professional development they have received, and the size and support of their

Professional Learning Communities (PLCs) or Communities of Practice (CoPs) and their potential impact their science teaching self-efficacy and beliefs.

Time and Lesson Planning Initiatives

No matter what initiatives a school district adopts, no teacher of science is above these constraints and affordances that influence them. One factor that influences every decision within an average school day is that of the allocation of time for activities that are planned and implemented. Time is something that is limited by its nature as well as by decisions of administrators that come those who exist apart from the individual teacher in the classroom. Not only are is the time allocated for a school day determined by the constraints of systems placed on teachers, it is also impacted by decisions that teachers make about classroom management and facilitating instructional activities, and in some cases, time spent on particular content area academic activities is determined by lesson planning initiatives that the participating districts have adopted (Banilower et al., 2018; Rosenshine, 2015; Smith, 2020). As Smith (2020) states, "...emphasis matters little if science is not being taught or not being taught much. Too often, in self-contained elementary classrooms, science instruction loses the battle for instructional time" (p. 604). Banilower et al. (2018) have shown that, on average, 20 minutes of science instruction takes place per day in the elementary classroom as compared to 80-90 minutes and 55-65 minutes for ELA/reading and mathematics, respectively. While science and its emphasis seem to be waning at the teacher preparation level, explicit, direct instruction in science is waning in elementary classrooms as well (Banilower, 2019; Banilower et al., 2018; Plumley, 2019).

In response to these time limitations, some elementary education programs are offering elective integrated social studies and science methods courses to meet the needs of preservice teachers in order to show them how to successfully integrate these subjects within other core subjects, which further stigmatizes social studies and science as fun, but unimportant, additions to an already full curriculum (Christou & Bullock, 2014). This trend of setting science instruction aside is also seen in the number of elementary schools that are adopting a special science time like music and physical education classes. In general, teachers often feel like they don't have enough time in the school day to effectively teach science (Carrier et al., 2013; Johnson & Dabney, 2018). Because teachers often feel like they don't have time to integrate effective science instruction strategies into their daily schedules (Johnson & Dabney, 2018; Park Rogers, 2011), some educators are taking a more integrated approach to science instruction, using their English-language arts or math time to double as science instruction time. Though it's often due to time constraints, it has been suggested that this is an effective strategy of teaching science concepts, though elementary inservice teachers often lack the training needed to access its benefits (Heisley & Kucan, 2010; Slavin et al., 2014).

In sum, time is of the essence in the elementary school classroom. Teachers are bombarded by a number of different constraints and limitations to the time they can spend on explicit science instruction, and this study recognizes that this limitation may impact self-efficacy among elementary inservice teachers of science.

Depth of the NGSS

Not only is time a constraint for elementary inservice teachers of science, but research-based science teaching is also dependent upon the teacher's content knowledge and pedagogical practices as they relate to the NGSS. Teachers' attitudes about NGSS directly impact their implementation of them (Channell et al, 2021). The framework of the NGSS blends three components together within science instruction time to support students as they construct their own science knowledge through interacting with the natural world and through simulations (National Research Council, 2012). The three components that should be blended throughout the science instruction at every level of education, Kindergarten through 12th grade, are the DCIs, the

SEPs, and the CCCs (NGSS Lead States, 2013; National Research Council, 2012). While elementary inservice teachers are required to integrate all three of these components into their science teaching, they are also required to understand and be able to teach a variety of topics within the field of science (NGSS Lead States, 2013). Elementary teachers are expected to be able to communicate with kindergarten students about the needs of plants and animals but also be prepared to teach a 6th grade class about the types, structures, functions, and needs of different cells (NGSS Lead States, 2013). In Figure 2-2 below are two examples of separate performance expectations that licensed K-6 teachers may be required to teach in any state that has adopted the NGSS for science instruction.

Figure 2.2

Kindergarten Performance Expectation Versus a Middle School Performance Expectation

Students who demonstrate understanding can:

MS-LS1-1. **Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.** [Clarification Statement: Emphasis is on developing evidence that living things are made of cells, distinguishing between living and non-living things, and understanding that living things may be made of one cell or many and varied cells.]

Students who demonstrate understanding can:

K-LS1-1. **Use observations to describe patterns of what plants and animals (including humans) need to survive.** [Clarification Statement: Examples of patterns could include that animals need to take in food but plants do not; the different kinds of food needed by different types of animals; the requirement of plants to have light; and, that all living things need water.]

NGSS Lead States, 2013. MS-LS1-1 and K-LS1-1.

Not only are the performance expectations vast in their content depth, but the philosophy of science teaching that is embedded within the NGSS is different than a lot of practicing teachers are used to or prefer. Sullivan-Watts et al. (2013) have shown that the best way for teachers to feel effective at implementing inquiry-based learning is by experiencing it as both a student and a teacher. This type of inquiry-based learning is the goal for the NGSS in elementary and secondary classrooms (NGSS Lead States, 2012). Smith (2020) in his discussion of Banilower et al. (2018) shows that, although teachers generally agree with some of the practices embedded within the Framework for K-12 Science Education (National Research Council, 2012), teachers are still resisting the philosophy behind the standards (Banilower et al., 2018; Plumley, 2019). For instance, the framers of the NGSS have promoted the use of inquiry-based learning through instructional models like the 5-E method, which promote student-centered discovery learning rather than the explicit instruction with science practices done at the end of the unit (Bybee, 2020; Bybee et al., 2006). Specifically, Smith (2020) mentions that more than half of science teachers still view laboratory practices used in science instruction as a way to "reinforce" science learning instead of facilitating avenues for students to discover the scientific governing principles in the natural world while creating their own learning (p. 603).

While the depth and the structure of the science standards have been the goals for many states for over a decade, the depth of the content and the philosophy undergirding the standards seems to be a hindrance to science teachers effectively enacting the NGSS in the classroom.

Physical Materials

Reform-based science teaching is very much dependent upon the access that inservice teachers have to the materials and supplies that reinforce the NGSS style of teaching. Unfortunately, physical resources are also a constraint or affordance in many elementary schools, depending on location and tax-base (Banilower et al., 2018; Johnson & Dabney et al., 2018; Plumley, 2019). Sullivan-Watts et al. (2013) have shown that when teachers have adequate physical resources, they are more apt to successfully implement science curriculum, but despite this connection, teachers often still feel constrained by the lack of physical resources that are available at any given time in their schools or classrooms (Johnson & Dabney, 2018). According to Kwan-Ping Lee (2012) preservice teachers often feel the same way in regard to the resources available, as well as their familiarity with implementing them. This perceived lack of resources could be because districts are focusing on the often-assessed subject areas of math and reading far and above science and social studies, due to the socioeconomic status of the school district, or its relative location. This may be true, but the point remains: if teachers feel like they don't have the resources, they may not feel comfortable teaching in the ways that are most beneficial for students. Although socioeconomic factors do have an impact on teacher and classroom resources (Johnson & Dabney, 2018), Hayes and Trexler (2016) have shown interestingly that these constraints have less of an effect on science education practices than other things like time to teach, and the amount of testing done on students, among other factors.

Banilower et al. (2018) have shown that, in most elementary classes, resources such as instructional technology, science equipment, and consumable supplies are all woefully lacking (p. 29). They have also shown that teacher perception of physical materials is considered a constraint by many elementary inservice teachers to implementing the types of science activities that they feel are most beneficial for students (Banilower et al., 2018).

Adopted Curriculum

Not only does inservice elementary teachers' access to physical materials help or hinder their ability to effectively implement the curriculum, their school's adopted curriculum also makes a difference as well (Smith, 2020; Zinger et al. 2020). In fact, Zinger et al. (2020) showed through their study of rural elementary school teachers that over 40% of teachers surveyed would be heavily reliant upon a curricular resource to feel effective at teaching the NGSS in their classrooms (p. 19). It would be a good inference to assume that, since the adoption of the NGSS in 2013 by most states, curricular resources used in the classroom would have changed to match the adopted state standards. This assumption would be woefully incorrect. Banilower et al. (2018) and Smith (2020) have shown that "In NGSS states, half or more of these science classes were using materials (textbooks, kits, or modules) published before 2009" (p. 604). This is important because of the reformation of the science standards in 2012-2013, but also because what it shows is a lack of attention to the nature of science, as what is stated in a textbook from 2009 might be outdated in some instances.

The curricular materials used by teachers in the elementary school setting being updated aren't only a detriment to the content knowledge that elementary students are building in their science lessons, they also impact the perceived self-efficacy of the teachers that use them. Nowicki et al. (2013) have shown that a substantial number of elementary inservice and preservice teachers are dependent upon the curricular resources, teaching guides, and explanations to supplement their own science knowledge before they teach their lessons. In fact, they have shown that, in many instances, novice teachers who are lacking these updated curricular materials fail to accurately represent the science concepts to their students (Nowicki et al., 2013).

Space and Facilities

In order to facilitate the types of learning that are embedded within the NGSS, there is often a need for the use of spaces around the school, both indoors and outdoors, for students to use as they interact with, explore, and explain the natural world through the lens of scientists. According to Banilower et al. (2018) and Plumley (2019), elementary inservice teachers indicate that they feel that access to physical spaces with the infrastructure necessary for their science lessons are also lacking, whether in their own classrooms or across the shared spaces at their schools. Banilower et al. (2018) define science accessible facilities as having access to lab tables, electricity outlets, sinks, and gas.

Professional Development

The emphasis in elementary schools on the teaching of reading and math has far-reaching implications, especially when it comes to professional development. Smith (2020) shows that the emphasis in elementary schools as it relates to professional development is placed on those subject areas more so than on science and social studies. Smith (2020) also states about elementary teachers receiving in-depth, science-specific professional development, that “more than four in ten elementary teachers had none” in the previous three years (p. 603). Plumley (2019) summarizes this report:

> ...elementary teachers have had limited opportunities for professional growth in science. Although the majority have participated in science-focused professional development in the last three years, only a very small percentage have had sustained professional development (more than 35 hours). Furthermore, fewer than a third reported that their professional development in the last three years included characteristics of effective professional development, such as examining classroom artifacts or rehearsing instructional practices during the professional development (Plumley, 2019, p. 32).

What’s interesting about these statistics, analyzed from Banilower et al. (2018), is that even though teacher self-efficacy and performance has been shown to be related to access to quality professional development (Seniveratne et al., 2019), its emphasis still seems to be lacking (Smith, 2020; Banilower et al, 2018; Nowicki et al., 2013).

Availability of professional development that corresponds with science instruction in the elementary classroom helps build and develop a robust content-knowledge in teachers and teacher candidates (Hayes & Trexler, 2016). It’s understandable that a teacher’s overall familiarity with the content knowledge they are required to teach has an impact on the science instruction practices (Boyer, 2016). Cofre et al. (2014) have shown that when even a small amount of time is spent working on certain aspects of pedagogy over the course of a year, teachers' content knowledge and classroom practices benefit from it.

Professional Learning Communities

Another area of constraint and affordance is the resources available to teachers as they strive to enact the science curriculum in their classrooms. The first resource that has an effect on the science instruction of teachers is their Community of Practice (CoP). CoP or professional learning communities (PLCs) are structures of collaboration between teachers as they strive to implement best-practices in their respective fields of education, whether a grade-level in an elementary school or a content area specialization in a middle or high school (Vescio et al., 2008). Vescio et al. (2008) describe five characteristics of a PLC or CoP which include: shared values and norms about how students best learn, a focus on student learning, extensive and continued dialogue about relationships between students, teachers, and the curriculum, de-privatizing practice or sharing strategies and resources for the collective good, and lastly, a focus on collaboration (p. 81). PLCs and CoPs are ways that teachers share their collective experiences to benefit each other, show multiple ways of problem solving through the curriculum, and reinforce best teaching practices.

It has been shown that access to PLC or COP impacts preservice and novice teachers alike either positively or negatively based on the nature of the interactions that occur between the professionals and how they cooperate (Mintzes et al., 2017; Park Rogers, 2011). In other words, the community that these professionals participate in is often the first resource they go to when encountering problems with implementing science content in their classrooms. Many school districts and teacher preparation programs allow communities or groups to work together to plan and implement the curriculum, believing that teachers who work collaboratively will have more success. As mentioned above, this can have either a positive or negative effect on the teams who work together. If like-minded individuals all have an aversion to science, the group's collective implementation of the science curriculum will be negatively impacted, and vice versa. The context of the teams creating and implementing curriculum influence science instruction, but so do some other factors.

In summary, there are many science teaching factors that influence the effectiveness of the science curriculum implementation of elementary teachers and preservice teachers. Some of these include the attitude of the science teacher toward the subject matter, the philosophy of the science teacher, and the teacher's prior experiences with the subject, the time, resources, and professional development given to the teachers as they strive to teach science effectively (Sullivan-Watts et al., 2013).

Self-Efficacy

One of the main constructs this study aimed to consider was that of science teaching self-efficacy. Self-efficacy studies have their beginning in the late twentieth century with Bandura's social learning theory (1977, 1982, 1986). Bandura (1977, 1982) and his theory of social learning gives the framework for this study over the influence of science teaching factors on elementary inservice teacher science teaching self-efficacy. One of the social learning theory studies conducted by Bandura (1982) was concerning social learning theory, and in particular self-efficacy. Self-efficacy as it relates to this study can be broken down into two components: personal efficacy and outcome expectancy. Bandura's emphasis on personal efficacy (1982) was studying, "how well one can execute courses of action required to deal with prospective situations" which come from a wide range of contexts (p. 122). Bandura (1982) showed that there are multiple components that determine someone's self-efficacy as it relates to a particular skill. The two components are what people believe about their own ability to complete an unknown task based on prior experiences and knowledge, or personal self-efficacy, as well as their perception of what behaviors lead to the most desirable outcome, or outcome expectancy (Bandura, 1982; 1986). According to Bandura (1986) there necessarily exist correlations between someone's performance in each area, and their self-efficacy scores. He writes that although it's true that some respondents in self-efficacy surveys will rank themselves in ways that don't correspond to reality, like low performers having high self-efficacy and vice-versa, statistically speaking they can be overcome through large sample sizes (Bandura, 1986). In summary, the self-efficacy presumed by individuals is a measure of the skills needed to perform a certain task as well as the perceived ability of the individual who is required to perform the task.

Measurements of Self-Efficacy Using the STEBI-A

Riggs (1988) and Riggs & Enochs (1990) make the application of this self-efficacy theory to the realm of science education. Using Bandura (1977, 1986) and Self-Efficacy theory, Riggs & Enochs (1990) crafted the STEBI-A for use with inservice elementary teachers. In Riggs & Enochs' (1990) instrument, different measures of self-efficacy regarding science teaching and learning are listed. The STEBI is an infusion of two separate constructs defined by Bandura (1982, 1986) and combines the measurement of two constructs: science teaching outcome expectancy (STOE), as well as personal science teaching self-efficacy (PSTE), and gives a reliable measurement of each through 5-point Likert scale responses either in agreement or disagreement with self-evaluative statements within the constructs (Shroyer et al., 2014, Hechter, 2011). There are 12 items measuring STOE, and 13 items measuring PSTE within the STEBI-A (Riggs & Enochs, 1990). Recently, the reliability of the instrument used in this research, the STEBI-A, was tested by Moslemi & Mousavi (2019) and was found to be a reliable measure of the constructs. These researchers tested the Cronbach's Alpha for the different constructs, and the reliability of the instrument was confirmed (Moslemi & Mousavi, 2019).

Given the nature of the STEBI-A survey instrument and the history of self-efficacy psychometric studies, the research conducted in this study using this operationalizing of "self-efficacy" is rooted in data.

Self-efficacy as it relates to teaching has also been found to have components that influence it: cognitive content mastery, cognitive pedagogical mastery, and simulated modeling (Palmer, 2006). Just as a musician who's not confident shies away from singing or playing the part they think is supposed to be played, often teachers shy away from treating content areas they are unfamiliar or unconfident with. The point is, teachers' beliefs about science instruction impact their implementation of science in the classroom (Boyer, 2016; Docherty-Skippen et al., 2020; Granger et al., 2019; Menon & Sadler, 2018). This can show itself in a number of ways: inservice teachers who view science as a body of content knowledge that is to be passively absorbed by the students are necessarily going to teach the content differently than a teacher who views the students as mini scientists actively investigating phenomena. The philosophy of the teacher necessarily impacts their implementation of the curriculum.

Inservice teachers' experiences and exposure to the subject matter impact their implementation and teaching practices. In general, teachers often feel ill-prepared to teach the sciences the ways they think they need to (Carrier et al., 2013). There are certain factors that increase and decrease teachers' self-efficacy score because they directly relate to the classroom implementation of the science curriculum. Because of this, it is important that research concerning these influencing factors be considered for review.

Summary

In this chapter a detailed summary was given of the literature which was reviewed for this study. The literature described in this chapter included modern trends in science teaching including the NGSS, the constructs of science teaching self-efficacy and beliefs and their theoretical roots, as well as an overview of the common constraints and affordances that impact elementary inservice teachers. There was discussion over the beginnings of Bandura's (1977) self-efficacy theory and its impact on the design of this study, and the coming chapters will show that these constructs directly impact the design, implementation, and analysis of this research.

The next chapter will show the methodology of this study. The final two chapters, chapters 4 and 5, discuss and analyze the data collected and make conclusions based on the data collected.

Chapter 3 - Methods

Rationale for Survey Research

This chapter explains the methodological framework and research design that was used in this study. This research investigated the influence of science teaching constraints and affordances of elementary inservice teachers and their relationship to science teaching self-efficacy and beliefs, and explored specific events that inservice elementary teachers see as impactful for their science instruction. The research questions considered in this study were:

1. Are there any statistically significant correlations between inservice elementary teacher perceptions of science teaching constraints and affordances and their score on the science teaching efficacy and belief instrument (STEBI-A)?
2. If any, what other statistically significant correlations can be made between demographic information and inservice elementary teachers' science teaching self-efficacy?
3. How do inservice elementary teachers describe the impact of policies, training or events like the COVID-19 pandemic on their science instruction?

Survey research, the tailored design method, was used in the creation and dissemination of the survey instrument in this study (Dillman et al., 2014). In this way, the researcher utilized strategies to reduce the social costs experienced by respondents (Dillman et al., 2014). This means that care was taken to reduce the amount of time, resources, and effort that was required of the participants (Dillman et al., 2014). The researcher also made sure that respondents were aware that participation in the research was voluntary and confidential using an embedded informed consent within the survey. The survey instrument had three sections. The first section of the survey collected demographic and information over inservice elementary teachers' contextual information, the second category within the survey analyzes their perceptions of the science teaching constraints and affordances they experience regarding science instruction, including events and COVID-19 policy on science instruction, and the last section measures their science teaching self-efficacy and beliefs.

This research analyzed the relationships between inservice elementary teacher's perceptions of science teaching constraints and affordances and their science teaching self-efficacy and beliefs. The independent variables in this study were the teacher perceptions of the categories of science teaching constraints and affordances. The dependent variables were the inservice elementary teacher science teaching self-efficacy and beliefs.

The hypotheses and aims of this study were the following:

H1: Science teaching constraints and affordances have statistically significant correlations to the science teaching self-efficacy and beliefs of elementary inservice teachers.

Null Hypothesis: There are no statistically significant correlations between the science teaching constraints and affordances and science teaching self-efficacy and beliefs.

H2: There are statistically significant correlations between the demographic information and science teaching self-efficacy and beliefs of inservice elementary teachers.

Null Hypothesis: There are no statistically significant correlations between the demographic information and science teaching self-efficacy and beliefs of elementary inservice teachers.

In addition to these statistically based hypotheses, this research also sought to explore the thoughts of inservice elementary teachers and how they perceive the impact of policy, and specifically COVID-19 policy, on the teaching of science in their classrooms using two-cycled coding of responses to the open-ended questions (Saldaña, 2021).

Participants

Inservice elementary teachers from a Midwestern state with self-contained classrooms were used in this study to determine the effects of the science teaching constraints and affordances on their science teaching self-efficacy and beliefs. Contact information for public elementary school principals was obtained through state-published contact information, and the principals were asked to forward the survey on to their elementary school faculty. The correspondence to the principals occurred three times over the course of three weeks, and districts with strict research protocols were able to opt-out through not responding to the solicitation to participate in the research. In each consecutive correspondence, the number of respondents that had participated were updated in an effort to show that teachers were participating in the research, and to reinforce that it was something that was easy to do (Dillman et al., 2014). This research also utilized an incentive of 5, $20 gift cards that were assigned randomly to participants who met the criteria. In the survey instrument, precautions were made to ensure that teachers who did not meet these criteria could be excluded from the data analysis through their responses to the demographic and contextual information within the survey.

Eligibility to Participate in the Research

For teachers to be eligible to participate in this research, a few criteria needed to be met by them and their classrooms in which they teach. The descriptors of the target sample population included inservice elementary teachers who teach in self-contained classrooms. This separated them from several populations that may have gained access to the survey through the contacted principals, so it is necessary to show that this sample population was unique.

Inservice teachers are teachers who are currently practicing in the field of education. This is a separate category from populations like preservice teachers who are in education preparation programs at the collegiate level. These teachers also had to be elementary teachers, meaning that they teach in an elementary or intermediate school instead of a middle school. The last criterion for participant eligibility is that these elementary teachers teach in self-contained classrooms. This means that these are teachers who are responsible for a group of students and their learning in all subject areas instead of one, or a few subject areas (Eichhorn & Lacson, 2019).

Increasingly, in some elementary schools, teachers are departmentalized, or teach one subject to many different sections of students (Eichhorn & Lacson, 2019). Teachers who teach departmentally were excluded for two reasons. First, if the elementary inservice teachers don't teach science, undue bias against the subject matter of science at the elementary level may exist. Secondly, and conversely, if they only teach science, they may have an undue proclivity and bias toward the subject matter. Teachers who teach science plus another subject area are also excluded from this research because this research solely focuses on the majority of elementary inservice teachers' experiences as it relates to teaching science and the majority of elementary teachers are not departmentalized, though the number of departmentalized cohorts in upper elementary has been increasing in recent years (Eichhorn & Lacson, 2019).

Instrument

To analyze the impacts of science teaching constraints and affordances on the science teaching self-efficacy and beliefs of elementary inservice teachers, an online survey instrument was created by adding the reporting of perceived constraints and affordances to an already-existing survey structure, the STEBI-A (Riggs & Enoch, 1990). After contacting Riggs (1990), permission was granted for the researcher to use the STEBI-A within the context of this research. Riggs & Enoch (1990) and their instrument have been used widely for several years. Though there are more current instruments that have been developed to measure inservice teachers' self-efficacy and beliefs, there have been studies to show the effectiveness of this survey instrument to measure the constructs (Deehan, 2016). Though there have been alternatives to the STEBI-A developed, such as the T-STEM scale, there exists a legacy of research regarding science teaching self-efficacy that is linked to the STEBI-A, and the STEBI-A uses a two-construct approach to measuring science teaching self-efficacy as opposed to a three-construct measure of it as in Unfired et al. (2022).

Through the development and implementation of this survey instrument, Dillman et al. (2014) was used as the basis for the construction, dissemination, and communication in the survey instrument itself. Dillman et al. (2014) discuss social exchange theory, which basically states that any survey instrument should have the benefits of participating in the survey outweigh the social costs. In this sense, the primary benefit of the research is explained in the informed consent, and the cost to the participant is primarily the time it takes to complete the survey. The benefits of this survey include the results being applied to the current body of research. Along with participating in meaningful research, the participants were also eligible to be randomly selected to receive one of ten $10 gift cards to Amazon. The use of an incentive was weighed carefully, and the researcher decided that more, lower-valued incentives would be more effective in increasing the sample size.

Section 1: Informed Consent

The first section of the survey instrument included a page that explained the type of research, the use of the research, and the nature of the participants' consent. If the consent form was denied, the survey ended and took the participant straight to a thank-you page. If the participants agreed to the consent form, it allowed them to continue to the page that collects data on them as a participant. In this section of the informed consent, participants were also asked to designate whether they would like to be informed of the final results of the research and were asked to provide an email address to send the finished document to. Lastly, participants were asked if they would like to be placed in a drawing for one of five, $20 Amazon gift cards. If they selected "yes," then participants were asked to provide an email address to be contacted at if they were to win the drawing. After these sections were completed by the respondents, the next section of the survey appeared.

Section 2: Demographics and Contextual Information

The second section of the survey was a range of questions that helped the researcher gain some insight into the context of the elementary teacher that was responding. Demographic and contextual information that was collected included information about the participants' age, gender, years of elementary teaching experience, level of education, current grade-level position, the number of grade-level sections at their school, subjects taught, the population of their community, their daily time to teach science, their adopted science curriculum, and the number of hours they have received in professional development that have been science-focused in the past year. This section of the survey was included in order to collect data with regard to the second research question in this study. The answers to these questions allowed the researcher to explore patterns in this demographic information and their possible impact on science teaching self-efficacy. These demographic survey items are listed in Appendix A. After the demographic information was collected from participants, the survey moved to collecting inservice elementary teachers' perceptions of some common constraints and affordances.

Section 3: Science Teaching Constraints and affordances

The third section of the survey included questions surrounding the perceived science teaching constraints and affordances that these inservice elementary teachers identify in their individual contexts. This section of the survey instrument was designed to have participants select a level of agreement with a statement describing their perceptions of certain constraints and affordances in their current positions. In this section of the survey, both negatively and positively worded items were included for each constraint and affordance that was being measured. All responses used a 5-point Likert scale, including: "Strongly Disagree," "Disagree," "Neither Agree nor Disagree," "Agree," and "Strongly Agree." The statements measure the participant's view of eight science teaching constraints and affordances that this research used to analyze their relationship to an elementary teacher's science teaching self-efficacy. The constraints and affordances included in this section of the survey were: time, lesson planning initiatives, standards, materials, curriculum, space/facilities, professional development, and professional learning communities. The statements in this section are listed in Appendix A.

In this section of the survey, there were also two open-ended response items in order to see what events or policies changed their science instruction over their time in the elementary classroom. The first question asked them what event, policy, or other change most affected the way they view science instruction at the elementary level. The second question asked them specifically how the events and policy changes of COVID-19 influenced them and their science instruction. The COVID-19 specific question was given to the respondents after a page-break in the survey instrument so the participants' answers to the first question wouldn't be unduly influenced. Both of these responses were open-ended, and long-text designated in the Qualtrics survey. After collecting data on the elementary inservice teachers' perceptions of these eight science teaching constraints and affordances, the fourth section of the survey measured each elementary teacher's science teaching self-efficacy and beliefs.

Section 4: STEBI-A Survey Instrument

This section of the survey instrument measures the respondents' views of their science teaching self-efficacy and beliefs. This section of the survey instrument was used from Riggs & Enochs (1990). Permission was obtained from Iris Riggs through contacting her via email to utilize the instrument in this research study. This section of the survey also utilized statements with a 5-point Likert-scale response that shows how the teacher views their own efficacy and beliefs about their view of their own science teaching. This 5-point Likert scale included responses like: "Strongly Disagree," "Disagree," "Neither Agree nor Disagree," "Agree," and "Strongly Agree." While research has shown that even-numbered Likert scale responses allow students to select either a positive or negative-leaning response, the 5-point Likert scale has a neutral response, which means that some responses won't have a positive or negative leaning regarding the research questions and hypotheses. Items in this section are listed in Appendix A. The STEBI-A measures two sub-components of science teaching self-efficacy with multiple items per sub-component. The sub-components it measures are Science Teaching Outcome Expectancy (STOE) as well as the Personal Science Teaching Expectancy (PSTE).

Procedures

Before the survey instrument was disseminated, the researcher asked colleagues from the regional university where they work to go through the survey and give feedback and ideas for change for the setup of the survey, the look of it, the flow, as well as the wording. In the span of a week, the colleagues gave specific, detailed feedback about changes that would help the look, flow, and logic of the survey itself. Specifically, they mentioned that the initial informed consent section could use some work. They encouraged me to change two written response questions into "yes or no" responses with a conditional written response so people could tell me where they'd like the results sent. This helped the look and feel of the survey and also decreased the confusion as the survey was starting.

The researcher applied for research approval to the research institution's Institutional Review Board (IRB). The informed consent document, the science teaching self-efficacy survey, and the IRB form were submitted to the university for analysis of compliance with research practices. Before the survey was disseminated, approval from the IRB was acquired.

Inservice Teacher Contact

Initially, the researcher sought out the state department of education where this research took place to secure contact information of licensed teachers in grades Kindergarten through 6th grade. The head of teacher licensure in this department said that no comprehensive list like this existed and that their staff couldn't make the time to compile a list for this research to use. Since no comprehensive list of teacher contact information existed, the researcher had to look for alternative routes for contacting elementary teachers statewide. In this state, building principal contact information is made public through documents that are published on the state's department of education website. The researcher used this public document, compiled all of the email addresses for building principals that employed elementary inservice teachers, and used those identified principals as the conduit to disseminate the survey instrument.

In this state, there were over 700 building principals whose buildings employed elementary inservice teachers which met the criteria of this research. The email solicitations were sent to these principals in hopes that they would forward the survey instrument along to their staff.

Dissemination of the Survey Instrument

The building principals were sent three solicitation emails over the course of three weeks in order for them to share the survey instrument with their elementary teaching faculty. To avoid the constraints of state testing and end of the year activities happening in schools, the survey was disseminated on April 7th, April 14th, and April 19th of 2023. The emails were sent at different times of the day during these weekdays. A total of n=708 principals were contacted via email during these three weeks. Over the course of the three weeks, a total of n=227 responses were collected from teachers. Of these n=227 initial responses, a little over half of the responses were from the target sample population, n=138.

Collection of Data

The data collected from the survey instrument was housed in Qualtrics, a password-protected, encrypted software often used for survey data collection. The researcher also used a password-protected computer and Microsoft Excel to clean up and re-code data, making sure to keep a copy of the original data. Data was transferred to the spreadsheet software so that responses could be sorted, and the data cleaned. When the data was cleaned, the responses and data that did not pertain to the nature of the research questions were removed. During this process, if teachers designated that they were interested in participating in the drawing for the gift cards, their information was placed in a separate spreadsheet to separate their contact information from their responses as well as allow the random assignment of the gift-cards to take place.

Data Analysis

Data was collected through the use of Qualtrics online survey technology and stored on their encrypted servers. To get the data to where it was useable for analysis with regard to the research questions and hypotheses of this research, the quality of the data needed to be established and ensured. In this research, the survey data was cleaned and coded.

In order for the data to qualify as usable for interpretation and analysis for this research, the respondents had to have completed the survey instrument in its entirety. In this research, the only responses that were recorded were complete responses. There are two reasons for this decision. First, with respect to this, the researcher wanted to be sure that consent for participation in the survey was maintained throughout the completion of it, and if respondents didn’t complete the survey, there is no way to know the reasons for the incompleteness of it, and to give the respondents the benefit of the doubt when it comes to their consent, this research excludes them from analysis.

The second reason why the incomplete surveys were discarded was due to the necessity of the completion of the survey instrument. With the STEBI, there are two constructs that are measured with multiple statements. This means that the incompleteness of the survey instrument may unnecessarily weigh the constructs differently if the number of statements that are completed aren't congruent. To limit this amount of data interference, the partial responses were excluded from the research entirely.

Coding of Answers and Creating Composite Scores

In order to analyze the data collected from the survey items, prior to data analysis certain items needed to be reverse coded to match the nature of the research questions. For the purposes of this study, there were eight negatively worded items found in the science teaching constraints and affordances section of the survey, there were five negatively worded items for the STOE construct within the STEBI-A, as well as eight negatively worded items within the PSTE construct (Riggs & Enochs, 1990). To reverse-code these items on their existing 5-point Likert scale, if a respondent answered "strongly agree" to a negatively worded item, it was coded as a 1 instead of a 5, and vice-versa. The reverse coding process used SPSS recoding values function to accomplish this without manually sifting through the responses, and thus limiting the input error from the researcher. The number of reverse-coded questions are listed in the "negative items" column in Table 3-1.

Table 3.1

List of Positive and Negatively Worded Survey Items

Construct	Positive Items	Negative Items	Total
Time	12.1	12.9	2
Lesson Planning Initiative	12.2	12.10	2
Standards	12.3	12.11	2
Materials	12.4	12.12	2
Curriculum	12.5	12.13	2
Facilities	12.6	12.14	2

Professional Development	12.7	12.15	2
PLC	12.8	12.16	2
STOE	15.1, 15.4, 15.7, 15.9, 15.14, 15.15, 15.16,	15.10, 15.11, 15. 13, 15.20, 15.25	12
PSTE	15.2, 15.5, 15.12, 15.18, 15.23	15.3, 15.6, 15.8, 15.17, 15.19, 15.21, 15.22, 15.24	13

The next step this research used was to create composite scores combining the answers for each question within a related construct (Song et al., 2013). For example, all responses to survey questions which measured the elementary teachers' perceptions of professional development were combined to form a composite score representing the teacher's perception of that construct. The creation of composite scores used the method of creating a simple sum based on related constructs (Song et al., 2013). With the assumption of reliability met through reliable Cronbach's α scores for related constructs, item scores can be averaged to create a single variable that can then be used for the purposes of statistical analyses while limiting the amount of Type-I error. The same thing was done for each construct listed in Table 3-2 below. This was done so that correlations could be explored, and so multiple data points for each construct could be combined to show with greater clarity where participants marked all questions in a related construct (Song et al., 2013). Along with reverse coding, the researcher needed to create a composite score for the constructs being measured. Composite scores were created in order to maximize the understanding of the impact of these constructs. For each construct, the researcher added the scores together and created a composite score that represented the participants' responses. For instance, there were two items for each of the science teaching constraints and affordances that were totaled for each participant. This means that the two questions with the 5-point Likert scale were summed to form a composite score that could range from 2-10. The same method was used for considering the scores from each of the constructs listed in the STEBI-A instrument, namely the STOE and PSTE scores (Riggs & Enochs, 1990). For those constructs there were 12 and 13 items in the survey instrument, respectively. This means that for the construct of STOE, there was necessarily a range of 12-60 points possible for the composite, and for the 13 questions representing PSTE, there was a possible range of 13-65 points possible. The benefits of including all of these items in composite scores for statistical analysis are that it limits the possibility or amount of type-1 error since the necessary statistical analyses will take place with fewer variables (Finch, 2005). With these items reverse-coded and summed, statistical analysis could take place.

Table 3.2

Number of Questions per Construct with Composite Ranges

Construct	Questions	Range of Composite Score
Time	12.1, 12.9	2-10 points
Lesson Planning Initiative	12.2, 12.10	2-10 points
Standards	12.3, 12.11	2-10 points
Materials	12.4, 12.12	2-10 points
Curriculum	12.5, 12.13	2-10 points
Facilities	12.6, 12.14	2-10 points
Professional Development	12.7, 12.15	2-10 points
PLC	12.8, 12.16	2-10 points
STOE	15.1, 15.4, 15.7, 15.9, 15.10, 15.11, 15.13, 15.14, 15.15, 15.16, 15. 20, 15.25	12-60 points
PSTE	15.2, 15.3, 15.5, 15.6, 15.8, 15.12, 15.17, 15.18, 15.19, 15.21, 15.22, 15.23, 15.24	13-65 points

Research Question 1

After this coding and processing of the data, correlations between contextual factors that elementary inservice teachers experience and their science teaching self-efficacy and beliefs were analyzed in this research. The researcher used SPSS statistical software to analyze both research questions. With regard to the first research question, correlations between science teaching constraints and affordances and science teaching self-efficacy and beliefs through STOE and PSTE were considered. Due to the multiple independent variables, and multiple dependent variables, the researcher used MANOVA to determine if there were statistically significant relationships between the constructs of the STEBI-A (STOE and PSTE) and science teaching constraints and affordances.

Reseach Question 2

To answer the second research question, this study used an exploratory MANOVA to observe possible relationships between demographic information and the dependent variables STOE and PSTE independently, or together (Field, 2018). For the statistical analysis, a $p<.05$ level of significance was used in determining whether correlations were statistically significant. Additionally, to answer the second research question, contextual information of participants was analyzed for statistically significant relationships to science teaching self-efficacy and beliefs.

Research Question 3

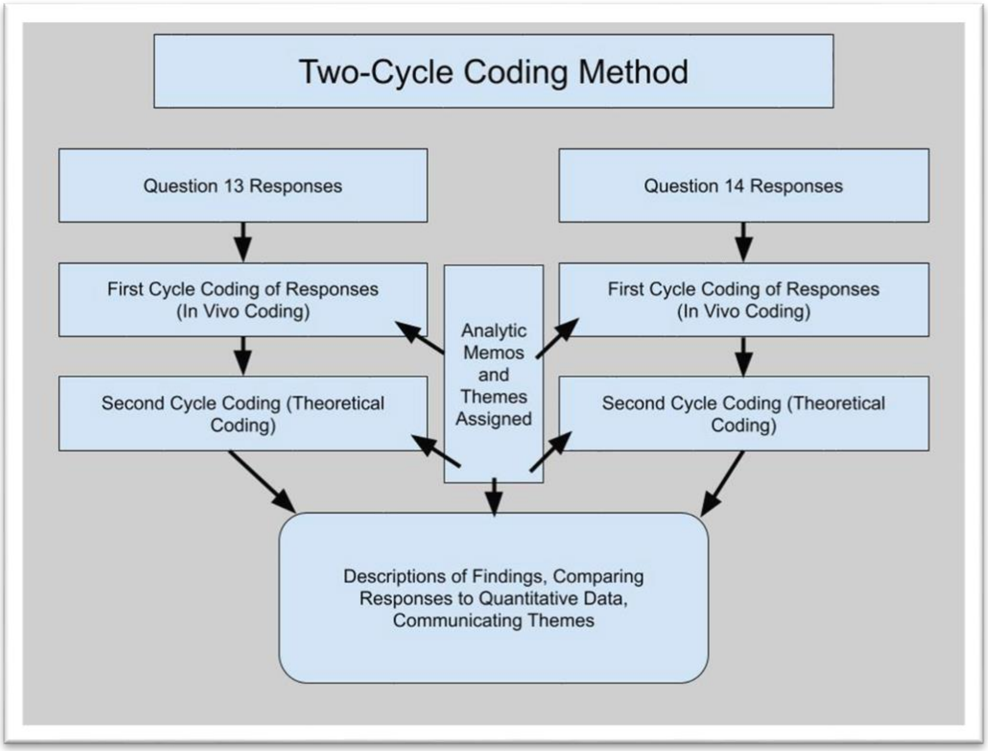
The analysis for the open-ended responses on the survey instrument took the form of two-cycle coding, following the method described in Saldaña (2021). This coding process was necessarily a priori due to the previously established goals that the quantitative research questions are seeking to accomplish. In this sense, the qualitative descriptions that teachers gave in these two, open-ended questions regarding their experiences with policies, events, and other things that they believe impact their science teaching will necessarily be informed by the types of questions they just answered about the eight designated science teaching constraints and affordances. The two open-ended questions that teachers had to answer are: 1) “In your experience teaching elementary students, what factor (training, event, policy, etc.) has most impacted your view of teaching elementary science? Write your response below, and 2) “Have COVID policies/responses impacted your science instruction? Why or why not? Write your response in the space below.” The first question was asked without respondents being able to see the second question in order to protect responses from being unduly influenced by the content of the second question. Teachers weren’t required to submit a response of length in this section, the field just couldn’t be empty in order for them to move on in the survey instrument.

From the answers to these two questions, there were two cycles of coding that were done for each question, and the answers to them were compared and contrasted with findings from the quantitative data as listed in figure 3.1. The first cycle of coding was inductive “In Vivo” or verbatim coding as listed in Saldaña (2021, p. 137). In Vivo coding is described as using “word[s] or short phrases from the actual language found in the qualitative data record.” (Saldaña, 2021, p. 137). Because research question 3 is seeking to have teachers describe their experiences with events/policies/etc., this research sought to utilize the descriptions that the inservice teachers themselves would use to describe their experiences. Saldaña (2021) describes this method as accessing and utilizing “a subculture’s unique vocabulary” in order to describe their perspectives and experiences (p. 138) This means that in this study, depths of meanings were assigned to text entries from teachers with regard to the open-ended questions. Concept coding takes words or descriptions from participants and assigns them to an “idea rather than an object or observable behavior” (Saldaña, 2021, p. 152). During and between coding cycles, this research utilizes researcher-generated analytic memos as themes and responses are processed (Saldaña, 2021). Analytic memos are described as, “a personal debriefing... by the researcher... to reflect on the process” (Saldaña, 2021, p. 151). For the purposes of answering this research question, analytic memos were thoughts from the researcher about the themes, codes, and synthesis of ideas as the coding process was ongoing.

The second cycle of coding used deductive “theoretical coding” as described in Saldaña (2021, p. 314). Theoretical coding is described as “conceptual coding,” and is the process of identifying the central theme of the data and “suggests a theoretical explanation of the phenomenon” (Saldaña, 2021, p. 314). Saldaña (2021) states that, “theoretical coding integrates and synthesizes the categories derived from coding and analysis to create a theory” (p. 315). After the data was collected and coded, it was then compared with the quantitative data. After this process, the researcher’s interpretations of the results were outlined with visual representation techniques drawn from Rouder et al. (2021), specifically using weights, colors, and sizes to represent themes found in the data.

Figure 3.1

Coding Method Flow Chart



Statement of Positionality

As the researcher I recognize that my own positionality impacts the context of this research as well as my interpretation of the results to the open-ended questions within the survey instrument. I taught 6th grade science for years, so the topic of science instruction at the elementary level is dear to my heart and thus I have the capacity to read into the data my own interpretations based on my experiences teaching in public schools. For the context of this research, the questions were set up so that I might be able to explore the ways that teachers had been influenced by certain events, policies, or decisions outside of their control, and in particular, I wanted to hear their perspective of how the COVID-19 pandemic influenced their view or practice of science teaching. Having gone through teaching science in the spring semester of 2020 I have my own thoughts and interpretations, which I wanted to limit the impact of in this research. I wanted to be able to separate myself and my experiences from the experiences and descriptions of the respondents. In this way, I wanted to be sure that the participants voices and words were used in at least one cycle of “In vivo” coding (Saldaña, 2021, p. 134). In addition, to ensure that the participants voices and perspectives were valued, I decided to use direct quotes to support the categories and themes that agree with the theoretical nature of this research study through theoretical coding (Saldaña, 2021, p. 314). I also wanted to highlight the voices of those teachers and the successes and struggles they face on a daily basis to effectively implement their respective science curricula. While the “In Vivo” codes aren’t the final coding process, they were utilized in the discussions and implications section of this survey research to showcase the experiences and views of those who completed this survey.

Summary

This chapter detailed the methodology, procedures, and data analysis used in the research which was conducted. Information about the sample population, sampling procedures, survey design and implementation, and data analysis were also explained in this chapter. This tailored-design survey research explored possible relationships between inservice elementary teachers’ views of science teaching constraints and affordances and their science teaching self-efficacy and beliefs. This study also considered exploratory relationships between contextual variables of inservice elementary teachers and science teaching through MANOVA and subsequent MANCOVA using demographic predictor variables. Lastly, this research aimed to consider how teachers perceive events and policy changes and their impact on science instruction at the elementary level. In chapter 4, the results of the quantitative and qualitative aspects of this research will be discussed, and in chapter 5, the implications of the findings of the research will be discussed.

Chapter 4 - Results

The purpose of this research was to explore elementary inservice teachers' perceptions of science teaching constraints and affordances and their possible relationships with their science teaching self-efficacy. Another purpose was to explore what other demographic information may be related to science teaching self-efficacy, and the last purpose of this research was to explore how events and policies have shaped elementary inservice teachers' perceptions of science teaching. This chapter provides an analysis of the following research questions:

1. Are there any statistically significant correlations between inservice elementary teacher perceptions of science teaching constraints and affordances and their score on the science teaching efficacy belief instrument (STEBI-A)?
2. If any, what other statistically significant correlations can be made between demographic information and inservice elementary teachers' science teaching self-efficacy?
3. How do inservice elementary teachers describe the impact of policies, training or events like the COVID-19 pandemic on their science instruction?

This research study utilized an online survey instrument distributed to inservice elementary teachers in a state in the Midwest in order to answer these research questions.

Sample Population

Response Rates

Recruitment emails were sent out to 708 elementary school building principals in a state in the Midwest. The researcher received contact back from two large school districts in the state with communication of district research protocol that needed to be followed. Those school districts were excluded from the survey due to time constraints placed on the research from their district-adopted research and data collection policies. From the building principals who forwarded the survey to their elementary inservice teacher faculty, a total of n=225 respondents completed the survey instrument. In the way this survey was conducted, responses had to be complete for the responses to be recorded so no partial responses were collected by the researcher for the purposes of data analysis. The Qualtrics survey instrument was set so that only full responses were collected for the purpose of this research. Of the n=225 responses that were collected, these responses had to be filtered through the purposes of the research questions. The research questions involved teachers who were licensed, currently teaching, and currently teaching at least all four core content areas at the elementary level. This excluded teachers who teach one, two, or three subjects, music, physical education, or gifted education across multiple grades or subjects. Those who were excluded from the analysis were n=87. After filtering the responses through the lens of the research questions and targeted sample population, the number of inservice elementary teachers who teach in self-contained classrooms who responded to the survey instrument were n=138.

Demographic Information

The population of inservice elementary teachers that responded to the survey and were in the target population for the study had diverse and unique contexts which are described through the demographic questions in the survey, listed in Appendix A. Of the total number of respondents (n=138) only 5 participants were male, which constituted 3.6% of the total respondents, as seen in table 4-1.

Table 4.1

Gender of Respondents

Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	5	3.6	3.6	3.6
	Female	133	96.4	96.4	100.0
	Total	138	100.0	100.0	

The participants' years of experience in teaching showed that the largest population of respondents were between year 6 and year 15 (n=56), veteran teachers with more than 15 years of experience had the second highest response rate (n=50), and novice teachers with less than 5 years constituted only 23.2% of responses (n=32), as seen in Table 4-2.

Table 4.2

Years of Teaching Experience

Years Experience Teaching

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0-5 Years	32	23.2	23.2	23.2
	6-15 Years	56	40.6	40.6	63.8
	Over 15 years	50	36.2	36.2	100.0
	Total	138	100.0	100.0	

Education levels of the respondents were diverse, with the highest number of teachers having a bachelor's degree or were working toward a master's degree (n=70), and the second-highest number having a master's degree and those working toward a doctoral degree (n=67).

Table 4.3

Education Level of Elementary Teachers

Education Level

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Associate's Degree	1	.7	.7	.7
	Bachelor's Degree	42	30.4	30.4	31.2
	Some Master's Coursework Completed	28	20.3	20.3	51.4
	Master's Degree	63	45.7	45.7	97.1
	Some PhD/EdD/Other Doctoral Coursework Completed	4	2.9	2.9	100.0
	Total	138	100.0	100.0	

The grade levels that this sample population were teaching are listed below in table 4-4. Table 4-4 shows that middle-level elementary grades are represented more often than the lower or higher elementary grades, with self-contained 6th grade classroom teachers making up just 1.5% of the sample population (n=2). Also, it's interesting that 7.2% of respondents were teaching in a self-contained classroom with more than one level of students (n=10).

Table 4.4

Grade Levels of Elementary Teachers

Grade-Level Currently Teaching

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Kindergarten	16	11.6	11.7	11.7
	1st Grade	16	11.6	11.7	23.4
	2nd Grade	19	13.8	13.9	37.2
	3rd Grade	29	21.0	21.2	58.4
	4th Grade	29	21.0	21.2	79.6
	5th Grade	16	11.6	11.7	91.2
	6th Grade	2	1.4	1.5	92.7
	Multiple Grades	10	7.2	7.3	100.0
	Total	137	99.3	100.0	
Missing	System	1	.7		
Total		138	100.0		

As seen in table 4-5, the community populations of the respondents to this survey were 59.4% rural (n=82), 27.5% suburban (n=27.5), and 13% urban (n=18).

Table 4.5

Community Population of School

Type of community/Population of Community

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Rural	82	59.4	59.4	59.4
	Suburban	38	27.5	27.5	87.0
	Urban	18	13.0	13.0	100.0
	Total	138	100.0	100.0	

In this sample population, elementary inservice teachers have a wide range of grade-level colleagues with which to work. Only 21% of the sample population had one section of their grade-level at their school (n=29), the largest portion of this sample had two sections of the same grade-level at their school, 30.4% (n=42), and only 7.3% of respondents designated that they have five or more sections of the same grade level at their school (n=10), as seen in Table 4-6.

Table 4.6

Number of Grade-Level Sections in Elementary Schools

Sections of current grade level at school

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	29	21.0	21.0	21.0
	2	42	30.4	30.4	51.4
	3	31	22.5	22.5	73.9
	4	26	18.8	18.8	92.8
	5	7	5.1	5.1	97.8
	More than 5 sections	3	2.2	2.2	100.0
	Total	138	100.0	100.0	

In Table 4-7, time allocated for science instruction is listed by grade-level. As seen at the bottom of the table, the overall mean of the minutes that teachers have to spend on science instruction is 27.18 minutes. What's interesting to note about this data is that, as grade-levels increase, the average number of minutes of science instruction time seems to increase, to an extent.

Table 4.7

Minutes of Science Instruction Time by Grade Level

Report

Time in minutes to teach science daily

Grade-Level Currently Teaching	Mean	N	Std. Deviation
Kindergarten	16.50	16	6.880
1st Grade	25.81	16	8.240
2nd Grade	22.05	19	6.416
3rd Grade	24.34	29	10.526
4th Grade	25.41	29	12.628
5th Grade	38.50	16	15.232
6th Grade	30.00	2	.000
Multiple Grades	37.10	10	12.306
Total	26.18	137	12.268

Along with science instruction time, this survey instrument asked inservice elementary teachers about the type of curriculum that they have adopted as a school. A breakdown of these responses is listed in Table 4-8. The survey item didn't ask about the dates on textbooks or resources, but Banilower et al. (2018) show they are often outdated. This survey only identified if curricular resources were available and what kinds were available. Of the 138 respondents, there was a wide variety of resources that were listed by teachers, but note that 14.5% of respondents didn't have a curriculum at all to reference (n=20). What's also not listed in this quantitative data is that on the "other" section, teachers could write in which resource/curriculum they use, and of respondents that marked "other" (n=45), another 4% of the sample (n=6) described that they either "use teacher-pay-teachers" or "create their own curriculum from the standards." This means that almost 19% of the sample didn't have an adopted curriculum to follow but were left to create or buy their own resources to use for science instruction.

Table 4.8

Adopted Science Curriculum

Adopted Science Curriculum

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Mystery Science	43	31.2	31.2	31.2
	McGraw Hill	17	12.3	12.3	43.5
	Discovery Education	5	3.6	3.6	47.1
	Amplify	8	5.8	5.8	52.9
	Other	45	32.6	32.6	85.5
	None	20	14.5	14.5	100.0
	Total	138	100.0	100.0	

The last piece of demographic information that was collected in this research was the number of science-specific professional development that teachers had in the past year, from fall of 2022 until spring of 2023. The results are listed in table 4-9. 92.8% of respondents had from 0-3 hours of science-specific professional development, and another 3 respondents listed “0” hours in the “other” response. This means a total of 95% of respondents claimed to have 0-3 hours of science-specific professional development in the last year (n=130).

Table 4.9

Self-Reported Science Professional Development Hours in the Past Year

Science Specific PD Hours Self-Report

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0-3 Hours	128	92.8	92.8	92.8
	3-6 Hours	5	3.6	3.6	96.4
	6-9 Hours	2	1.4	1.4	97.8
	Other	3	2.2	2.2	100.0
	Total	138	100.0	100.0	

With this understanding of the sample population and their demographics and contexts, we can now describe the sample populations’ perceptions of the science teaching constraints and affordances as well as their connections to teachers’ PSTE and STOE.

Reliability of Science Teaching Constraints and Affordances

The first portion of this survey instrument, which deals with teachers' perceptions of science teaching constraints and affordances had yet to be established as a reliable and valid from of data collection, so after data was collected, it was important to establish this instrument as reliable. This study used Cronbach's α to determine the reliability of the constructs within the survey instrument. Note in table 4-10 that the alphas are acceptable for most constructs, but there is a construct that falls below the confidence interval needed for data analysis to occur, namely the construct "Lesson Planning Initiatives" (α=.503). Two constructs listed are marginal, namely physical materials (α=.675), and STOE (α=.637). The rest of the constructs fall within the limits of reliability and shows how uniform the responses to similar constructs are (Tavakol & Dennick, 2011). According to the results of the statistics for this survey instrument, the majority of constructs were reliable, while some should be read with some caution.

Table 4.10

Science Teaching Constraints and Affordances Cronbach's α *by Construct*

Construct	**Questions**	**Cronbach's α**
Time for Science	12.1, 12.9	.751
Lesson Planning Initiatives	12.2, 12.10	.503
NGSS Standards	12.3, 12.11	.824
Physical Materials	12.4, 12.12	.675
Curriculum	12.5, 12.13	.775
Facilities	12.6, 12.14	.786
Professional Development	12.7, 12.15	.734
Professional Learning Community	12.8, 12.16	.811
STOE	15.1, 15.4, 15.7, 15.9, 15.10, 15.11, 15.13, 15.14, 15.15, 15.16, 15. 20, 15.25	.637
PSTE	15.2, 15.3, 15.5, 15.6, 15.8, 15.12, 15.17, 15.18, 15.19, 15.21, 15.22, 15.23, 15.24	.889

With regard to the implemented survey instrument, the reliability statistics showed that "Lesson Planning Initiatives" showed little uniformity, and "Physical Materials" as well as one piece of the STEBI-A, the construct "STOE" showed some discrepancies. As a result of this, the data analysis from those constructs should be analyzed with this lack of reliability in mind.

Data Analysis

Data analysis was accomplished by using an exploratory MANOVA to show correlations between the independent variables or the science teaching constraints and affordances, and the STOE and PSTE constructs listed in the STEBI-A (Riggs & Enochs, 1991).

Research Question 1

The first research question was looking to see if there any statistically significant correlations between inservice elementary teacher perceptions of science teaching constraints and affordances and their score on the science teaching efficacy belief instrument (STEBI-A). The null hypothesis that this research question tested was that there is no statistically significant correlation between the constructs of the STEBI-A (STOE and PSTE) and science teaching constraints and affordances. To answer this question, a MANOVA was conducted using the composite scores of the STOE and PSTE as dependent variables (DVs), and the eight science teaching constraints and affordances as independent variables (IVs) input as covariates. The null hypothesis for this question was that there are no statistically significant correlations between STEBI-A results and the eight science teaching constraints and affordances. What was shown in this initial MANOVA was that there are statistically significant correlations between some of the science teaching constraints and affordances and STOE and PSTE.

Multivariate Analysis

The multivariate analysis from the MANOVA showed that there were statistically significant ($p<.05$) correlations between STOE and PSTE and perceptions of the NGSS, physical materials, facilities, curriculum, professional development, and PLCs. While the multivariate tests don't account for the DVs respectively, it does show where there are statistically significant correlations between the IVs and the DVs. As seen in figure 4.1, when looking at the tests of multivariate analysis, it was shown that there were correlations ($p<.05$) between five of the IVs and the DVs, including perceptions of the NGSS, materials, curriculum, professional development and PLCs.

The test of teachers' perceptions of the NGSS and their impact on STOE and PSTE combined had a Wilk's λ of .897, $F(2, 128) = 7.343$, $p<.05$, partial eta squared (η_p^2) was .103, observed power =.934. Based on this data, the null hypothesis that there wasn't a correlation between perceptions of the NGSS and STOE and PSTE when combined. According to the test, the effect size is significant and given the limitations of the population distribution of this research, has implications for analyzing inservice elementary teachers as they relate to the NGSS.

The test of teachers' perceptions of materials and their relationship to STOE and PSTE combined had a Wilk's λ of .946, $F(2, 128) = 3.682$, $p<.05$, partial eta squared (η_p^2) was .054, observed power =.668. This test yielded that material constraints and affordances have significant and moderate impact on teacher's STOE and PSTE when combined. This analysis is subject to its limitations based on the sample population and the reliability of the materials construct, but with this sample, there was a moderate correlation between the DVs and inservice elementary teachers' perceptions of materials in their contexts.

The test of teachers' perceptions of curriculum and their relationship to STOE and PSTE combined had a Wilk's λ of .937, $F(2, 128) = 4.319$, $p<.05$, partial eta squared (η_p^2) was .063, observed power =.742. This test yielded that curriculum constraints and affordances have a moderate impact on teacher's STOE and PSTE together for this sample population.

The test of teachers' perceptions of professional development and their relationship to STOE and PSTE combined had a Wilk's λ of .930, F (2, 128) =4.793, p<.05, partial eta squared (η_p^2) was .070, observed power =.788. This test showed that inservice teacher's perceptions of professional development constraints and affordances also have a moderate impact on teacher's STOE and PSTE when combined for this particular group.

The test of teachers' perceptions of their PLCs and its relationship to STOE and PSTE combined had a Wilk's λ of .927, F (2, 128) =5.056, p<.05, partial eta squared (η_p^2) was .073, observed power =.810. This test yielded that material constraints and affordances also have a moderate impact on teacher's STOE and PSTE when combined.

The multivariate analysis showed that three constructs weren't statistically significantly related to STOE and PSTE, namely time, lesson planning initiatives, and facilities. For each of these constructs, p>.05. Since the construct of time had a Cronbach's alpha of .751, the construct was relatively reliable, so for this construct the results of the multivariate test show that there isn't a correlation to STOE or PSTE. Lesson planning initiatives seems to have been influenced by the lack of reliability in the survey instrument that was used (Cronbach's alpha=.503), as well as teacher's perceptions of the construct, "facilities" was a reliable construct (Cronbach's alpha=.786), so it is shown that there is no relationship between facilities and STOE and PSTE.

Univariate Analysis

Within the multivariate analysis there is no distinction between the levels of dependent variables included in this research, namely the two components of science teaching efficacy and beliefs, teachers' STOE and PSTE. The Between-subjects tests analyzed the impact of the science teaching constraints and affordances on these two variables. As was shown in the multivariate analysis, the constructs of time, lesson planning initiatives, and facilities did not have any statistically significant correlations to either construct within the STEBI-A.

The first univariate correlation that was discovered to be statistically significant was teachers' perceptions of the NGSS and their impact on PSTE. For this construct, F (1, 129) =14.799, p<.05, partial eta squared (η_p^2) was .103, observed power =.968. Based on this analysis, we can reject the null hypothesis that there is no significant relationship between teachers' perceptions of the NGSS and PSTE. This data also means that there exists a significant and strong relationship between the participants' perceptions of the standards and their PSTE among the sample, given the limitations of the population this instrument was distributed to.

The second univariate correlation that was discovered to be statistically significant was teachers' perceptions of their science teaching materials and their impact on their STOE. For this construct, F (1, 129) =5.625, p<.05, partial eta squared (η_p^2) was .042, observed power =.653. Based on this analysis, we can reject the null hypothesis that there is no significant relationship between teachers' perceptions of the science teaching materials and STOE. This data also means that there exists a statistically significant but moderate relationship between the teachers' perceptions of their science teaching materials and their STOE among this sample population.

The third univariate correlation that was discovered to be statistically significant was teachers' perceptions of their science curriculum and their impact on PSTE. For this construct, F (1, 129) =7.47, p<.05, partial eta squared (η_p^2) was .057, observed power =.789. Based on this analysis, we can reject the null hypothesis that there is no significant relationship between teachers' perceptions of their curriculum and their PSTE. This data also means that there exists a significant but moderate relationship between the teachers' perceptions of their science curriculum and their PSTE.

The next univariate correlation that was shown to exist in this research was a relationship between teachers' perceptions of professional development and STOE. For this construct, F (1, 129) =7.59, p<.05, partial eta squared (η_p^2) was .055, observed power =.779. Based on this information, we can reject the null hypothesis that there is no significant relationship between teachers' perceptions of the science teaching materials and STOE. This data also means that there exists a statistically significant but moderate relationship between the teachers' perceptions of their professional development and their STOE among this sample population.

The last univariate correlation that was shown to exist in this research was a relationship between teachers' perceptions of professional learning communities and STOE. For this construct, $F(1, 129) = 6.38$, $p < .05$, partial eta squared (η_p^2) was .047, observed power =.708. Based on this analysis, we can reject the null hypothesis that there is no significant relationship between teachers' perceptions of the science teaching materials and STOE. This data also means that there exists a statistically significant but moderate relationship between the teachers' perceptions of their science teaching materials and their STOE.

Due to the nature of the research question and the findings from this study, the null hypothesis for research question 1 can be rejected as there have been shown to be statistically significant relationships between perceptions of science teaching constraints and affordances and the STEBI-A (STOE and PSTE).

Research Question 2

The second research question was an exploratory question that had analyses of demographic variables. In this study, there were a few demographic variables that had been collected from participants, including age, gender, years of teaching elementary school, level of education, current grade level, number of sections of their grade-level in their school, the subjects they teach, population of their community, daily time to teach science, and adopted science curriculum. Using these demographic variables as IVs, this research utilized a MANOVA to explore their possible effects on STOE and PSTE (Field, 2018; Riggs & Enochs, 1990). Due to the skewed sample with regards to male and female, gender was excluded from this analysis.

Multivariate Analysis

After running the MANOVA with these demographic variables as the independent variables and STOE and PSTE as the dependent variables, there were no statistically significant correlations between any of the predictor variables and the outcomes. For this multivariate analysis there were no statistically significant correlations with regards to demographic variables and both STOE and PSTE combined. However, there were two constructs of note listed within this analysis that were marginally significant. The years of experience and the curriculum noted by teachers had close to significant effects. For years of teaching experience, Wilk's λ reported as .963, F (2, 127) =2. 422, p=.093, partial eta squared (η_p^2) was .037, and its observed power =.481. For curriculum type, Wilk's λ reported as .966, F (2, 127) =2. 262, p=.108, partial eta squared (η_p^2) was .034, and its observed power =.453. With these marginal results in the multivariate analysis, the univariate breakdown by DV was considered.

Univariate Analysis

In the univariate analysis, it was shown that PSTE was shown to have statistically significant correlations with teachers' years of experience as well as their adopted curriculum (p<.05). The influence of years of experience on PSTE could be described as statistically significant, but small: F (1, 128)=4.816, p=.030, partial eta squared (η_p^2) was .036, and its observed power =.586. The influence of curriculum on teachers' PSTE could also be described as statistically significant, but smaller than the effect of experience: F (1, 128)=4.036, p=.047, partial eta squared (η_p^2) was .019, and its observed power =.514. None of the other IVs or DVs showed any statistically significant correlations (p<.05).

The null hypothesis for this research question was that there exist no statistically significant correlations between demographic information and the results of the STEBI-A. Due to this, it is clear from the data that the null hypothesis can be rejected.

Research Question 3

Research question 3 sought to explore how teachers describe the impact of events and policies on their views of science teaching. The respondents answered the open-ended long-text question: “In your experience teaching elementary students, what factor (training, event, policy, etc.) has most impacted your view of teaching elementary science? Write your response below.” The answers to this question were put through two cycles of coding, the first used “In Vivo coding” (Saldaña, 2021, p. 137), using the words from the respondents themselves to derive themes and patterns from the data. Afterwards, themes were derived from the In Vivo codes using theoretical coding (Saldaña, 2021). The themes found in the data are listed in table 4.12 below.

Table 4.11

Theoretical Codes Generated from Qualitative Responses to Question 13

Question 13 Themes	**Number of Responses with Theme**
Time	55
NGSS	27
Initiatives	26
Curriculum	24
Materials	24
Professional Development	13
Personal Interest	11
Professional Learning Community (PLC)	11
Integration of Subjects	9
Facilities	4
Preservice teacher preparation	4
Science as "Specials" Content	3
Student Behaviors	3
Philosophy	3
Education Level	3
Politics	2
State testing	2
Administrators	1

Through the same process, themes were derived from question 14 in the survey instrument which states: “Have COVID policies/responses impacted your science instruction? Why or why not? Write your response in the space below.” In response to this survey item, there were In Vivo codes taken from the data as the first cycle of coding (Saldaña, 2021), and then there were themes derived from those In Vivo codes through theoretical coding (Saldaña, 2021). The themes are listed below in table 4.13.

Table 4.12

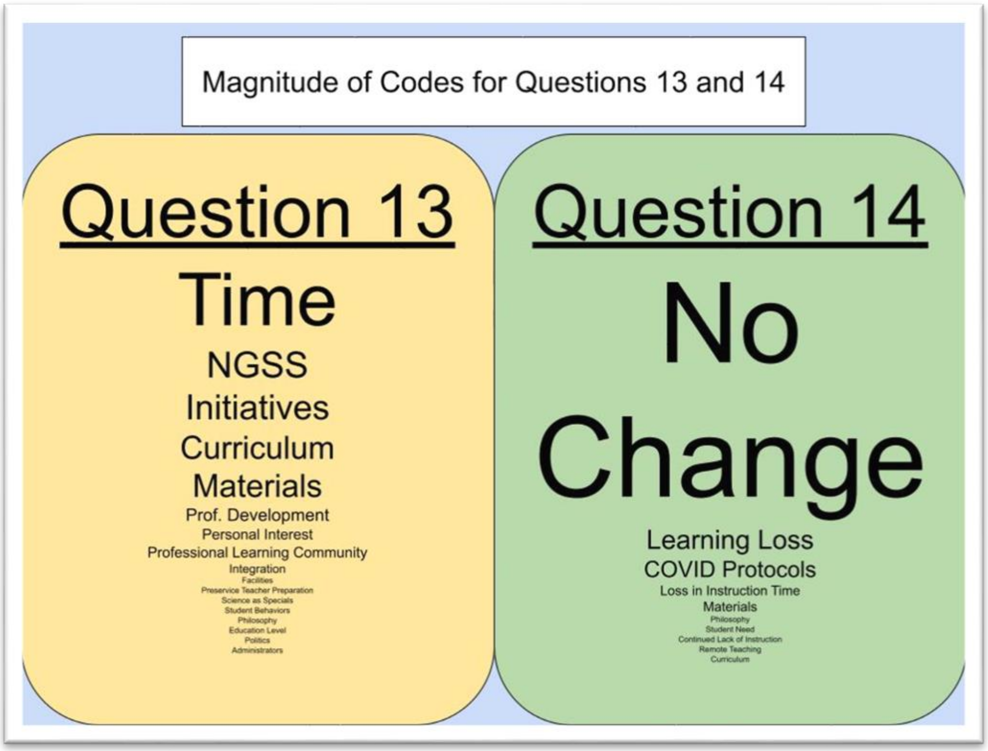
Theoretical Codes Generated from Qualitative Responses to Question 14

Question 14 Themes	**Number of Responses with Theme**
No change in science instruction	84
Learning Loss	20
COVID Protocols	17
Loss in Instruction Time	10
Materials	8
Change in Philosophy of Instruction	6
Student need increased	6
Continued Lack of Instruction Time	4
Remote teaching	2
Curriculum	2

The themes that were generated from the qualitative responses are listed by question and volume below in figure 4.1.

Figure 4.1

Magnitude of Codes for Questions 13 and 14



Note that the emphasis in question 13 is overwhelmingly on the amount of time teachers have to implement whatever curriculum their district has or hasn't assigned. Secondarily, the next-highest volume of responses was coded with reference to the things that directly influence teachers as they strive to implement their science curriculum, namely their understanding of the NGSS, their school or district's initiatives or emphases, their access to curriculum, as well as access to physical materials. Responses that were coded fit a third level of emphasis as well. Responses fit into these four codes: professional development, personal interest, professional learning community, and experience integrating science into other content areas. The lowest volume codes that were identified within responses included facilities, preservice teacher preparation, science being taught as a "special" like music or physical education, student behaviors, teaching philosophy, education level of the elementary teacher, politics, state testing, and the involvement of administrators.

In answering question 14 on the survey instrument, it is interesting to note that most teachers responded that no change to their science has occurred as a response to policy changes of the COVID-19 pandemic (n=84). Respondents in this category may have noted that they have not changed anything during or after the responses to the COVID-19 pandemic even though protocols and changes to the day-to-day operation of schools changed during that time. The next most popular theme revolved around “learning loss” (Donnelly & Patrinos, 2022). Seventeen participants responded that COVID-19 protocols negatively impacted their students, instruction, and learning environments during the COVID-19 pandemic (n=20). The third code that was established through the two cycles was that instruction time has been lost as a result of responses to the COVID-19 pandemic (n=10). Surprisingly, there were respondents (n=8) who mentioned that they received more materials and supplies for classroom science activities as a result of the COVID-19 pandemic. The last codes that were identified in the two-cycle process were changes in philosophy of education, for example, moving from collaborative, hands-on work to more independent work and flipped classrooms (n=6), respondents also identified that the needs of students seemed to have increased as a result of the responses to the COVID-19 pandemic (n=6). Responses included mentions of social-emotional learning (SEL) as well as self-regulatory practices when it comes to students conducting inquiry-based learning activities in the classroom. A few (n=4) teachers noted that there isn’t much change when it comes to science instruction time because the pattern before the COVID-19 pandemic was that English language arts (ELA) and mathematics were taking precedent, so the status-quo hasn’t changed with regard to science instruction. Lastly, teachers also described that they have seen changes to instruction based on the remote-learning models they experienced during the height of the COVID-19 pandemic as well as negative changes to availability of curriculum due to the removal of emergency funds from the pandemic (n=2, respectively).

Summary

To answer the first research question, the MANOVA which was used to isolate correlations between Inservice elementary teachers' perceptions of science teaching constraints and affordances and the constructs of the STEBI-A showed a few statistically significant interactions. Teachers' perceptions of the NGSS and their PSTE were shown to be significantly correlated within this population. Teachers' perceptions of their science teaching materials had a significant but small impact on their views concerning STOE, though the construct was shown to be questionable when it comes to reliability. Teachers' perceptions of their curriculum were shown to have a statistically significant relationship with their PSTE. Perceptions of professional development as well as perceptions of PLC had a statistically significant but small correlation with this population's views on STOE, with the given limitations of the construct within the survey. The data from this research shows that we can reject the null hypothesis that there are no statistically significant relationships between constructs of the STEBI-A and science teaching constraints and affordances.

To answer the second research question, the demographic variable analysis showed that years of experience and adopted curriculum were the only factors correlated with constructs from the STEBI-A, singularly the construct of PSTE, and only to a small degree in both cases given this sample population.

Analysis of the data with regards to the third research question showed that time was the biggest factor that influences the science instruction of elementary teachers, though other factors like understanding the standards, availability of curriculum, materials, as well as building and district initiatives impact their science instruction as well. In this analysis, there were no statistically significant correlations between the multivariate analysis when looking at the interactions between demographic variables and the STEBI-A, though there was a small and statistically significant correlation between teachers' years of experience and PSTE.

Specific comments from this data will be included in the discussions and implications in chapter 5, as well as application of these findings to future research.

Chapter 5 - Conclusions and Implications

While studies have been done to highlight the general constructs of science teaching self-efficacy and beliefs (Menon & Sadler, 2018; Menon, 2020; Riggs & Enochs, 1990), the perceptions that K-12 inservice teachers have of their science teaching constraints and affordances (Banilower, 2019, Banilower et al, 2018), and qualitative studies have been conducted over rural elementary teachers' perceptions of science teaching constraints and affordances (Sandholtz et al., 2019; Zinger et al., 2020), this research sought to add a quantitative look into the perceptions that inservice elementary teachers have of their constraints and affordances as well as their impact on science teaching self-efficacy and beliefs (Riggs & Enochs, 1990).

The purpose of this tailored-design survey research was to explore the relationships between perceptions of science teaching constraints and affordances and demographic variables on the science teaching self-efficacy and beliefs through the STEBI-A (Riggs & Enochs, 1991). In this non-experimental, mixed-methods research, statistical analyses as well as qualitative two-cycle coding were conducted to explore the following research questions:

1. Are there any statistically significant correlations between inservice elementary teacher perceptions of science teaching constraints and affordances and their score on the science teaching efficacy belief instrument (STEBI-A)?
2. If any, what other statistically significant correlations can be made between demographic information and inservice elementary teachers' science teaching self-efficacy?
3. How do inservice elementary teachers describe the impact of policies, training or events like the COVID-19 pandemic on their science instruction?

Summary of the Findings

The data collected through this research allowed the exploration of the research questions listed above using statistical analyses as well as the coding of qualitative data (Field, 2018; Saldaña, 2021). There were statistically significant correlations shown between some science teaching affordances and constraints and the two constructs of the STEBI-A, STOE and PSTE. In this chapter, there will be discussion over the results of the data which was analyzed to answer the three research questions. However, discussion of the results can't overlook the issues in sampling, skewness, and reliability of the survey instrument itself before discussing implications and findings. While there are results from the study, they can't be looked at without understanding these concerns.

Sampling Issues

The primary sampling issue that was seen in this research was the lack of access to direct contact with the target sample population. Due to the nature of the methodology of disseminating the survey instrument, future studies would do well to use direct access to inservice elementary teachers to improve the sample of the target population.

Limitations

Skewness of Demographics

One concern regarding this research is the skewness of the sample population as it relates to gender. This means that the results of this study, namely the correlations discovered between inservice elementary teachers' perceptions of constraints and PSTE and STOE. Only 3.6% of respondents who qualified to be included within the sample population were male (n=5). This is a significant deviation from the 11% of total elementary teachers who are male, according to the National Center for Education Statistics (2023). This means that the generalizability of the results of this study are limited, due to the nature of the sample population. Plumley (2019) showed that the NSSME+ had similar results, with only 6% of the sample reporting as male (p. 3).

Another data point that should be taken into consideration before generalizing results of this study is the skewness of the number of years of experience. As is shown through the data, 77% of teachers (n=106) have more than 5 years of experience in the classroom. Podolosky et al. (2019) have shown that experience in the classroom has an impact on teaching practice, often for the betterment of student achievement. This should be considered as a data point to consider for future research. In the future it would be beneficial to see if there are statistically significant differences between more experienced and less experienced teachers.

Another skewed data point to consider before generalizing the results of this study include the level of education that the respondents reported. A large portion (48.6%) of the sample population reported that they had a master's degree or higher amounts of education (n=67). Respondents with a bachelor's degree constituted 50.7% of respondents. This sample is similar to national statistics listed by the NCES, with bachelors and masters being similar, but the NCES showed that nationally, an average of 41% of elementary teachers had attained a bachelors as their highest degree, and that 49% of elementary teachers had attained a master's degree. While the skewness of this sample is limited, it is good to consider as implications are drawn from the data.

The last variable to note before generalizations of the results of this study occur is the ratio of the types of communities represented by the sample population. In this sample, 59.4% of the population designated that they lived in a rural area (n=82), while suburban and urban teachers represented 27.5% (n=28) and 13% (n=8), respectively. This means that conclusions based on this data should be considered with this substantial number of rural teachers in mind. In general, phenomena seen within this dataset may prove to be different if the context and communities of the teachers had been better distributed.

Reliability of Survey Constructs

Other than the skewness of the sample population, another area of this research that should be considered before implications are drawn from the data is the reliability of the survey instrument. Two considerations for future studies and changes are increasing the number of items per construct for science teaching constraints and affordances and combining constructs into similar categories as seen through analyzing the respective Cronbach's alpha scores for the survey items.

The first consideration resulting from this research concerning the constructs of science teaching constraints and affordances is the number of questions listed per construct. In this research, two questions, one positive and one negative, were used for analyzing these perceptions, while research suggests that to have a significant understanding of the participants' perceptions of the construct, more than five items are needed to be considered. For this research two similar but reworded statements were used to analyze these constructs with the constraints listed wholly within them. In future research, it would be wise to take a construct like "perceptions of the NGSS" and use more subcomponents of them integrated into statements to combine for more effect. For instance, using a statement like, "I know where to find the listed Disciplinary Core Idea for my grade-level science standard" might be a positive addition that utilizes a sub-component of the NGSS to explore the teacher's perception and comfortability with the NGSS in part, but also reflect what they believe about the NGSS as a whole. This could be done for sub-components of all of the constructs listed as science teaching constraints and affordances and is a limitation of this study.

The second limitation of the survey instrument itself was the inadequate correlation between items within a few constructs. The constructs with limited reliability were lesson planning initiatives, physical materials, and the STOE portion of the STEBI-A. Due to these constructs not having significant enough correlations between survey items there are questions about whether the survey items measure similar concepts. Lesson planning initiatives had the lowest reliability score, so that shows that teachers were unclear about what was meant by the terms in the survey instrument. This survey item's lack of reliability could be removed or combined with another category in future research using similar methods. Physical materials was another construct that had limited reliability (Cronbach's alpha=.675). For future research it would be wise to consider combining a few of these constructs into one. For instance, when computing Cronbach's alpha for materials, curriculum, and facilities combined, alpha=.82. The implications for future research with regard to these constructs would be to use them all as components of a greater variable that covers the gamut of curricular resources that teachers have access to. Similar modifications could be made in future research concerning the variable "Lesson Planning Initiatives" and "Time". Both of these constructs relate to the amount of instructional time teachers are allocated during the school day. For this dataset when these constructs are combined and analyzed for reliability, their reliability was greater (alpha=.77).

Contextualization of Open-Ended Questions Introduces Bias

The open-ended questions about events and policies, and COVID-19 in particular, are placed after teachers described their perceptions of science teaching constraints and affordances. This is an important observation to consider because, within the responses to the open-ended questions, it was clear that the constraints were particularly prevalent in the thinking and writing of the participants as they wrote their open-ended responses to the questions. While it's true that teachers may have been influenced by identifying their perceptions of the constraints and affordances in their contexts, one might also consider that those questions allowed the respondents to think critically about their teaching contexts before the answers to the policies, events, and impact of COVID-19 were explained.

Given these limitations of the sample population as well as the survey instrument itself, there are still conclusions that can be drawn from the results of considering the research questions as well as implications from the results.

Findings

Research Question 1

When considering the first research question, this study aimed to explore possible correlations between science teaching constraints and affordances and science teaching efficacy and beliefs through inferential statistics. Through conducting the MANOVA, statistically significant correlations were observed between some of the science teaching constraints and affordances and both the STOE and PSTE constructs within the STEBI-A survey instrument. Specifically, teacher perceptions of the NGSS and their PSTE was shown to be correlated with great effect within this sample population. Statistically significant correlations with moderate effect were shown between teacher perceptions of material availability and STOE, as well as curriculum and PSTE, teacher views of professional development and PLCs with STOE.

Research Question 2

In answering the second research question about the impact of demographic information on inservice elementary teachers' science teaching self-efficacy and beliefs, data showed that there were statistically significant relationships between teacher experience and adopted curriculum with PSTE. While the effect sizes were small, it can be inferred from the data that there exists a relationship between these variables.

Research Question 3

The third research question this study explored was the interaction of events and policies on the perceptions of inservice elementary teachers as they teach science. This research question used two open-ended survey questions to explore this in general, and then a follow-up question was asked with particular relation to COVID-19 response and policy. Responses to the first open ended question yielded a lot of discussion over the impact that limited time has on the teaching of science. Discussion about building and district schedules and their emphasis on this issue of time were prevalent as well. Table 5.1 below shows some prominent examples of how teachers described some of this impact by code.

Table 5.1

Quotes for Question 13 by Code

Question 13 Codes	**Select Quotes from Respondents**
Time	"I do find social studies and science very hard to fit into schedules with the large chunks of time required for math, reading, and writing." "Science is hard for us to make time and teach along with hands on experiments." "There just appears to be little time to be able to implement it at the level of discovery our students deserve."
NGSS	"Most of our staff does not even know where to find the NGSS" "...some of the standards are fairly broad and hard to cover completely." "My experience reading through the state standards guides my lesson plans."
Initiatives	"If anything is deemed unnecessary, it is always science!" "I feel like there's a heavy emphasis on math and language instruction in lower elementary, so it is sometimes difficult to meet the needs of students in 5th (where science is a state tested subject). There are times that we have to fill gaps with content before we can teach our standards-- mostly because they're quickly pushed through those standards in the early grades."
Curriculum	"Our current curriculum does not follow the science standards for our grade." "This year is the most I've ever taught science and that's simply because I'm at a new school and they buy a subscription to Mystery Science." "I have no training in Science at all, I am just going from what the book and the lesson is telling me to do."
Materials	"I feel that due to the lack of resources it is hard to do hands on [experiments] but easier to look at diagrams, videos, models, etc."
Professional Development	"I think the lack of training and PD for teaching science has had the most impact. I am hardly ever evaluated when teaching science if ever and we don't keep data hardly on science standards. I feel like it is an after-thought."

Personal Interest	"All of the training I have received for science, I have gone to on my own during the summer. I took a two-year course from [graduate-level program] during the summer over STEM and how to incorporate that into the classroom."
Professional Learning Community (PLC)	"My coworker has shared her love for science and has helped it become fun to teach."
Integration of Subjects	"Typically, we alternate science and social studies units. We try to integrate the best we can." "[Because of limited time] we do incorporate [science] into our ELA and Math curriculum, however." "I wish it was taught daily and went hand in hand with our ELA, but ELA has taken over our time and we get two 45-minute sections [of science] each week."
Facilities	"...lack of space for labs"
Preservice teacher preparation	"My science methods professor made teaching science effectively a goal of mine.”
Science as "Specials" Content	"Our school has 1 hour a week of science with a separate science teacher." "The district had a science teacher and kids went to her for science."
Student Behaviors	"Student engagement and achievement [are the most impactful on science instruction]."
Philosophy	"I find that teaching science with a hands on approach reaches a majority of my students interest level."
Education Level	"I have my bachelors in biology from [four-year university] and my Masters in Elementary Ed and pull from both degrees to plan Science instruction for all of third grade."
Politics	"Current anti-science politics"
State testing	"Because of state testing I have to prioritize reading/math over science."
Administrators	"Administrators present to know what I am doing"

With response to COVID-19 in particular, teachers overwhelmingly showed that policy changes have not impacted their current teaching practices as it relates to science. From the generated codes, it was clear that a lot of teachers are concerned that learning loss is impacting their science instruction due to emphasis on math and ELA, as well as having a limited science background knowledge due to remote teaching practices exercised during the COVID-19 pandemic. Table 5.2 below shows quotes from the specific codes that were generated from the responses.

Table 5.2

Quotes for Question 14 by Code

<u>Question 14 Codes</u>	**Select Quotes from Respondents**
No change in science instruction	“In our rural area I don't feel like it's impacted science instruction.”
Remote teaching	"The year that COVID had an impact I was teaching remotely, which significantly impacted science instruction. This year, things have been normal [with regards to science]." "...teaching virtually did not require science to be taught in our daily schedule. It was up to teachers to decide how and when to teach it." "In the 2020-2021 school year, my science instruction was GREATLY impacted, as I was teaching remotely."
Learning Loss	"many districts seem to have abandoned science teaching... in favor of trying to catch up students' reading and math skills lost during COVID." "students are behind in reading" "Students are behind in their knowledge of Science due to COVID policies"
COVID Protocols	"...during the time I was student teaching we were still using shields and six feet of space." "...during covid students could not work with their partners for science... and then in 2020 that class missed out on most of the experiments in the end of the year."
Materials	"Although we had factors to consider, we purchased more materials and provided different opportunities that allowed students to experiment and build inquiry with science without putting them at risk for COVID."
Loss in Instruction Time	"When student teaching in 2019 (5th and 2nd grade) I felt they had more time to teach [science]." "It seems we are more focused on ensuring students get reading and math instruction (and SEL) than science and social studies, so we have less time to teach."
Curriculum	"...many districts seem to have abandoned science teaching and given up using curriculum or materials purchased before COVID" "My district doesn't have a set science curriculum, but I use the NGSS guidelines, develop my own lesson plans, and use free resources available to give my students daily science instruction."
Change in Philosophy of Instruction	"Elementary students LOVE science, and teaching science expands and deepens both their reading/ELA skills and their math skills, while giving them the science-based experiences and background knowledge that are crucial to future academic success." "I get to show the kids more cool videos of things that I couldn't replicate in a classroom. This is nicer than lecturing at them. Sometimes there are video instructions, which can be helpful if I need to differentiate for students." "COVID really impacted hands-on labs and collaboration. Science is a

	perfect time to incorporate both of these, but the virus limits the possibilities in science."
Student need increased	"...students aren't focused which makes everything harder to teach." "Students seem to lack the motivation and desire for learning. Their critical thinking skills are also weakened... causing struggle and frustrations with science learning."
Continued Lack of Instruction Time	"The lack of time, due to so many demands for numerous small groups, is what has impacted my ability to teach it." "The importance of teaching science was already in decline before Covid, since Covid it seems that there is no importance because reading and math were impacted drastically by the shut-downs." "There hasn't been much of an impact because we struggled before to teach science effectively." "We didn't have science instruction time or professional development on science even before COVID began."

Implications

Key Takeaways

As I was sifting through and observing this data, there are some interesting trends that stuck out to me. These trends are influenced by my educational background as well as my passion for science education, but they are interesting nonetheless. The first major takeaway was the impact of perceptions of the NGSS on PSTE. The second was the lack of resources and time that are still designated by teachers a decade after the NGSS have been adopted. The last was the number of teachers who described their experiences in the elementary schools as having not been impacted by COVID-19 so much as general policy with regard to their science instruction.

The first key takeaway was how the standards impact perceptions of science teaching self-efficacy. While it makes sense that teachers who are familiar and comfortable with the standards would be more comfortable with science teaching, this coupled with the overwhelming lack of emphasis on professional development when it comes to science education at the elementary level is concerning. In general, the principle is true: we invest in what we value. This saying is true of finances as well as other areas of life, including education. In the spirit of pithy, wise sayings: if you give someone a fish they'll eat for the day, but if you teach them to fish they will eat for the rest of their lives. With the findings from the first research question, it should allow administrators and preservice teacher educators alike to see that if we teach our teachers how to dive into the standards and own them, they will be more comfortable with their grade-band performance expectations and how they should be taught three-dimensionally.

The second takeaway which in my estimation was demoralizing when it comes to the status of elementary science education was the number of educators who responded that they had limited resources, including professional development as well as available curriculum. Many teachers responded that they had to invest their own money and time into understanding and printing resources from online resource-sharing companies, which aren't vetted for quality and alignment to the NGSS. Once again, we invest in what we value.

The last key takeaway from my perspective was the interesting note that COVID-19 policy had little effect from teachers' perceptions on their teaching of science at the elementary level, save a few comments about the resilience of students in the face of challenges and increased amount of time spent on "catching up" from lost time. The most interesting comments from answering research question 3 came with regard to teachers perceptions of science education before and after the COVID-19 pandemic. Multiple teachers commented that emphasis and importance that's placed on science instruction at the elementary level was already waning prior to the pandemic, and that there hasn't been a noticeable difference.

With these initial take-aways in mind from my perspective, discussion and implications of the results overall are listed below.

Time Constraints and Integration as a Possible Solution

As was seen in the qualitative responses, there was a lot of emphasis from the respondents on the amount of time that they had to teach science in their classrooms daily. Most teachers in their open-ended responses didn't reference events or other factors that they are subject to as impacting their science instruction, the biggest factor was time. It's interesting to note that in the quantitative analysis there were no statistically significant correlations between teacher perceptions of time and its relationship with their science teaching self-efficacy and beliefs. What can be inferred from the data is that teachers may feel well-prepared to teach science in their classrooms, but seem to be influenced greatly by the schedules, policies and structures that are required of them. While COVID-19 policy seemingly hindered student performance during the height of the pandemic, many teachers also recognize that policies in their schools haven't changed the emphasis. Specifically, one respondent stated, "The importance of teaching science was already in decline before COVID, since COVID it seems that there is no importance because reading and math were impacted drastically by the shut-downs."

As a response to the data collected in this survey, it would be wise for school administrators to consider challenging their current scheduling practices to promote the explicit teaching of science, as well as what many teachers in this survey mentioned, integrated learning. Many teachers in this survey liked the idea of integrating science topics and instruction into their ELA and mathematics instruction, but research suggests that many teachers don't successfully do this where mastery is attained in both content areas without substantial investments in professional development (Gresnigt et al., 2014).

Next Generation Science Standards Affordance and Constraint

According to the quantitative data, perceptions of the NGSS were correlated with PSTE, and qualitatively teachers also often responded that their familiarity with the NGSS impacted their comfort level in teaching science. Positively, teachers who knew about the NGSS saw the standards as an affordance, but there were also descriptions of teachers' experiences that negatively interpreted the NGSS in their context. One respondent said, "My experience reading through the state standards guides my lesson plans" which designates a positive view of the standards as they relate to the instructional process for this individual. Negatively, one respondent noted that the standards themselves are "broad" and "hard to cover completely." Another respondent noted that their perception of the NGSS standards as it relates to their faculty, "Most of our staff does not even know where to find the NGSS.' This is concerning given the fact that the NGSS are the adopted standards of the state in which this research took place.

Implications of these findings include dedicated yearly time for teachers to understand and be able to effectively implement the NGSS in their classrooms, as well as understand the principles of reform-based science instruction (Ames, 2014; Yager, 2000).

School/District Initiatives Impact Time and Emphasis

While the survey construct for lesson planning initiatives didn't meet the criteria needed for reliability for quantitative analysis, there were some interesting comments from teachers that fit into this category or theme. What was seen in this construct were things like scheduling, emphasis or priority at the school or district level, among other factors that teachers are subject to within their contexts. One teacher noted that, "If anything is deemed unnecessary, it is always science!" and they weren't alone in their sentiment. One teacher explained how this emphasis and scheduling priority around math and ELA instruction was impacting them:

> I feel like there's a heavy emphasis on math and language instruction in lower elementary, so it is sometimes difficult to meet the needs of students in 5th (where science is a state tested subject). There are times that we have to fill gaps with content before we can teach our standards-- mostly because they're quickly pushed through those standards in the early grades.

The crunch for time seems to be impacted by decisions about scheduling based on school district initiatives, test results, and other factors. While the quantitative data infers that the lack of time doesn't have an impact on inservice elementary teachers' science teaching self-efficacy and beliefs, it is clear from the perspective of these teachers that it does have an impact on their teaching of the standards on a daily basis.

Implications of these findings show that teachers feel that policies and procedures set outside of their control often influence the amount of time and emphasis they place on science instruction. While PBL and citizen science are often labor-intensive for teachers, there could be renewed perspective in elementary classrooms: instead of teaching science through math and ELA, elementary teachers should view science as an avenue by which to teach contextualized reading and mathematics skills through the 3-dimensions of the NGSS (Krajcik et al., 2023).

Curriculum, Materials and Facilities

According to the quantitative data, the type and perceptions of curriculum teachers impacts their PSTE, while materials had an impact on STOE, while facilities had no statistically significant impact on either STOE or PSTE. The qualitative data supports this aspect of the results, and also gives them a more robust context. One teacher described their curriculum like this: "Our current curriculum does not follow the science standards for our grade." With regard to materials, teachers in many grades are required to teach lessons that require materials. Think about a 4^{th} grade teacher trying to teach about circuits and electrical energy without having circuit boards, or at the very least copper wire, batteries and lights. One teacher said, "I feel that due to the lack of resources it is hard to do hands on [experiments]," and one teacher described that their facilitation of science experiments and inquiry-based learning experiences for students was hindered due to "lack of space for labs."

This data and responses show that, while a lot of the standards can be met with common resources, often teachers are required to overcome these constraints in order to effectively teach their students. Teachers in this study described how they were dependent upon the often-outdated curriculum resource in order to effectively teach their science lessons. If teachers feel this way, the logical conclusion is that elementary schools should invest in modern, reformed-based resources as well as professional development for teachers to effectively implement them (Forbes, 2011; Smith, 2020).

Professional Development and Learning Communities

Professional development and professional learning communities can impact teacher effectiveness and perceptions of support (Anderson et al., 2014). In this research professional development and PLC didn't have any statistically significant impact on STOE or PSTE, but discussions obtained through the qualitative data describe teacher perceptions of these constructs. One teacher described the constraint of professional development like this, "I think the lack of training and PD for teaching science has had the most impact. I am hardly ever evaluated when teaching science if ever and we don't keep data hardly on science standards. I feel like it is an after-thought." Yet another teacher described their experience like this: "All of the training I have received for science, I have gone to on my own during the summer" indicating that it was their own personal initiative and interest in science that drove them to go to professional development. In a similar vein, this study showed that there were small correlations between teachers' perceptions of their PD experiences and their STOE. With regard to PLCs, respondents to this survey research reported that their experiences were mostly positive. One teacher wrote, "My coworker has shared her love for science and has helped it become fun to teach." While another wrote about their colleagues not being able to find the correct standards, an assumed detriment to their PLC experience. Like professional development, perceptions of PLC had a small but statistically significant impact on teachers' STOE.

While PLC dispositions aren't necessarily in the control of administrators or grade-level leaders, professional development is. Teachers feel that the lack of emphasis on science is felt within their professional development, so investing in yearly or bi-yearly science-specific professional development could impact the self-efficacy and beliefs of elementary teachers (Roth et al., 2019).

Impacts of COVID-19 Policy on Science Instruction

With regard to COVID-19, there was shown to be a clear majority of teachers who feel as if policies from the COVID-19 pandemic have not continued to affect their science instruction. Of those that responded that COVID policy had impacted their classroom science instruction, mentions of “learning loss” and the feeling of needing to “catch students up” in ELA and mathematics was seen as a hindrance to science instruction. For some, descriptions of their school’s use of COVID-19 relief funds had a positive effect on their perceptions of curriculum and materials, but a few of those respondents noted that since those funds have been discontinued, their curricular and material increases have discontinued as well. This might imply that topic-specific funding increases the access to and quality of instructional resources that teachers have at their disposal and would be worth considering for studies in the future.

Another theme from the COVID-19 specific prompt that is worth considering is the impact of the pandemic on the dispositions and emotional state of elementary students. Many respondents noted that there was an increased need shown in students as it relates to behavior management and classroom protocols. One teacher even noted that they refrain from using classroom experiments for fear that the students will harm themselves or others with the materials. A few more noted that students lack the resiliency to complete challenging tasks such as engineering and problem-based lessons. This phenomenon would be worth considering in the future, and perhaps exploring how social-emotional learning, like ELA and math, can be taught explicitly and implicitly through quality elementary science instruction.

Implications for District Leaders

In the United States, the responsibility of educating the public falls squarely on local school districts. While the majority of respondents in this study were self-designated as being in a rural area, there are implications for the policies districts can implement to support elementary teachers as they teach science. With the NGSS being adopted by state legislatures in 20 states, and the NRC framework influencing another 24, it's time that we address the elephant in the room concerning science education at the elementary level: a lot of districts are in dereliction of duty to their elementary students concerning the planning, teaching, and assessing of science. NGSS Lead States have had over a decade to implement the standards and to adequately prepare their teachers to address the standards through professional development, district accountability, and follow through, yet we are seeing similar patterns in elementary teachers' perceptions of the NGSS now as we were a decade ago (Smith, 2020). If the teachers implementing the curriculum at the classroom level say that they don't have enough time to teach the standards in their entirety, perhaps audits and accreditation criteria should be more thoroughly assessed and supported from the district level. This means giving teachers the freedom to take time to teach the standards how they see fit, but it also means supporting them with the opportunities they need in order to effectively teach science. Districts should also provide resources and materials that aid the teachers, the experts in the standards they teach in their assigned grade levels, as they teach science.

Curriculum adoption often happens at the district level as well. Implications from this research show that curriculum adoption is important and does have some impact on the PSTE of elementary educators, but curriculum adoption should be a supplement to the teachers' own knowledge of the standards they are required to teach. Districts shouldn't consider a new or flashy curriculum as the ultimate solution when it comes to preparing educators in their systems to implement the curriculum. Just as an electric saw helps a skilled tradesman do their job well, adopted curriculum should assist teachers in owning the standards and implementing them in their classrooms. It's the comfortability and familiarity with the standards of the trade that help teachers the most, which is aided by professional development along with practice.

In the same way, educational leaders shouldn't require elementary educators to address both the science standards as well as the mathematics and literacy standards in their classrooms by integrating without properly supporting teachers in that practice. They need to be shown how to do it and supported as they try. All of this comes through professional development. Professional development is often controlled and directed by district-level initiatives. In this way, districts can provide quality, reform-based science professional development to teachers, starting with a focus on the NGSS and NRC (2012) framework, that allows teachers to understand why they should address the standards in this way before they implement these instructional practices in their classrooms. Professional development can't just be a one-time activity that teachers experience, but should include professional accountability, goal management, and assessment concerning the goals. While many districts have curriculum specialists that support teachers in this regard, elementary schools often don't have the extended, longitudinal support they need to effectively change their science teaching practices (Andersen et al., 2014; Banilower et al., 2019; Maeng et al, 2020). Through professional development, teachers can be educated on how to navigate, use, and assess the NGSS at their grade levels, and thus feel more competent and effective at using the standards to plan instruction.

In sum, districts shouldn't neglect the science standards in the elementary grade levels which this study has suggested is happening. Districts should be willing to offer support, curriculum, professional development, and resources to teachers as they implement reform-based science instruction.

Implications for Preservice Teacher Preparation

In a similar vein as was explained for district educational leaders, there are clear implications for those who are involved in preservice teacher preparation at the graduate and undergraduate level. Elementary preservice teachers often come to elementary science methods classes with preconceived notions about the nature of science, what it means to learn science, and how to effectively teach science that are impacted by their own previous experiences as well as interests (Dalvi et al., 2021). Elementary teachers in this study claimed that their preservice teacher preparation was where they received the majority of their science teaching understanding before, and even long after, they have entered the classroom. This means that preservice teacher preparation programs are the gatekeepers for the teachers who are entering the field and must therefore equip these new teachers with the skills and understanding necessary to be change-agents for the good of science education practices as they begin their careers. Elementary science methods courses should prepare these future educators to know the philosophical foundations of the standards, access the standards, plan instruction based on the standards, understand the three-dimensionality of the standards, and assess student understanding in the three dimensions of the standards. Elementary educators should walk away from their preservice teacher preparation with these skills in their toolbox, as well as a voice for articulating the need for change as they enter systems that are designed to focus on specific content areas for the purpose of increasing test scores. This means that preservice elementary science methods programs should have students elbow-deep in hands-on experiences that simulate rigorous three-dimensional instruction but should also have them understanding the philosophical foundations of the NGSS. By the end of their preservice teaching experience, elementary educators should be equipped to teach the NGSS with nothing but the standards and their own ingenuity, because increasingly it seems that's all they will have provided to them for support. To add to the list of pithy, wise sayings: prepare for the worst, hope for the best.

On another note, professional development school (PDS) models of teacher preparation must be diligent in supporting these preservice teachers as they are mentored and influenced by school systems that clearly devalue science instruction at the elementary level as well as veteran teachers whose science teaching has been subjugated by these systems for many years. Preservice teacher educators must be ready and willing to work with mentors and mentees alike to promote and exemplify elementary science instruction that follows the guidelines of the National Research Council (2012), as well as the adopted standards in their respective states. Perhaps when these things are accomplished, we might see a revolution in science education as we partake in the process of reformation.

Recommendations for Future Study

This study was one of the first to operationalize and quantify “science teaching constraints and affordances.” While this initial study showed there were flaws with the sampling and survey instrument, it shows that there is a statistical phenomenon to explore within the realms of this particular field. Future research should take into consideration the sub-constructs and increased survey items that help to define “science teaching constraints and affordances” and if done well, could provide insights into elementary teachers’ perceptions of their constraints and affordances and see the impact they have on their self-efficacy as well as other constructs such as instructional decisions and career and employment choices.

There exists a correlation between perceptions of the NGSS and PSTE that could use further exploration. In particular, future research could further define the constructs listed in the NGSS such as perceptions of navigating the website, perceptions of DCIs, SEPs, and CCCs, perceptions of the embedded cross-curricular connections, perceptions of the evidence statements, and perceptions of the referenced framework that are all included in the standards (NGSS Lead States, 2013). This could be done as a stand-alone study in order to see what sub-constructs within the NGSS elementary teachers feel the least comfortable with and would thus inform areas for future professional development and goals for implementing the NGSS in Lead States.

Another avenue for future research is to utilize this operationalizing of the perceptions of these science teaching constraints and affordances and to use them on elementary preservice teachers. As was listed above, increasingly elementary education preparation needs to prepare teachers to teach the standards with limited time and resources allocated to it, so it would be helpful to utilize these measures as a quasi-experimental pre and post-test measure before the treatment of a science methods course is given to preservice teachers. It would be interesting to see how their perceptions of the resources they think are necessary to teach the standards change as they interact with the standards as well as other common resources and materials they have access to on a daily basis.

Conclusion

Teachers are often limited or supported by the structures and resources in place within their teaching contexts. This study examined the effects of elementary inservice teachers' perceptions of these constraints and affordances on their science teaching self-efficacy and beliefs. Through this study it was shown that science teaching constraints and affordances were shown to have a small to moderate effect on both constructs of the STEBI-A, STOE and PSTE. While there were threats to validity and reliability within this study, it suggests that there are avenues for exploration concerning the perceptions of elementary inservice teachers' views of constraints and affordances and their impact on a variety of phenomena in elementary science education.

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Appendix A - "Elementary teachers' perceptions of science teaching constraints and affordances and their influence on science teaching self-efficacy" Survey Instrument

Purpose: In an effort to measure how elementary teachers' experiences impact their views of their own science teaching, this research asks questions about your context and about your beliefs about your science teaching. There are a total of 56 responses included and the survey itself should take about 10-15 minutes to complete. After the data is collected, the researcher will then use it to analyze the effects of these factors on your view of teaching elementary science. After the conclusions are drawn, the finished results will be emailed to all who mark their interest below.

Consent/Risks: Your participation in this research is voluntary, and consent is assumed when the survey is submitted. The only identifying information collected will be your email address and it will be stored confidentially on password-protected devices and servers and used to randomly award the five $20 gift cards for participating and will be deleted after the research is completed. Use of your data will not be used or disseminated for future studies. If you have any questions or concerns as you complete the survey, please reach out to the researcher at the contact information listed below.

Researcher Contact Information:

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Informed Consent Questions:

IC1: Do you agree to the informed consent?

Yes/No

IC2: Would you like to be informed of the results of this research?

Yes/No

IC2.1: What email address would you like the results sent to?

Small text entry

IC3: Would you like to be placed in the drawing for one of the five, $20 Amazon gift cards?

Yes/No

IC3.1: Please list your email below to be placed in the drawing for the gift card.

Small text entry

Participant Descriptors

Age

Gender

Years of Experience in Elementary

Level of Education

Current Grade Level

Number of sections of your grade in your school

Subjects Taught

Population of Community where you teach

Daily time to teach science

Adopted Science Curriculum (Resource) (if available)

Number of science-focused professional development sessions per year (if available)

Directions: read the statement on the left and mark your level of agreement or disagreement with it on the right.

12.1 I have enough time in my daily schedule to facilitate science learning that is effective for students. (Time+)

12.2: I struggle to find the time to effectively teach science lessons. (Time-)

12.3: The structures for lesson planning used in my school allow me to teach science effectively. (Lesson Planning Initiatives+)

12.4: Lesson planning initiatives make it hard to teach science the way I think is best. (Lesson planning initiatives-)

12.5: The Next Generation Science Standards used in my grade level are easy for me to teach. (Standards+)

12.6: The Next Generation Science Standards are hard for me to teach. (Standards-)

12.7: I feel that my school provides all the materials I need to effectively teach science. (Materials+)

12.8: I find that I have to buy most of the materials that I use to teach science in my classroom. (Materials-)

12.9: The science curriculum used in my school is helpful to teach the science standards to my students. (Curriculum+)

12.10: I feel that the science curriculum that my district uses is outdated or unmatched to the current standards. (Curriculum-)

12.11: My school has the space/facilities that help me to teach science effectively. (Spaces/Facilities+)

12.12: I often feel like I don't have the space/facilities I need in order to teach science effectively. (Space/Facilities-)

12.13: I receive the professional development I need in order to grow as an elementary teacher of science. (Professional Development+)

12.14: Professional development for me rarely covers science education. (Professional Development-)

12.15: My colleagues are often helpful for me as I teach science content. (Professional Learning Community+)

12.16: My colleagues aren't very helpful to me to improve my science teaching. (Professional Learning Community-)

13: OPEN ENDED: In your experience teaching elementary students, what factor (training, event, policy, etc.) has most impacted your view of teaching elementary science? Write your response below.

14: OPEN ENDED: Have COVID policies/responses impacted your science instruction? Why or why not? Write your response in the space below.

STEBI-A

Directions: read the statement on the left and mark your level of agreement or disagreement with it on the right.

15.1: When a student does better than usual in science, it is often because the teacher exerted a little extra effort. (STOE+)

15.2: I am continually finding better ways to teach science. (PSTE+)

15.3: Even when I try very hard, I don't teach science as well as I do most subjects. (PSTE-)

15.4: When the science grades of students improve, it is most often due to their teacher having found a more effective teaching approach. (STOE+)

15.5: I know the steps necessary to teach science concepts effectively. (PSTE+)

15.6: I am not very effective in monitoring science experiments. (PSTE-)

15.7: If students are underachieving in science, it is most likely due to ineffective science teaching. (STOE+)

15.8: I generally teach science ineffectively. (PSTE-)

15.9: The inadequacy of a student's science background can be overcome by good teaching. (STOE+)

15.10: The low science achievement of some students cannot generally be blamed on their teachers. (STOE-)

15.11: When a low achieving child progresses in science, it is usually due to extra attention given by the teacher. (STOE-)

15.12: I understand science concepts well enough to be effective in teaching elementary science. (PSTE+)

15.13: Increased effort in science teaching produces little change in some students' science achievement. (STOE-)

15.14: The teacher is generally responsible for the achievement of students in science. (STOE+)

15.15: Students' achievement in science is directly related to their teacher's effectiveness in science teaching. (STOE+)

15.16: If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child's teacher. (STOE+)

15.17: I find it difficult to explain to students why science experiments work. (PSTE-)

15.18: I am typically able to answer students' science questions. (PSTE+)

15.19: I wonder if I have the necessary skills to teach science. (PSTE-)

15.20: Effectiveness in science teaching has little influence on the achievement of students with low motivation. (STOE-)

15.21: Given a choice, I would not invite the principal to evaluate my science teaching. (PSTE-)

15.22: When a student has difficulty understanding a science concept, I am usually at a loss as to how to help the student understand it better. (PSTE-)

15.23: When teaching science, I usually welcome student questions. (PSTE+)

15.24: I don't know what to do to turn students on to science. (PSTE-)

15.25: Even teachers with good science teaching abilities cannot help some kids learn science. (STOE-)

Appendix B - Informed Consent Document

Purpose: In an effort to measure how elementary teachers' experiences impact their views of their own science teaching, this research asks questions about your context and about your beliefs about your science teaching. There are a total of 56 responses included and the survey itself should take about 10-15 minutes to complete. After the data is collected, the researcher will then use it to analyze the effects of these factors on your view of teaching elementary science. After the conclusions are drawn, the finished results will be emailed to all who mark their interest below.

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Researcher Contact Information:

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620-341-5737 (Emporia State Office)

Principal Investigator Contact Information:

F. Todd Goodson

tgoodson@k-state.edu

785-532-5550

IRB Office:

Dr. Lisa Rubin

rubin@k-state.edu

785-532-5583

Informed Consent Questions:

IC1: Do you agree to the informed consent?

Yes/No

IC2: Would you like to be informed of the results of this research?

Yes/No

IC2.1: What email address would you like the results sent to?

Small text entry

IC3: Would you like to be placed in the drawing for one of the five, $20 Amazon gift cards?

Yes/No

IC3.1: Please list your email below to be placed in the drawing for the gift card.

Small text entry

Appendix C - Initial Email to Elementary Principals

Greetings principals,

If you could forward this message to your teachers, I would greatly appreciate it.

My name is Russell Swanson, and I am an instructor at Emporia State University in the elementary education department. I am currently conducting research over elementary science teaching as part of a doctoral dissertation at Kansas State University. Linked in below is my survey instrument asking about your teaching context and how you view teaching science at the elementary level. Your participation would be greatly appreciated. It will only take about 10-15 minutes and completing it will put you in a drawing for one of five $20 Amazon gift cards.

https://kstate.qualtrics.com/jfe/form/SV_6PDLMK6dzFM9RTU

Please reach out if you have any questions over the survey, and thank you for your consideration!

Best,

Russell Swanson

620-341-5737

rswanso2@k-state.edu

Appendix D - Second Follow-Up Email to Principals

Greetings again principals, if you could forward this message to your teachers again, I would greatly appreciate it.

So far, 100 teachers have completed the survey, and I am very grateful. I am emailing you again to see if you would be willing to participate in my research to help me complete my dissertation. The results will inform administrators and policymakers about what may help you to teach elementary science. The survey is linked in below and should only take 10-15 minutes to complete. Completing it will also place you in a drawing for one of five, $20 gift cards.

https://kstate.qualtrics.com/jfe/form/SV_6PDLMK6dzFM9RTU

Please reach out if you have any questions over the survey, and thank you again for your consideration!

Best,

Russell Swanson

Instructor/PDS Supervisor

Elementary Education

Emporia State University

620.341.5737

www.emporia.edu/teach

Appendix E - Third Follow-Up Email to Principals

Greetings again principals, if you could forward this message to your teachers again, I would greatly appreciate it.

So far, 150 teachers have completed the survey, and I am very grateful. I am emailing you again to see if you would be willing to participate in my research to help me complete my dissertation. The results will inform administrators and policymakers about what may help you to teach elementary science. The survey is linked in below and should only take 10-15 minutes to complete. Completing it will also place you in a drawing for one of five, $20 gift cards.

https://kstate.qualtrics.com/jfe/form/SV_6PDLMK6dzFM9RTU

Please reach out if you have any questions over the survey, and thank you again for your consideration!

Best,

Russell Swanson

Instructor/PDS Supervisor

Elementary Education

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