Teacher Perceptions of Next Generation Science Standards
Professional Development Effectiveness

A dissertation submitted in partial fulfillment of the requirements
for the Doctor of Education Degree in Educational Leadership

By
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Dedication

This dissertation is dedicated to the many educators who work relentlessly every day to ensure each of our students receives the absolute best education. May this work help amplify your voices.
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Abstract

Teacher Perceptions of Next Generation Science Standards

Professional Development Effectiveness

By

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Doctor of Education Degree in Educational Leadership

The Next Generation Science Standards (NGSS) generate new expectations for teachers’ classroom behaviors and place new demands on teachers that require changes in their knowledge and instructional practice. Empowering teachers to teach the new science standards requires effective professional-development opportunities that deepen their understanding of the standards and provide them with effective strategies for implementation. Current research only provides broad guidelines for designing professional-development experiences and provides minimal information about the professional-development needs of science teachers. Additionally, the authors of the national Framework on which the new science standards were based indicate that the professional development of teachers will need to change to support their implementation of the NGSS.

Conducted in the interpretivist, phenomenological paradigm using a qualitative research approach with a quantitative component in a case study tradition, this study sought to shed light on the professional-development perceptions and needs of science teachers charged with implementing the NGSS. Research participants were 23 prekindergarten through 12th-grade teachers working to implement the NGSS. Teachers had participated in various professional-development opportunities to learn about the
NGSS and participated in a large urban district’s STEAM Micro-Credentialing Program. Data were collected through a survey, focus groups, and follow-up emails. Quantitative analysis of closed-ended survey questions and qualitative analysis of open-ended survey responses, focus group responses, and follow-up emails provided valuable insights into teachers’ perceptions of the effectiveness of various NGSS professional-development activities.

The findings revealed several professional-development activity features that supported learning along with several areas for improvement, which may help professional developers capitalize on the affordances of the most effective professional-development activities while avoiding the pitfalls of professional-development activities that teachers perceived as less effective. Effective professional-development activity features included providing teachers with something practical to use in their classroom along with steps for implementation, providing time for teachers to process and discuss their learning, providing teachers with hands-on opportunities to see examples of NGSS in action as learners, and having prepared, professional, and clear facilitators who could break the learning down for the teachers. Hearing from expert speakers and providing opportunities for the collaborative design of lessons and units were also perceived as effective professional-development activity features. An area in which the teachers’ prior professional-development experiences could improve to support the shifts in their knowledge and instruction to implement the standards fully was providing differentiation for teachers’ diverse needs and experiences.
Chapter 1: Statement of the Problem

Introduction

Educators have long been concerned with supporting teacher growth, improvement, and change through high-quality professional-development experiences that truly transform teacher practice and provide critical learning (Adams & Pegg, 2012, p. 382; Barlow et al., 2014; Blanchard et al., 2013; Hayes et al., 2016; Herrington et al., 2016; Southerland et al., 2016; Westendorf, 2013; Zhang et al., 2015). The recent adoption and implementation of the Next Generation Science Standards (NGSS) and the Common Core State Standards for English Language Arts/Literacy in History/Social Studies, Science, and Technical Subjects (Common Core State Standards for English Language Arts/Literacy) that supplement them increased the urgency for providing high-quality professional development opportunities to teachers to support the changes in knowledge and instructional practice required as teachers of science implemented these new science standards in their classrooms.

According to Garet et al. (2001, p. 916), “The central elements of systemic reform—high standards, curriculum frameworks, and new approaches to assessment aligned to those standards—generate new expectations for teachers’ classroom behaviors, as well as for student performance.” The NGSS generated new expectations for teachers’ classroom behaviors and placed new demands on teachers that required changes in their knowledge and instructional practice. A significant shift in teacher knowledge and instructional practice required of the new science content standards was that teachers needed to shift their instruction to facilitate student learning through hands-on, inquiry-based science and engineering practices such as modeling, argumentation, or mathematical and
computational thinking rather than traditional, lecture-based science instruction (Cheuk, 2016; National Research Council, 2012, 2015; NGSS Lead States, 2013a). However, even though the new science standards called for students to engage in these inquiry-based science and engineering practices, a disparity existed in many classrooms between student sense-making through participation in the science and engineering practices and the more common science teaching practices grounded in the older science standards (Southerland et al., 2016).

Empowering teachers to teach the new science standards required effective professional-development opportunities that deepened their understanding of the new standards and provided them with effective strategies for their implementation. This need for effective professional development was proposed in the National Research Council’s *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (Framework) (National Research Council, 2012) on which the new science standards were based: “Teachers are the linchpin in any effort to change K-12 science education…. In order to support implementation of the new standards and the curricula designed to achieve them, the initial preparation and professional development of teachers will need to change” (National Research Council, 2012, p. 256).

However, Westendorf (2013) pointed out that traditional professional-development methods were failing: “Despite the more than $3 billion invested annually in teacher PD, few in our industry would say the money is well spent. If you've ever observed a typical PD session, it's obvious why: undifferentiated ‘sit and listen' sessions abound, requiring little engagement from teachers and generating few personal insights as a result” (Westendorf, 2013). Others (Darling-Hammond et al., 2017; Horn & Arnett,
2017; Supovitz & Turner, 2000; Zhang et al., 2015) agreed that very few of the professional-development activities teachers experienced were effective at improving teacher knowledge and practice. Zhang et al. (2015), Rotherham et al. (2008), and Huberman Field (2018) proposed that so few professional-development experiences were effective because we knew very little about teachers’ professional development needs. As a result, their professional-development experiences were not personalized and were often misaligned to their needs.

While the authors of the national Framework on which the new science standards were based indicated that the professional development of teachers would need to change to support the implementation of new science standards (National Research Council, 2012, p. 256), the authors stated that they were not charged with developing new standards or recommendations for professional development. Because of this, they suggested that until new recommendations for professional development were made, the professional development recommendations from their 1996 *National Science Education Standards (NSES)* (National Research Council, 1996) should continue to be used (National Research Council, 2012, p. 242). They went on to recommend that a review of the professional development recommendations in their 1996 publication would be a valuable complement to the efforts of the new science framework (National Research Council, 2012, p. 242). In this spirit, this study sought to address the 1996 National Research Council’s professional-development recommendations and to shed additional light on the professional-development perceptions and needs of the science teachers charged with implementing the NGSS.
Problem Statement

Ambitious efforts are taking place to implement a new vision for science education in the United States (National Research Council, 2012) through the new Next Generation Science Standards (NGSS Lead States, 2013a). Penuel et al. (2015) explained that the significant shifts in teaching called for in the new science Framework and standards required extensive professional development. Pruitt (2015a) stressed that helping teachers understand the science and engineering practices in the standards took time and that professional development that dwelled only on the standards themselves did not allow teachers to see the innovations required of the standards. Pruitt recommended that educators engage in curriculum design, task design, and intense discussion with the new standards to stimulate their greater understanding of them. Others (Garet et al., 2001; Supovitz & Turner, 2000) found that professional development that impacted teacher knowledge and instruction was sustained over time, focused on core science content, and gave teachers specific ideas for engaging in student-centered teaching. Presumably, these findings would hold for professional development related to the NGSS.

Zhang et al. (2015), however, pointed out that while there was generally a broad consensus regarding the features of effective professional-development experiences for teachers that could inform professional-development design, these characteristics were still too broadly defined to provide detailed guidance for the design of professional-development activities (p. 474). Zhang et al. (2015) and others (Huberman, 2018; Rotherham et al., 2008) also argued that we knew very little about teachers’ professional-development needs. As a result, the professional-development opportunities they were
offered often failed because the learning was frequently neither personalized nor aligned to their needs.

The National Research Council, who authored the Framework upon which the NGSS were based, suggested a review of the professional-development recommendations since their 1996 publication (National Research Council, 1996, 2012, p. 242). Similarly, Southerland et al. (2016) indicated a need to identify effective means of professional development around the NGSS and the new curricular practices they entailed. Others (Huberman, 2018; Rotherham et al., 2008; Zhang et al., 2015) stressed the importance of understanding the needs of teachers to align our professional-development efforts better, yet their perspectives were often missing (Huberman, 2018).

The problem this study addressed was that while the authors of the science Framework upon which the new science standards were based indicated that there was a need for the professional-development experiences of teachers to change for them to implement the new science standards (National Research Council, 2012, p. 305), the current research only provided broad guidelines for the design of professional-development experiences and provided minimal information about what the professional-development needs of science teachers were. The Framework’s authors highlighted that “Although there is some evidence about approaches to professional development for K-12 science teachers, the research base needs further evidence from studies across K-12 teachers at different grade levels and across different [science] disciplines” (National Research Council, 2012, p. 257). They also emphasized:

The typical learning trajectory for teachers and how it changes with learning opportunities also require empirical investigation. Questions for inquiry include:
Under what conditions and in what contexts can teachers best learn particular scientific and engineering practices, crosscutting concepts, and disciplinary core ideas during their teacher preparation and with ongoing professional development? (National Research Council, 2012, p. 320)

The problem this study addressed related to a gap in teacher knowledge and practice because while there was a large body of research that involved case studies of classroom teaching, evaluations of specific approaches and programs, and a large body of best practice literature related to professional development in general and the previous science standards specifically (Supovitz & Turner, 2000; Wilson, 2013), there was a need to update the available research base in light of the new standards, based on the actual perceptions and needs of the teachers the professional-development activities were designed to serve (Huberman, 2018; Rotherham et al., 2008; Zhang et al., 2015).

**Research Purpose and Significance**

The purpose of this study was to explore teachers’ perceptions of the professional-development activities in which they engaged to support their implementation of the Next Generation Science Standards and Common Core State Standards for English Language Arts/Literacy that supplement them and the effectiveness of these activities in supporting the shifts required in their instructional practice to implement the standards fully.

Prior research provided some evidence about approaches to professional-development experiences for science teachers. However, as the authors of the new science Framework indicated, the research base needed to be updated and include further evidence from studies across K-12 teachers. This study sought to fill this gap by providing information about teachers’ perceptions of the professional-development
activities in which they engaged and how these activities did or did not support their implementation of the new science standards.

The findings of this study provided valuable insights into teacher perceptions of the effectiveness of various NGSS professional-development activities. They may help professional developers capitalize on the affordances of the most effective NGSS professional-development activities while avoiding the pitfalls of NGSS professional-development activities that were perceived as less effective. This study's findings also helped identify teachers’ professional-development needs as they shifted their knowledge and instructional practice to meet the demands of the NGSS.

**Research Questions**

In an effort to fill the gap in the research, the following research questions guided this study:

**Research Question**

What are teachers’ perceptions of the professional-development activities in which they engaged to support their transition to the Next Generation Science Standards and the effectiveness of the various features of these professional-development activities in supporting their implementation of the Next Generation Science Standards and the Common Core State Standards for English Language Arts/Literacy that supplement them?

**Sub-Questions**

1. What types of professional-development activities have teachers engaged in to support their implementation of the NGSS and the Common Core State Standards for English Language Arts/Literacy that supplement them?
2. What knowledge and skills do teachers perceive they gained from participation in NGSS professional-development activities that supported their implementation of these content standards in their classrooms?

3. What are the features of professional-development activities that teachers perceive as most helpful for gaining new knowledge and skills to support their implementation of these content standards?

4. What areas for improvement in NGSS professional-development activities do teachers identify to better support their implementation of these content standards?

**Overview of the Methodology**

This study was conducted in the interpretivist, phenomenological paradigm (Glesne, 2016) using a qualitative research approach with a quantitative component in a case study tradition (Creswell, 2015; Durdella, 2019). The setting for this study was a large urban school district in the western United States. Since 2013, teachers within the district had been working to implement the NGSS, and the district’s location within a large urban area afforded teachers many opportunities to engage in professional-development activities around these new science standards.

The research participants in this study were 23 prekindergarten through 12th-grade teachers working to implement the NGSS in schools within the large urban district. The 23 study participants were part of a larger group of 94 teachers who all completed cohort one or cohort two of their district’s STEAM Micro-Credentialing Program during the 2018-2019 or 2019-2020 school years and who were all invited to participate in the study in the spring of 2021. The STEAM Micro-Credentialing Program allowed district
teachers to receive 105 hours of NGSS-based professional-development activities over one school year, culminating in earning a competency-based micro-credential as an open digital badge. During their time in the Program, participants seeking the STEAM Micro-Credential engaged as a community of practice in the 105 hours of blended and personalized coursework. The 105 hours of coursework consisted of six modules and included 30 hours of face-to-face, instructor-led training; 45 hours of self-paced eLearning content training online; and 30 hours of homework and fieldwork. Throughout the process, each educator produced five Evidence of Learning Artifacts (EOLAs) to demonstrate mastery and application of their learning in their classrooms.

The EOLAs teachers produced included an action plan for how they intended to implement STEAM instruction within their classroom and a STEAM assessment and unit plan they could deliver to their students. Additionally, educators completed a Capstone project that required them to document the enactment of one EOLA in their classroom, reflect on their work by answering reflection questions about their implementation, and identify the next steps and resources for their future growth. Additional details regarding the district’s STEAM Micro-Credentialing Program are included in Chapter Three as part of this study's research setting and context.

These teachers were selected for the study because they had demonstrated through their participation in the STEAM Micro-Credentialing Program that they were committed to effectively implementing the new science standards, had a diversity of experiences in professional-development activities developed for the NGSS, and could provide rich information regarding their perceptions of the NGSS professional-development experiences they have had in the region.
This study's data sources included a survey, focus groups, and follow-up emails. The triangulation of data through the use of different data-collection instruments provided information from multiple sources, increasing the validity of my research. The data sources helped me collect information about the types of professional-development activities the teachers engaged in and their perceptions of these activities.

In this study, answers to closed-ended survey questions providing general demographic, contextual, and professional-development information about the teachers were quantitatively analyzed, while responses to the open-ended survey question, focus groups, and follow-up emails were continuously analyzed using preliminary data analysis, thematic data analysis, and interpretation of data (Bloomberg & Volpe, 2016).

**Limitations**

The following were identified limitations:

- The study consisted of a small sample size of teachers from a large district who volunteered to participate. This might have limited the study because my findings only included the voices of this small group and did not include the many other voices of teachers also implementing the NGSS within the large district.
- This study was conducted as “backyard research,” where I was very familiar with the STEAM Micro-Credentialing Program from which teachers were selected for this study, and with other NGSS professional-development opportunities in the studied district. This may have biased my study because I had my ideas, based on my research and experience, about what effective professional-development activities entail.
Additionally, it may have biased participants’ responses as they were aware of my positionality in the study.

- This study only investigated teacher perceptions of the effectiveness of various professional-development activities through a survey, focus groups, and follow-up emails. It did not quantify the changes in their knowledge, practices, or student outcomes. Still, their perceptions of their professional-development activities and how well they met their needs were important (Huberman, 2018; Rotherham et al., 2008; Zhang et al., 2015) and presumably would drive their implementation of what they learned and student outcomes (Rutherford et al., 2017).

- This study consisted of participants who were all from the same large district. While they all have access to various NGSS professional-development activities, they all shared the common experience of participating in the year-long STEAM Micro-Credentialing Program. While they were free to share any of their NGSS learning experiences, they may have been biased to draw from their STEAM Micro-Credentialing experience, and their ideas about effectiveness may have been related to the specifics of teaching in their district.

**Delimitations**

The following were identified delimitations in this study:

- Participation in the study was delimited to only prekindergarten through 12th-grade teachers who volunteered to participate in the 2018-2019 or 2019-2020 cohorts of the STEAM Micro-Credentialing Program. The choice to include
only these teachers excluded the voices and perceptions of many other teachers working to implement the NGSS.

- The study was delimited by the case study tradition in which it was conducted. While this approach gave me an in-depth picture of teachers’ perspectives on NGSS professional-development activities, the findings may not be generalizable to other settings. Still, the understanding and knowledge gained from the study might be transferable to similar contexts and settings.

- The study used only a survey, focus groups, and follow-up emails to gather perceptual data regarding the effectiveness of various professional-development activities. Observations of teacher practice and document reviews of teacher lesson plans and student work, resulting in participation in professional-development activities, were not conducted. This limited the amount of data that could be gathered regarding the effectiveness of various professional-development activities.

Dissertation Organization

The purpose of this study was to explore teachers’ perceptions of the professional-development activities in which they engaged to support their implementation of the Next Generation Science Standards and Common Core State Standards for English Language Arts/Literacy that supplement them and the effectiveness of these activities in supporting the shifts required in their instructional practice to implement the standards fully. Chapter One briefly described how the NGSS generated new expectations for teacher practice, including shifting their instruction to facilitate student learning through hands-on, inquiry-based science and engineering
practices. It also discussed how empowering teachers to implement the new science standards successfully required effective professional-development opportunities for teachers. The chapter went on to discuss the National Research Council’s Framework recommendation to review previous professional-development standards for science and the need to provide more detailed guidelines for the design of science professional-development activities to complement the general consensus about effective professional-development features.

Chapter Two reviews the literature related to the demands placed on teachers through the NGSS and Common Core State Standards for English Language Arts/Literacy, the process of teacher change, and a review of the literature around the characteristics and features of effective professional-development experiences. It also discusses the important role of teacher voice and perceptions in professional learning.

Chapter Three provides information about the study’s methodology and includes an overview of the research design, data-collection instruments, data analysis procedures, and the role of the researcher.

Chapter Four provides the study’s findings, which are discussed in Chapter Five. In addition to discussing this study’s findings, Chapter Five also discusses the implications of the findings and opportunities for further research.
Chapter 2: Review of Literature

Introduction

Nearly every proposal for supporting changes in teacher practice and improving student learning includes high-quality teacher professional-development experiences as a central component because of their presumed potential to support teacher change and lead to improved instructional practice, resulting in increased student learning (Guskey, 1986, 2002; Opfer & Pedder, 2011; Supovitz & Turner, 2000). Unfortunately, more than $18 billion is spent annually on teacher professional development (Horn & Arnett, 2017, p. 95) by states and districts, but very little of that professional development improves teacher practice to improve student learning (Darling-Hammond et al., 2017; Horn & Arnett, 2017).

This chapter examines teacher professional-development experiences by first looking at the demands placed on teachers of science through the recent adoption and implementation of the Next Generation Science Standards (NGSS) and the Common Core State Standards for English Language Arts and Literacy in History/Social Science, Science, and Technical Subjects (Common Core State Standards for English Language Arts/Literacy) that supplement the NGSS and the changes in teacher practice that are required as teachers of science implement these new standards in their classrooms. To better understand the process through which teachers change their practice and how it might relate to the new standards, the chapter continues by exploring the general process of teacher change. Because high-quality professional-development experiences are a central component for supporting teacher change, the chapter continues by examining the literature on the characteristics of effective professional-development experiences.
Furthermore, as districts work to provide more effective professional-development offerings to their teachers, the chapter concludes by discussing the role of teacher voice and perceptions in professional learning.

The foundation presented in this chapter helps to support this study’s purpose of exploring teachers’ perceptions of the professional-development activities in which they engaged to support their implementation of the NGSS and Common Core State Standards for English Language Arts/Literacy that supplement the NGSS, and the effectiveness of these activities in supporting the shifts required in teachers’ knowledge and instructional practice to implement these standards fully.

**Demands Placed on Teachers by New Standards**

In recent years, many states have adopted the NGSS and the Common Core State Standards for English Language Arts/Literacy that supplement them. These new standards place additional demands not only on students but also on their science teachers, who are charged with designing and delivering instruction aligned to them.

**Next Generation Science Standards**

Billed as “an unprecedented opportunity to transform science education for all students” (Penuel et al., 2015), the NGSS (NGSS Lead States, 2013a) were released in 2013. These new science standards have been adopted by roughly 19 states and the District of Columbia (NSTA, 2019) and significantly influence science education throughout the country (Pruitt, 2015a).

**Vision and Implications of the Framework for the New Standards**

The NGSS, released in 2013, are based on the National Research Council’s *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core*
Ideas (Framework) (National Research Council, 2012). This Framework attempts to address and overcome what the authors indicate are weaknesses in previous K-12 science education. Specifically, the authors state that science education before their Framework was not systemically organized across multiple years of school, that it focused more on breadth and discrete facts rather than depth, and that it did not provide students with engaging opportunities that would allow them to experience how science is actually done (National Research Council, 2012, p. 1).

The Framework was used to create the NGSS, which, in terms of architecture, are distinct from previous science standards in that they provide Performance Expectations for each standard. Performance Expectations are assessable statements that clearly describe what all students must be able to do to demonstrate their mastery of each standard. This contrasts previous science standards written as lists of what students should know or understand (NGSS Lead States, 2013b). Each Performance Expectation in the NGSS is three-dimensional and incorporates a science and engineering practice, disciplinary core idea, and crosscutting concept from the Framework. Each Performance Expectation also lists connections to the Common Core State Standards for Mathematics and English Language Arts/Literacy. Figure 2.1 illustrates the architecture of a new science standard and its connection to the Framework and Common Core State Standards for Mathematics and English Language Arts/Literacy (NGSS Lead States, 2013b).
Figure 2.1

Architecture of a Next Generation Science Standard

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<td>(A Performance Expectation is an assessable statement of what students should know and be able to do to demonstrate they have met the standard. It is based on the science and engineering practice, disciplinary core idea, and crosscutting concept articulated in the Foundation Box below.)</td>
<td>(The Foundation Box contains the science and engineering practice, disciplinary core idea, and crosscutting concept that were derived from the Framework and used to construct the Performance Expectation above.)</td>
</tr>
</tbody>
</table>

| Science and Engineering Practices | Disciplinary Core Ideas | Crosscutting Concepts |

<table>
<thead>
<tr>
<th>Connection Box</th>
</tr>
</thead>
<tbody>
<tr>
<td>(The Connection Box shows how the Performance Expectation connects to the Common Core State Standards for Mathematics and English Language Arts/Literacy by listing the relevant standards from those content areas.)</td>
</tr>
</tbody>
</table>

The National Research Council’s Guide to Implementing the Next Generation Science Standards (National Research Council, 2015) highlights several significant changes teachers must make to achieve the vision articulated in their Framework on which the Next Generation Science Standards are based. The shifts and changes teachers must make to implement the standards are outlined in Table 2.1 (National Research Council, 2015).
Table 2.1

Implications of the Vision of the Framework and the NGSS

<table>
<thead>
<tr>
<th>Science Education Will Involve Less</th>
<th>Science Education Will Involve More</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rote memorization of facts and terminology</td>
<td>Facts and terminology learned as needed while developing explanations and designing solutions supported by evidence-based arguments and reasoning</td>
</tr>
<tr>
<td>Learning of ideas disconnected from questions about phenomena</td>
<td>Systems thinking and modeling to explain phenomena and to give a context for the ideas to be learned</td>
</tr>
<tr>
<td>Teachers providing information to the whole class</td>
<td>Students conducting investigations, solving problems, and engaging in discussions with teachers’ guidance</td>
</tr>
<tr>
<td>Teachers posing questions with only one right answer</td>
<td>Students discussing open-ended questions that focus on the strength of the evidence used to generate claims</td>
</tr>
<tr>
<td>Students reading textbooks and answering questions at the end of the chapter</td>
<td>Students reading multiple sources, including science-related magazines, journal articles, and web-based resources Students developing summaries of information</td>
</tr>
<tr>
<td>Preplanned outcomes for “cookbook” laboratories or hands-on activities</td>
<td>Multiple investigations driven by students’ questions with a range of possible outcomes that collectively lead to a deep understanding of established core scientific ideas</td>
</tr>
<tr>
<td>Worksheets</td>
<td>Students writing journals, reports, posters, media presentations that explain and argue</td>
</tr>
<tr>
<td>Oversimplification of activities for students who are perceived to be less able to do science and engineering</td>
<td>Providing supports so that all students can engage in sophisticated science and engineering practices</td>
</tr>
</tbody>
</table>

As illustrated in Table 2.1, the new science standards have several significant classroom implications for instruction. First, the standards emphasize moving away from having students engage in the rote memorization of facts and terminology and towards learning facts and terminology in the context of having students develop explanations and solutions supported by evidence-based arguments. The new standards also emphasize
phenomena and strive to move science instruction away from learning ideas that are disconnected from questions about phenomena and towards instruction that involves system thinking and modeling to explain phenomena. Additionally, the new standards require that students conduct investigations and solve problems while engaging in discussion. During these student discussions, the teacher guides the students rather than providing information directly to them. In contrast to instruction where the teacher poses questions with only one correct answer, the NGSS classroom requires students to discuss open-ended questions while generating claims supported by strong evidence.

This more significant focus on argumentation, explanation, and discussion within the Framework and standards requires that science teachers create a classroom environment that fosters science content and English language development in an interdependent, rather than separate, way (Cheuk, 2016). Cheuk (2016) points out that the discussion-focused classroom interactions required of the NGSS must help students develop both science content and language knowledge (p. 104) and that it will be essential to guide teachers in how to create classroom structures that support the participation of diverse language learners in collaborative conversations (p. 105).

Table 2.1 also indicates that instead of reading a textbook chapter and answering the questions at the end, the NGSS require students to summarize information from multiple sources. Rather than engaging in “cookbook” style laboratory investigations, in the NGSS, students conduct multiple investigations that are driven by their own questions and that can have multiple outcomes. The NGSS call for students to write journals and reports and move away from the completion of worksheets. And finally, in the NGSS, and from the Framework’s focus on equity, teachers are expected to support the success
of all students in mastering the content rather than oversimplifying activities for students who are perceived as less able. This means that teachers develop lessons allowing all their diverse students to engage in grade-level science and engineering practices while providing differentiated supports to ensure their success. As an example, given the focus on discourse within the new science standards and the diversity of language learners teachers serve, these differentiated supports might include support structures such as discourse prompts that foster language production by all students (Cheuk, 2016, p. 102). In this example, a teacher having their students construct arguments from evidence might provide graphic organizers so they can select and organize evidence to support a claim and then provide language prompts and sentence frames so that the students can verbally share their arguments.

From the many implications of the new science standards, their emphasis on phenomena-based instruction and their three-dimensional nature are significant differences from previous science standards. They will be further discussed in the following sections.

**Phenomena Based**

The NGSS and the Framework on which they are based focus on having students build progressively more sophisticated explanations of scientific phenomena (National Research Council, 2012). The Framework states that: “The goal for students is to construct logically coherent explanations of phenomena that incorporate their current understanding of science, or a model that represents it, and are consistent with available evidence” (National Research Council, 2012, p. 67). For teachers, this focus on phenomena implies that they must ask students to demonstrate their understanding of
scientific ideas by having them develop their own explanations of phenomena that are based on their observations or models they have created. This contrasts with other science teaching practices highlighted in Table 2.1 that might have the students learning science ideas disconnected from questions about phenomena, the teacher providing information to the whole class, or students reading a textbook and answering chapter questions. Because the NGSS focus on helping students better understand phenomena, Pruitt (2015b) describes the new standards as providing an opportunity for a more coherent approach to science instruction.

**Three-Dimensional**

Unlike past science standards, the Next Generation Science Standards have three dimensions: science and engineering practices, crosscutting concepts, and disciplinary core ideas.

Science and engineering practices are behaviors scientists engage in as they explore the natural world. The eight science and engineering practices include: 1. Asking questions (for science) and defining problems (for engineering); 2. Developing and using models; 3. Planning and carrying out investigations; 4. Analyzing and interpreting data; 5. Using mathematics and computational thinking; 6. Constructing explanations (for science) and designing solutions (for engineering); 7. Engaging in argument from evidence; 8. Obtaining, evaluating, and communicating information (National Research Council, 2012, p. 3). The Framework indicates that teachers should provide all students equitable opportunities to learn science by engaging in these eight science and engineering practices. Teachers must provide students with increasingly sophisticated experiences with all eight science and engineering practices (National Research Council,
Additionally, the science and engineering practices of developing and using models, constructing explanations, and engaging in argument from evidence require intensive student discussion, which are significant shifts from previous science standards (Cheuk, 2016; Penuel et al., 2015).


The third dimension of the NGSS is the disciplinary core ideas, which are the core ideas in each of the disciplines of physical science; life science; earth and space science; and engineering, technology, and applications of science (National Research Council, 2012, p. 3). Rather than focusing on many individual discrete facts, the disciplinary core ideas are intended to give students the core scientific knowledge they will need so that they can later acquire information on their own (National Research Council, 2012, p. 31). For example, the Framework upon which the NGSS are based outlines four disciplinary core ideas in life science. The first life science disciplinary core idea, From Molecules to
Organisms: Structures and Processes, “addresses how individual organisms are configured and how these structures function to support life, growth, behavior, and reproduction” (National Research Council, 2012, p. 140). Students develop this life science disciplinary core idea through a progression of learning as they progress from kindergarten through high school, and along the way, develop a deep understanding of the unifying life science principle that cells are the basic unit of life.

Given the three-dimensional nature of the NGSS, the focus of science instruction becomes helping students develop an integrated understanding of the disciplinary core ideas of science within each science discipline and the set of eight science and engineering practices while applying the seven crosscutting concepts, such as cause and effect, that unify the science and engineering disciplines. The Framework for the standards stresses that all three dimensions must be integrated into curriculum, instruction, and assessment to support students’ meaningful learning of science (National Research Council, 2012, p. 2). The integration of the three dimensions of the NGSS is frequently represented as a three-stranded rope (Figure 2.2).
This integration of the three dimensions is not an easy task for teachers, and as Isabelle (2017) asserts, “It is quite clear that the NGSS have raised the bar for the teaching of science in K-12 classrooms” (p. 84). The NGSS not only shift what teachers need to know but also what they must do in their classrooms.

**Implications for Teachers**

Implementing the Next Generation Science Standards places significant demands for change on students, teachers, and leaders (Penuel et al., 2015). The NGSS focus on
phenomena-based instruction, three-dimensional learning, and the shifts outlined in Table 2.1, means teachers must create classroom cultures supporting this type of instruction. Pruitt (2015a) emphasizes that this is hard for teachers, and learning how to create these classroom cultures takes considerable time and effort. To successfully implement the NGSS and achieve the vision for science education articulated in the Framework, the Framework’s authors state that:

- Teachers should understand students’ naïve ideas and learning processes well enough to assess and guide them, and they should understand the crosscutting concepts, disciplinary core ideas, and scientific and engineering practices well enough to select appropriate instructional materials and strategies and apply them effectively. Teachers should use assessments to plan for, revise, and adapt instruction; to evaluate teaching and learning; to guide and pace the direction of instruction; and to select tasks, representations, and materials that engage students’ interests and provide learning opportunities. (National Research Council, 2012, pp. 319-320)

The Framework’s authors highlight some specific demands placed on teachers to achieve the vision articulated in the Framework. Specifically, teachers will need to be thoroughly grounded in the three dimensions of the standards, and they will need to understand how to engage students in each dimension and how to develop three-dimensional activities. Teachers will need to be comfortable facilitating multiple student investigations and effective discourse in their classrooms. As Cheuk (2016) points out, the prominence of argumentation within the standards means teachers must feel comfortable supporting students with diverse language backgrounds in generating claims
supported by evidence and reasoning. They will also need to develop specific strategies for highlighting the crosscutting concepts in their instruction (National Research Council, 2012, p. 258).

**Common Core State Standards for English Language Arts/Literacy**

The Common Core State Standards for English Language Arts/Literacy were developed by the National Governors Association Center for Best Practices and the Council of Chief State School Officers from 2009-2010 by a consortium of 48 states with funding from the Bill and Melinda Gates Foundation (J. O. Lee, 2011; Shanahan, 2015b). The new standards were intended to help states adopt higher goals for students to ensure that all students were college and career ready. The standards established guidelines for English Language Arts and the literacy demands of reading, writing, speaking, and listening in history/social studies, science, and technical subjects.

While the NGSS and Common Core State Standards for English Language Arts/Literacy were developed separately, the two sets of standards work in tandem and directly intersect in several areas (O. Lee, 2017; Rhodes, 2014). For example, Rhodes (2014) highlights the intersection between the NGSS science and engineering practice of “obtaining, evaluating, and communicating information” and the literacy in science portion of the Common Core State Standards for English Language Arts/Literacy.

Similarly, Cheuk (2016) highlights how the standards work in tandem through the practice of argumentation with evidence, which is shared across the three major disciplines of science, mathematics, and English language arts. To illustrate this interdependence, Figure 2.3 (Cheuk, 2016, p. 94) lists the eight science and engineering practices of the NGSS (SP 1-SP 8), the eight standards for mathematical practice found in
the Common Core State Standards for Mathematics (MP1-MP 8), and the seven English capacities found in the Common Core State Standards for English Language Arts/Literacy (EP 1-EP 7). There are several areas of overlap, and Figure 2.3 shows that the student discourse practice of argumentation with evidence is shared across the disciplines.
Figure 2.3


The Common Core State Standards for English Language Arts/Literacy have some significant differences from previous English language arts standards, and, like the NGSS, teachers must shift their knowledge and instructional practices to implement them effectively.

**Emphasis on Opinion and Argument Writing**

Most past English language arts standards and the state tests that accompanied them emphasized persuasive writing, where the goal was to convince the reader, through persuasion, to agree with the author. On the other hand, the Common Core State Standards for English Language Arts/Literacy focus more on opinion writing in the lower grades and argument, with anticipated counterarguments and multiple sources of evidence, in the upper grades (Shanahan, 2015a). Unlike persuasive writing, opinion and argument writing require evidence to support claims. To illustrate the intersection between the Common Core State Standards and the NGSS, in her book, Rhodes (2014) gives an example of how the Common Core State Standard for English Language Arts/Literacy practice of “making arguments” supports the NGSS practice of “engaging in argument from evidence” (p. 10). In her example, at the high school level, both sets of standards require students to “Develop claim(s) and counterclaims fairly, supplying data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form and in a manner that anticipates the audience’s knowledge level and concerns” (Rhodes, 2014, p. 10).

**Close Connection Between Writing and Reading**

Shanahan (2015a) stresses that the close connection between writing and reading in the new standards is a significant change from past standards. The new standards
emphasize summarizing, analyzing, and synthesizing information from texts. Past standards typically treated reading and writing separately; the new standards’ greater integration with the Common Core State Standards for English Language Arts/Literacy and those for English language development and the increased emphasis on the deep reading of grade-level texts, especially informational texts, as the basis for much of the writing a student does will directly impact instruction and will require teachers to shift their practice. With the new standards, rather than teaching reading and writing as separate activities, teachers must know how to teach their students to summarize, analyze, and synthesize information from grade-level informational texts.

**Focus on Technology**

In addition to their greater emphasis on argument writing and writing from text, the Common Core State Standards for English Language Arts/Literacy and those for English language development are much more explicit about using technology in writing (Shanahan, 2015a). Specifically, Shanahan describes how the standards require students to use the internet and other technologies to produce writing, collaborate with others around their writing, and publish their writing. He also suggests that using this technology requires students to learn keyboarding skills and how to use software programs. For many teachers, this, too, will place a demand to build new skills and shift their practice as they will need to design and deliver instruction that supports their students’ successful use of these technologies in writing.

**Assessment**

Since “No Child Left Behind” in 2002, states have been required to test students in English language arts and mathematics in grades three through 12 to determine
whether they are reaching state standards. This requirement for testing is not altered in any way with the Common Core State Standards (Shanahan, 2015b). With the new standards, however, several states have opted to administer either the Smarter Balanced Assessment Consortium (SBAC) or Partnership for Assessment of Readiness for College and Careers (PARCC) tests. Both of these computer-based tests were developed through a collaboration of states to measure student mastery of the Common Core State Standards and student readiness for college and career. While not a Common Core State Standards requirement, these tests appear more ambitious than previous tests (Shanahan, 2015b). One thing that makes them more challenging is the greater emphasis on writing in elementary schools than in the recent past (Shanahan, 2015a).

**Language Development**

While implementing the Common Core State Standards for English Language Arts/Literacy that supplement the NGSS, science teachers must ensure their students master the standards' content while also supporting the English language development of multilingual learners they might have in their classrooms. California’s 2014 *English Language Arts/English Language Development Framework* (Curriculum Framework and Evaluation Criteria Committee, 2015) highlights the major elements of instruction for the Common Core State Standards for English Language Arts/Literacy, along with the major elements of instruction for English Language Development (ELD). These elements are highlighted in Figure 2.4 and include the overarching themes, context, and goals of English Language Arts/Literacy and ELD instruction.
The two sets of standards and their focus on reading, writing, speaking and listening, and language in all disciplines are shown in the blue circle in the center of Figure 2.4.

Moving outward in Figure 2.4, the key themes of the two sets of standards are shown in the five blue circles surrounding them and include language development, meaning making, effective expression, foundational skills, and content knowledge.

The overarching context in which the instruction of the two sets of standards occurs, shown in the inner white portion of Figure 2.4, indicates that instruction should occur in a setting where the learning is integrated, motivating, engaging, respectful, and intellectually challenging.

Finally, the overarching goals for the instruction of the two sets of standards, shown in the outer orange ring of Figure 2.4, are that students: become broadly literate; acquire 21st-century skills; are ready for college, careers, and civic life; and attain the capacities of literate individuals.
Figure 2.4

Circles of Implementation of ELA/Literacy and ELD Instruction

Considering language even further, for science teachers teaching in bilingual settings, delivering instruction in both English and the target languages while supporting science content mastery and development of two languages, the demands become even greater.

**Implications for Teachers**

The Common Core State Standards for English Language Arts/Literacy are the shared responsibility of teachers in multiple disciplines, including those in science who are also implementing the NGSS. The implementation of these standards places additional demands on teachers, including those of science, as they shift their knowledge and instruction to focus more on opinion and argument writing, provide opportunities for their students to produce writing from grade-level informational texts, incorporate technology into the production and publication of writing, and support their students in meeting the demands of the more ambitious assessments. Adding to the challenge, Lee (2011) notes that implementing reforms such as the Common Core State Standards for English Language Arts/Literacy can be difficult because most school cultures are conservative. Schools tend to prefer to conduct business as usual while resisting reforms, such as the Common Core State Standards for English Language Arts/Literacy, designed by outside experts.

**Teacher Change and Implications for Professional Development**

The adoption and implementation of the NGSS and Common Core State Standards for English Language Arts/Literacy that supplement them require teachers to deepen their content knowledge and shift their practice to meet the demands of these new standards (J. O. Lee, 2011; Penuel et al., 2015; Shanahan, 2015b). To support the
learning and required shifts in teacher practice, it is essential to understand the process of teacher change so that teachers can be provided the support and professional learning experiences that support meaningful learning and shifts in their practice they will need to make to implement these new standards fully and successfully.

Guskey (1986) suggests that teacher change is a learning process that is developmental and primarily based on experience. He argues that most teachers want to get better at their craft and willingly participate in professional-development activities to grow their ability to impact student achievement positively. Because of their desire to improve student achievement, he suggests that a significant factor in changing a teacher’s beliefs and attitudes and in the endurance of any change in their instructional practices is demonstrable results concerning the learning success of their students as a result of a change in their practice. As a result, his model for teacher change posits that for the beliefs and attitudes of teachers to change significantly, they must gain evidence that the changes they made to their practice resulted in improved learning outcomes for their students. Guskey summarizes these stages of teacher change in his four-step model: 1. Professional Development; 2. Change in teachers’ classroom practices; 3. Change in student learning outcomes; 4. Change in teachers’ beliefs and attitudes (1986, 2002).

Without verification of improved learning outcomes from students in the classroom, teachers are unlikely to change their beliefs and attitudes about any new program or innovation. As a result, they are not likely to change their practice permanently (Guskey, 1986). In his model, improved learning outcomes for students generally precede, and may be a prerequisite to, significant change in the beliefs and attitudes of most teachers (Guskey, 1986), and teachers become committed to new
practices only after they have actively engaged in using them in their classrooms and they have demonstrated success (Crandall, 1983).

In contrast to his four-step model for teacher change, Guskey (1986) discusses how teacher professional-development efforts frequently attempt to first change teachers' beliefs and attitudes in the hope that this will lead to specific changes in their classroom behaviors and practices, which, in turn, will result in improved student learning. He gives the example of how many staff developers try to change teachers' beliefs about certain aspects of teaching or about how desirable a particular curriculum or instructional innovation might be.

In response to this, Guskey (1986) points out that what teachers hope to gain through professional learning experiences are specific, concrete, and practical ideas that directly relate to the day-to-day operation of their classroom. Therefore, to be effective, he posits that professional learning programs must offer teachers practical ideas that can be efficiently used to enhance the desired learning outcomes of their students.

Guskey’s (1986, pp. 9-10) four-stage model for teacher change is guided by three principles:

1. Teacher change is a gradual and difficult process for teachers, and the likelihood of teachers initially implementing a new program or innovation depends primarily on their judgment of the magnitude of change required. Guskey indicates that programs and innovations dramatically different from a teacher’s current practice are unlikely to be implemented, so it is better to ease into their use and implement them incrementally so they do not disrupt the teacher or create too much extra work.
2. Throughout the process of change, teachers need to receive regular feedback on student learning progress. When teachers receive regular feedback on how the changes in their practice positively impact student achievement, the changes in their practice are more likely to be sustained. On the other hand, teachers are more likely to abandon new practices that do not provide evidence of increased student learning.

3. Teachers must receive continued support and follow-up after their initial training regarding a new program or innovation. Further, the change is most successful when teachers can regularly discuss their experiences in an atmosphere that supports collegiality and experimentation.

**Teacher Professional Learning**

The adoption of new standards and the need for teachers to update and change their knowledge and practice to meet the demands of these new standards and improve student achievement places a renewed emphasis on professional-development experiences as a means for supporting teacher change (Guskey, 1986, 2002; Opfer & Pedder, 2011). Professional-development initiatives and experiences are essential because they systematically attempt to change teachers’ classroom practices, student learning outcomes, and beliefs and attitudes (Guskey, 1986, 2002).

However, given that research has found that many professional-development initiatives appear ineffective in supporting teacher change and improving student learning outcomes (Darling-Hammond et al., 2017), it is essential to understand better the characteristics and features of professional development that have been found to be effective. Fortunately, research exists on what makes teacher professional development
most effective (Darling-Hammond et al., 2017; Garet et al., 2001; Supovitz & Turner, 2000; Wilson, 2013). Furthermore, despite research indicating that many professional-development initiatives are ineffective, well-designed professional-development programs have been shown to effectively reform classroom instruction (Supovitz & Turner, 2000).

**Effective Professional Development**

Wilson (2013) identified five characteristics of effective professional-development activities. According to Wilson, to be effective, professional-development activities must focus on specific subject area content and engage teacher participants in active learning rather than as passive recipients of undifferentiated, passive, sitting and listening sessions of professional development that Westendorf (2013) describes as being common. Wilson (2013) also found that professional-development activities are most effective when they coherently align with other school policies and practices and when the activities within the professional-development experience closely resemble what teachers are meant to practice in their classrooms. Keeping professional-development participants physically and psychologically comfortable was also found by Wilson to be a characteristic of the most effective professional-development experiences.

In a study by Garet et al. (2001), the authors describe three structural features of professional-development programs that help set a positive context for effective professional-development experiences. The authors found that the structural features of providing teachers with extended study time, allowing for collective participation of groups of teachers from the same school, and emphasizing activities like study groups and mentoring had the most significant impact on teacher practice. In addition to these
three professional-development structures, the authors describe three core features of effective professional-development experiences: focusing on subject area content knowledge, active learning, and coherence with other professional-development experiences teachers are engaged in.

In their study of effective professional development, Darling-Hammond et al. (2017) reviewed 35 studies conducted over the last 30 years that demonstrated a positive link between teacher professional development, the teacher’s teaching practices, and improved student outcomes. The study found that the effective professional-development experiences within the 35 studies shared some common features that included: 1. Being content focused; 2. Incorporating active learning that uses adult learning theory; 3. Supporting collaboration; 4. Using models of, and modeling, effective classroom practice; 5. Providing coaching and expert support; 6. Offering opportunities for feedback and reflection; and 7. Being of a sustained duration (Darling-Hammond et al., 2017, p. 1).

Finally, looking specifically at science professional-development activities, Supovitz and Turner (2000, pp. 964-965) summarized the national consensus of six critical components of high-quality professional-development experiences for science teachers. These six critical components of high-quality professional-development experiences include:

1. Professional-development activities must model inquiry forms of teaching and immerse participants in inquiry, questioning, and experimentation.
2. Professional-development activities must be intensive and sustained.
3. Professional-development activities must engage teachers in concrete teaching tasks based on their experiences with students.
4. Professional-development activities must deepen teachers’ content skills and focus on subject-matter knowledge.

5. Professional-development activities must be grounded in a common set of professional-development standards, and they must show teachers how to connect their work to student performance standards.

6. Professional-development activities must be connected to other school reform strategies.

Figure 2.5 compares the effective professional-development characteristics identified by Wilson (2013), the structural and core features described by Garet et al. (2001), the features from Darling-Hammond et al. (2017), and Supovitz and Turner’s (2000) structural components, with similarities between the findings of each researcher highlighted in the same color.
**Figure 2.5**

*Comparison of Effective Professional-Development Characteristics, Features, and Components*

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td><strong>Five Characteristics:</strong></td>
<td><strong>Five Structural and Core Features:</strong></td>
<td><strong>Seven Features:</strong></td>
<td><strong>Six Structural Components:</strong></td>
</tr>
<tr>
<td>1. Focusing on specific content</td>
<td>1. Sustained and intensive PD</td>
<td>1. Being content focused</td>
<td>1. Model inquiry teaching</td>
</tr>
<tr>
<td>2. Engaging teachers in active learning</td>
<td>2. Focus on academic content</td>
<td>2. Incorporating active learning that uses adult learning theory</td>
<td>2. Intensive and sustained</td>
</tr>
<tr>
<td>5. Sufficient duration</td>
<td>5. Collective participation</td>
<td>5. Providing coaching and expert support</td>
<td>5. Grounded in professional development standards</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6. Offering opportunities for feedback and reflection</td>
<td>6. Connected to school reform strategies</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7. Being of a sustained duration</td>
<td></td>
</tr>
</tbody>
</table>

Note. Similarities between the findings of each researcher are highlighted in the same color.

From a study designed to understand the needs of in-service science teachers, Zhang et al. (2015) point out that while there is generally a broad consensus regarding the features of effective professional-development experiences for teachers that can inform professional-development design, these characteristics are still too broadly defined to
provide detailed guidance for the design of professional-development activities (p. 474). Furthermore, there has been advocacy for reviewing previous professional-development recommendations in light of more recent research (National Research Council, 2012, p. 242). Others (Supovitz & Turner, 2000; Wilson, 2013) agree that while there is currently a large body of best-practice literature related to professional development in general and the previous science standards specifically, there is a need to update the available research base on effective professional development in light of the new standards.

**Teacher Voice and Perceptions in Professional Learning**

With an understanding of the curricular demands facing teachers, the process through which teacher change occurs, and the characteristics of high-quality professional development, this section will examine teacher voice and perceptions in professional learning.

As previously discussed, Zhang et al. (2015) state that while there is a generally broad consensus regarding the features of effective professional-development experiences, the characteristics are too broadly defined. In that same study, Zhang et al. (2015) argue that “PD should be relevant to teachers’ needs and coherent with their goals—a key feature of effective PD. Yet, we know little about what those needs are” (p. 474). Rotherham et al. (2008) agree with this assertion, stating, “Inside the classroom, induction, mentoring, and professional development are typically underdeveloped and misaligned with the needs of teachers” (p. 244). Huberman (2018) also agrees and points out that although we have emphasized personalizing learning for students based on their individualized needs, this same emphasis has not been placed on teachers, leading to ineffective professional-development experiences that fail to support teacher progress.
For this reason, my study focused on seeking to hear the perceptions of teachers who had engaged in various NGSS professional-development activities to gain a better understanding of their professional-development needs and a more focused understanding of the features of NGSS professional-development activities that were perceived as effective in building knowledge and shifting practice to implement the NGSS.

**Review of the Theoretical Framework**

The theoretical framework for this study was grounded in the work of Guskey (1986, 2002) and his model of teacher change. Guskey’s model of teacher change suggests a sequence of change events teachers must go through to create enduring change to their professional practice, beliefs and attitudes, and student learning outcomes towards an articulated goal. In this study, that articulated goal was the implementation of the NGSS and Common Core State Standards for English Language Arts/Literacy that supplement them. Because effective professional-development experiences are a part of Guskey’s model of teacher change, he contends that his model can help guide the creation of teacher professional-development programs that are more effective (Guskey, 2002, p. 382).

Guskey (2002) indicates that most teachers engage in professional-development activities because they want to be better teachers (p. 382), and these professional-development activities are the first change event, or component, in his model of teacher change. For this first event in his model of teacher change, he explains that teachers are generally attracted and motivated to engage in professional-development programs because they believe professional-development programs will expand their knowledge.
and skills, will contribute to their growth, and that the professional-development programs will enhance their effectiveness with students.

The second change event, or component, in Guskey’s model of teacher change occurs when teachers change their classroom practice by implementing what they learned in their professional-development activity. During this stage of the change process, he stresses that it is essential that teachers gain evidence that their implementation of the new strategy or innovation learned from the professional-development activity results in improved student performance. For this reason, he suggests that providing feedback to the teacher during this second stage of the change process is essential.

The change in student learning outcomes is the third event in Guskey’s model of teacher change. For a change in the teachers’ practice to endure, they must see that the instructional approach or innovation they are implementing works with their students. Teachers rarely commit to new instructional approaches until they have seen them work in their classrooms with their students. Teachers will only become committed to new practices after implementing them in their classrooms and obtaining evidence of their success. Because of this, Guskey is clear to point out that it is not the professional-development activity from the first event in his change model itself that will ultimately produce an enduring change in teachers’ beliefs and attitudes, but rather their experience of success in improving student learning outcomes as a result of implementing the new practice or innovation that will change teachers’ beliefs and attitudes.

The fourth and final event in Guskey’s model of teacher change is the enduring change in teachers’ beliefs and attitudes resulting from the evidence of increased student outcomes they gathered while enacting new practices in their classrooms. This enduring
change in a teacher’s beliefs and attitudes will result in an enduring change in their practice.

There are several implications of Guskey’s model of teacher change. One implication of his model is that providing teachers with professional-development activities alone will not result in an enduring change in their practice, beliefs, or attitudes. For an enduring change in their practice, beliefs, and attitudes to occur, in addition to the professional-development activity, they need evidence that implementing the new practice resulted in improved student learning. Along those same lines, if a teacher’s implementation of a new practice gained from a professional-development activity does not provide evidence of improvements to student learning, there will not likely be an enduring change to their practices, beliefs, and attitudes.

While Guskey’s model of teacher change was the grounding for the theoretical framework used in this study, and the lens through which the process of teacher change was viewed, the work of Garet et al. (2001), Supovitz and Turner (2000), and Darling-Hammond et al. (2017) informed the study’s theoretical framework. Each of these researchers studied the features and elements of high-quality, effective professional-development experiences for teachers. While each set of features was slightly different, each researcher found some common elements of effective professional-development activities that included having the professional-development experiences be content-focused, coherent, collaborative, and focused on active learning.

Connecting the work of Garet et al. (2001), Supovitz and Turner (2000), and Darling-Hammond et al. (2017) to Guskey’s theoretical framework that grounded this study provided information about the features of effective professional-development
activities that were inputs into the first event in Guskey’s model of teacher change: professional-development programs. For teachers’ practices, beliefs, and attitudes to align with the new science standards, teachers must leave their professional-development experiences with instructional practices they could enact in their classrooms so that they could see the positive impact of these new practices on their students’ learning. This positive impact on their students’ learning could lead to an enduring change in their beliefs and attitudes.

In the context of this study, new demands were being placed on teachers through the implementation of the NGSS and Common Core State Standards for English Language Arts/Literacy that supplement them. Implementing these new standards required teachers to build their knowledge and change their instructional practice to align with the vision of the new standards. Supporting teachers through this change required understanding the model of teacher change they go through. The first event in this change process is professional-development experiences. This study sought to understand better the professional-development experiences that are an important part of a teacher’s change process.

Summary

The NGSS and the Common Core State Standards for English Language Arts/Literacy that supplement them placed additional demands on teachers charged with designing and delivering instruction aligned to them. Because educators are driven and motivated to get better to improve student achievement, they must be provided with the highest quality professional-learning opportunities that will build their knowledge and support their implementation of the new practices required by the standards. When their
implementation of the new practices results in improved student achievement, enduring change to their practice, beliefs, and attitudes will occur.

While we already know quite a bit about the elements of effective professional-development experiences, this study looked more closely at teachers’ perceptions of the professional-development activities in which they engaged and their perceptions of the effectiveness of these activities in supporting the shifts required in their instructional practice to implement the standards fully. The findings of this study helped to update the research base on effective professional-development experiences for science teachers in light of the NGSS. They helped fill the gap regarding more specific information about their experiences and needs.
Chapter 3: Methodology

Introduction

The purpose of this study was to explore teachers’ perceptions of the professional-development activities in which they engaged to support their implementation of the Next Generation Science Standards and Common Core State Standards for English Language Arts/Literacy that supplement them and the effectiveness of these activities in supporting the shifts required in their instructional practice to implement the standards fully. The goal of this study was to collect and report teachers’ perceptions of the NGSS professional-development activities in which they engaged and their perceptions of the degree to which the features of these professional-development activities provided them with knowledge and skills that supported their implementation of the new content standards. The findings from this study provided valuable insights into teacher perceptions of the effectiveness of various NGSS professional-development activities that can help professional developers capitalize on the affordances of the most effective NGSS professional-development activities while avoiding the pitfalls of NGSS professional-development activities perceived as less effective. The findings of this study also helped identify teachers’ professional-development needs as they shift their knowledge and instructional practice to meet the demands of the NGSS.

This study achieved its purpose and met its goals by addressing the following questions:

Research Question

What are teachers’ perceptions of the professional-development activities in which they engaged to support their transition to the Next Generation Science Standards
and the effectiveness of the various features of these professional-development activities in supporting their implementation of the Next Generation Science Standards and the Common Core State Standards for English Language Arts/Literacy that supplement them?

Sub-Questions

1. What types of professional-development activities have teachers engaged in to support their implementation of the NGSS and the Common Core State Standards for English Language Arts/Literacy that supplement them?

2. What knowledge and skills do teachers perceive they gained from participation in NGSS professional-development activities that supported their implementation of these content standards in their classrooms?

3. What are the features of professional-development activities that teachers perceive as most helpful for gaining new knowledge and skills to support their implementation of these content standards?

4. What areas for improvement in NGSS professional-development activities do teachers identify to better support their implementation of these content standards?

Following this introduction, I will discuss the research design for this study and the rationale for choosing it. Next, I will discuss the research setting and context. Then I will discuss the research participants and data sources, followed by the data-collection instruments used. Next, I will discuss the data collection and analysis procedures. The chapter concludes with a discussion of my role as a researcher in this study and includes several appendices. Appendix A contains the research invitation for this study, Appendix
B contains the human research participant consent form, Appendix C includes the teacher survey used, and Appendix D contains the focus group interview protocol utilized.

**Research Design**

My study was conducted in the interpretivist, phenomenological paradigm (Glesne, 2016, p. 7) using a qualitative research approach in a case study tradition (Creswell, 2015, p. 465; Durdella, 2019, p. 95) with a quantitative component. The interpretivist paradigm aims to interpret the social world and its phenomena from the perspectives and interpretations of the people involved (Glesne, 2016, p. 9). Through this paradigm, in my study, the NGSS professional-development activities in which teachers engaged were the phenomena under study. I sought to understand the effectiveness of various professional-development activity features from the perspectives and interpretations of the teachers involved in the study.

The case study tradition informed my methodological decisions regarding research design and methods. It provided a clear unit of study and analysis and allowed me to interact significantly with the teachers. It also allowed me to develop an in-depth picture of their experiences with, and perceptions of, NGSS professional-development activities (Bloomberg & Volpe, 2016, p. 46). Through the case study tradition, I collected detailed descriptions of the NGSS professional-development activities in which the teachers engaged as well as their perceptions of these activities, which allowed me to analyze a large amount of data for themes, patterns, and issues (Bloomberg & Volpe, 2016, p. 46).

The research participants in this study were 23 prekindergarten through 12th-grade teachers working to implement the NGSS in schools within a large urban district in
the western United States. The 23 study participants were part of a larger group of 94 teachers who all completed cohort one or cohort two of their district’s STEAM Micro-Credentialing Program during the 2018-2019 or 2019-2020 school years and who were all invited to participate in the study in the spring of 2021. The focus of my case study was an in-depth exploration of this population of teachers’ professional-development experiences as I sought to explore their perceptions.

I gathered data through a survey, focus groups, and follow-up emails. Collecting data from these multiple forms of data collection allowed for triangulation, or the corroboration of evidence from different methods of data collection (Creswell, 2015, p. 259), increasing the validity of my findings.

From the cohort of 94 teachers who completed the STEAM Micro-Credentialing Program during the first two cohorts, all were invited to take the survey. After completing the survey, teachers were asked if they would be willing to volunteer to participate in a focus group. Following the focus groups, I emailed the teachers to clarify and extend my findings during data analysis.

The case study approach used in this study allowed me to gain an in-depth picture of the teachers’ perspectives on NGSS professional-development activities. Bloomberg and Volpe ((Bloomberg & Volpe, 2016, p. 47) caution, however, that generalizability is not the goal of case study research. Instead, they note that the understanding and knowledge gained from a case study might be transferable to similar contexts and settings. In this way, information gained from this study might help inform how future professional-development activities could be designed to best support the transition to NGSS for teachers in the large urban district under study or in similar contexts.
Additionally, the information might also help professional developers capitalize on the affordances of the features of the most effective professional-development activities while avoiding the pitfalls of NGSS professional-development activity features that were perceived as less effective.

**Research Setting and Context**

The setting for this study was a large urban school district in the western United States. Since 2013, all elementary, middle, and high schools within the district had been working to implement the NGSS, and the district’s location within a large urban area afforded teachers many opportunities to engage in professional-development activities around these new science standards.

The district in this study served a large urban student population ([Redacted], 2018). The district had a mostly Hispanic student population, and less than 20% of the students were African American or white. About a quarter of the students were English Language Learners, and more than three quarters were socioeconomically disadvantaged. Given its large size and large number of teachers, the district was divided into smaller regional sub-districts. Nearly half of the teachers were Hispanic, and roughly 40% were white or African American (Education Data Partnership, 2019). The average teacher had been teaching in the district for 15 years (Education Data Partnership, 2019).

The district under study provided myriad options for teacher professional-development activities. When the district began its implementation of the NGSS in 2013, one central office provided science professional development for the entire district. Starting in 2014, in addition to professional-development activities offered through the central office, additional professional-development activities were provided through its
smaller regional sub-district offices. Furthermore, the area in which the district was located was served by several universities and many informal science institutions that provided science professional-development experiences to teachers. Science teachers within the district could participate in science professional-development activities offered through the district’s central office, the smaller regional sub-district offices, or their school sites. They may have also taken advantage of the professional-development opportunities provided by local universities, surrounding informal science education institutions, or other professional-development providers. With limited time and funding, and full implementation of the new science standards expected for the 2018-2019 school year, the teachers within the district had great urgency to learn about and fully implement the new science standards and make the instructional shifts they call for.

In addition to the professional-development offerings discussed previously, in the 2018-2019 school year, the district launched a Micro-Credentialing Program in STEAM. The STEAM Micro-Credentialing Program allowed selected district teachers to receive 105 hours of NGSS-based professional-development activities over one school year, culminating in earning a competency-based micro-credential in the form of an open digital badge.

During their time in the Program, participants seeking the STEAM Micro-Credential engaged as a community of practice in 105 hours of blended and personalized coursework. The 105 hours of coursework consisted of six modules and included 30 hours of face-to-face, instructor-led training; 45 hours of self-paced eLearning content training online; and 30 hours of homework and fieldwork. Throughout the process, educators produced five Evidence of Learning Artifacts (EOLAs) to demonstrate mastery
and application of their learning in their classrooms. All teachers in this study completed this STEAM Micro-Credentialing Program.

**Research Participants and Data Sources**

I worked with a district administrator to access the record of teachers who participated in the first and second years of the STEAM Micro-Credentialing Program during the 2018-2019 or 2019-2020 school years to solicit the participation of 94 prekindergarten through 12th-grade teachers in this study. I emailed them inviting their informed and consensual participation (Appendix A) in the spring of 2021.

The 94 teachers invited to participate in this study in the spring of 2021 were from across the large district. Within this sample of 94 teachers, 54 taught multiple subjects, including science, in elementary grades. The sample also contained 26 middle school teachers, with 11 teaching science, four teaching math, seven teaching English language arts, two teaching electives, one teaching physical education, and one teaching history. For high school, 14 teachers were invited to participate, with four teaching science, eight teaching math, one teaching English language arts, and one teaching history.

Of the 94 prekindergarten through 12th-grade teachers invited to participate in this study, 23 provided their informed consent and completed the survey. After the survey, 13 teachers consented to participate in voluntary focus groups and follow-up emails.

Data sources for this study included a survey with 28 questions, focus groups, and follow-up emails. After teachers provided their informed and consensual participation in the study via the email I sent inviting their participation (Appendix A), they were provided with a link to the survey that gathered demographic and contextual information.
and included questions about their grade span, role, and primary subject area(s), and familiarity with the NGSS (Appendix C). The survey also asked them to describe both the NGSS professional-development activities in which they had engaged and their perceptions of these professional-development activities. The survey also asked all participants if they would volunteer for a focus group.

After the survey was administered, my initial goal was to use the information from the survey to invite elementary, middle, and high school teachers who had participated in the widest variety of NGSS professional-development activities to participate in focus groups (Appendix D). However, because only eight elementary school teachers, three middle school teachers, and two high school teachers volunteered for the focus groups, I invited all 13 of them to participate in one of four focus groups held virtually via Zoom in June 2021 to help me learn more about their perceptions of the NGSS professional-development activities in which they participated and their perceptions of how they supported, or not, the shifts in their knowledge and practice required of the NGSS.

Following the grade band focus groups, while data analysis was occurring, I followed up with individual participants as needed via email (Appendix E) to clarify or request elaboration on their responses in the focus groups.

The 23 teachers who completed the survey and 13 who participated in the focus groups and follow-up emails from this process provided the information-rich cases I used to answer my research questions (Bloomberg & Volpe, 2016).

Several steps were taken to protect the human subjects within this study. Before the study began, I received approval from the California State University, Northridge
Institutional Review Board (IRB), and the district’s external research review committee. Once both institutions approved the study, I used the record of teachers who participated in the first two cohorts of the STEAM Micro-Credentialing Program to solicit and invite, via email, the informed, consensual, and voluntary participation of the teachers in this study. In reporting results, I used pseudonyms for teachers’ names rather than their real names. During the focus groups, I established confidentiality among the participants by asking that they not reveal to anyone who was in the focus group, nor what was shared. Finally, all survey responses, audio recordings, transcripts, and other data were stored on a secure, password-protected computer that only I could access. This sequestering and anonymizing of participant data assured the participants of the safety of speaking their minds without affecting their employment by what they expressed. Research records were retained for at least three years after the completion of the research.

**Data-Collection Instruments**

Data were collected from the participating teachers using two main data-collection instruments: a survey (Appendix C) and a focus group interview protocol (Appendix D). Additionally, while data analysis occurred, follow-up emails (Appendix E) with individual teachers were used to ask further questions derived from the data analysis. The triangulation of data through these different data-collection instruments provided information from multiple sources and data-collection methods, increasing the validity of my research (Bloomberg & Volpe, 2016). The survey and focus group interview protocol supported my in-depth exploration of teachers’ perceptions of NGSS professional-development experiences as part of my case study research design.
Survey Instrument

In the spring of 2021, 94 teachers who had completed cohort one or cohort two of their district’s STEAM Micro-Credentialing Program during the 2018-2019 or 2019-2020 school year were invited to participate in this study via an email (Appendix A) that provided a link to a 28-question survey (Appendix C) in Qualtrics that gathered demographic and contextual information regarding participants’ grade spans, roles, and primary subject areas. The survey also included questions to measure their self-reported familiarity with designing and delivering NGSS instruction, their familiarity with the NGSS design and use in planning, the frequency with which they engaged their students in NGSS instruction, and their engagement in professional-learning experiences to learn about the NGSS. Additionally, the survey contained a question that asked the teachers to describe the professional-development activities they engaged in to support their implementation of the NGSS and their perceptions of these activities. The survey also asked all respondents if they would be interested in volunteering to participate in a focus group.

Focus Group Interview Protocol

Following the administration of the survey, I invited all 13 teachers who volunteered to participate in a focus group to join one of four focus groups held virtually via Zoom in June 2021. To accommodate scheduling and keep the focus groups small, the four 90-minute virtual focus groups included: two elementary focus groups of four elementary teachers each, one middle school focus group of three teachers, and one high school focus group with two teachers.
During each virtual focus group via Zoom, I used the focus group interview protocol in Appendix D. The focus group interview protocol consisted of 10 main questions with probes and helped me facilitate a candid conversation to clarify and extend the findings from the survey. While I began each focus group with my set of focus group questions, I remained open to re-forming and adding to the questions and incorporating more impromptu in-depth probes throughout the process (Glesne, 2016). The focus group questions sought to explore the types of professional development the teachers have engaged in to support their implementation of NGSS, their perceptions of the professional development they received, what knowledge and skills they perceived they gained through their participation, the types of professional-development activities they perceived as helpful, changes in their practice that might have resulted from their professional-development experience, and areas for improvement in NGSS professional development that they might identify to support their implementation of the content standards better.

The focus group format helped participants share and generate ideas and helped spark discussion. It also allowed me to ask questions that elicited rich, thick descriptions of each teacher’s professional-development experiences and to clarify and probe for additional information about their perceptions of their professional-development experiences. The focus groups conducted using the focus group interview protocol created a permissive atmosphere for candid conversations between the teachers that allowed for the expression of a range of opinions that provided a “more complete and revealing understanding of the issues” (Bloomberg & Volpe, 2016, p. 174) than individual interviews. The focus groups also provided interactivity and dialogue between
myself and the teachers that helped me clarify and extend the findings from the survey and allowed me to identify their perceptions of the professional-development activities in which they engaged to support their transition to the NGSS and their effectiveness and impact on supporting their implementation of the NGSS and the Common Core State Standards for English Language Arts/Literacy that supplement them.

**Data Collection Procedures**

Data were collected and triangulated using data collection procedures that primarily included a survey and focus groups. Additionally, follow-up emails requesting additional information for clarification were sent as needed while data analysis was occurring. In the following sections, I will describe the procedures and data collection activities followed with each data collection instrument. I will also provide a timeline for each procedure.

**Survey Procedure**

Approval for this study was obtained in December 2020. After that, in spring 2021, I used the Micro-Credentialing Program records to solicit participation in this study via an email (Appendix A) sent to 94 prekindergarten through 12th-grade teachers who participated in and completed either cohort one or cohort two of the district’s STEAM Micro-Credentialing Program during the 2018-2019 or 2019-2020 school years (Appendix A). The email included a short introduction of myself and my study and invited each teacher to participate in my study via a link to the research participation form (Appendix B) that shared the risks and rewards of their participation and asked for
their informed consent to participate. For the 23 teachers who granted their informed consent to participate, the same email linked them to the 28-question survey administered via Qualtrics (Appendix C).

**Focus Groups Procedure**

In June 2021, following the administration of the survey, I invited 13 teachers to participate in one of four focus groups. Each focus group consisted of 10 main questions with probes and was approximately 90 minutes long.

My initial goal for the focus groups was to use the information from the survey to invite elementary, middle, and high school teachers who had participated in the widest variety of NGSS professional-development activities. However, because only eight elementary school teachers, three middle school teachers, and two high school teachers volunteered for the focus groups, I invited all 13 of them to participate in one of four focus groups held virtually via Zoom in June 2021. To accommodate scheduling and keep the focus groups small, the four 90-minute virtual focus groups included: two elementary focus groups of four elementary teachers each, one middle school focus group of three teachers, and one high school focus group with two teachers.

During each virtual focus group via Zoom, I used the focus group interview protocol in Appendix C to facilitate a candid conversation that helped me to clarify and extend the findings from the survey and learn more about the teachers’ perceptions of the science professional-development activities in which they participated and their perceptions of how it supported, or not, the shifts in their practice required of the NGSS.

During each focus group, I took notes and audio-recorded the session. Following each focus group, the recordings were submitted to a transcription service. Once the
focus group transcripts were returned to me, I listened to the recording for each focus
group while reading the transcript to ensure correctness. During this time, I also added
additional notes to what I wrote during each focus group.

**Follow-Up Emails Procedure**

From 2021-2023, while data analysis was occurring, I sent individual follow-up
emails to the focus group teachers to ask further questions derived from the data analysis
(Appendix D). These follow-up emails helped me clarify and elaborate upon my findings
from the focus groups.

**Data Analysis Procedures**

Data from the focus groups and follow-up emails were continuously analyzed
using preliminary data analysis, thematic data analysis, and interpretation of data
(Bloomberg & Volpe, 2016). Open-ended survey responses were qualitatively analyzed,
and closed-ended survey responses providing general demographic, contextual, and
professional-development information about the teachers were quantitatively analyzed.

In the following sections, I will describe the analytical techniques and the process
by which each was used. I will also make connections to my case study research tradition
and my study's purpose and research questions.

**Survey Analysis**

The closed-ended survey questions involving continuous and categorical scales
were quantitatively analyzed to identify trends in the data. As part of this analysis, data
for questions regarding survey respondents’ (a) familiarity with designing and delivering
NGSS instruction, (b) familiarity with the NGSS design and use in planning, and (c)
engagement of students in NGSS instruction were desegregated between elementary
teachers (non-science specialists) and secondary teachers (science specialists). The open-ended survey question was qualitatively analyzed using preliminary data analysis, thematic data analysis, and interpretation of data.

**Focus Groups Analysis**

Following each focus group, I uploaded the transcript to Atlas.ti, the software tool I used for qualitative data analysis. In Atlas.ti I first engaged in preliminary data analysis to familiarize myself with the data by carefully reading each focus group transcript to identify big ideas, patterns, and concepts as I began to make meaning of the data.

After my preliminary analysis, I used thematic data analysis to segment and code my data. To do this, I segmented the text from the focus group transcripts according to each research question. I then highlighted any significant quotes within each segment that helped to answer each research question and applied descriptive codes to each quote that captured the content of the text. In some cases, multiple codes were applied to a single quote. Once codes were created for the text associated with each research question, I combined similar codes and counted the number of times each code occurred. Finally, I grouped the codes for each research question into themes and totaled the frequency of occurrence for all codes under each theme.

Once preliminary and thematic data analyses were completed, and I identified the codes and emerging themes, I interpreted my data. In my data interpretation, I described the emerging patterns and drew conclusions from the themes related to each research question.
Researcher Roles

My primary researcher role in this study was a qualitative researcher. As such, I interacted with the study participants to collect, analyze, and interpret data gathered from the surveys, focus groups, and follow-up emails.

In addition to being a qualitative researcher and graduate student in a doctoral education program, I conducted this study as “backyard research.” I was very familiar with the STEAM Micro-Credentialing Program from which the teachers were selected for this study. I have worked to support the implementation of the NGSS through various roles where I planned and delivered NGSS professional-development activities. While I did not hold an official supervisory or evaluative role over the teachers in the district or this study, I was known by the teachers from my professional work.

Before holding these various professional-development roles, I taught secondary science for 16 years in both the United States and East Africa as a Peace Corps volunteer. I participated heavily in designing and delivering teacher professional-development programs during this time. I was also acknowledged for excellence in teaching by receiving a district Teacher of the Year award and National Board Certification in early adolescence science. My position as a doctoral student and educator recognized for teaching success and my positionality as a known professional-development provider conducting backyard research could have impacted the data collection, analysis, and interpretation. These positions and positionalities could have also influenced the types of questions I asked during the focus groups and follow-up emails, and the analysis and interpretation of the collected data.
I also had a bias in favor of the new science standards and believed that professional-development programs were an effective means for supporting the growth of all teachers. Additionally, I had a strong bias in favor of the hybrid, competency-based professional-development experience the participating teachers engaged in through the STEAM Micro-Credentialing Program.

My position and positionality may have also impacted the participants in my study. Because I was known to the participants, they may have given answers to questions that were more in line with what they thought I wanted to hear rather than what they genuinely thought and felt.

It was essential to mitigate these researcher effects in the backyard context of the study to minimize their impact on the quality of the data collected and their analysis and interpretation. To mitigate these effects, I used several strategies.

I conducted the focus groups online via Zoom rather than in a district location to make the participants feel more comfortable. The questions I asked in the focus groups and follow-up emails were open-ended and non-leading. While I conducted the focus groups, I paraphrased the answers given by participants to ensure their accuracy in the moment.

To mitigate my effects on the study even further, I assured participants that the information they shared would remain confidential, that their names and other personal information would not be used in the study, and that the data I gathered would be securely stored on a private, password-protected computer so they might feel safer speaking their minds. I was very clear with the teachers about my purpose and goals to learn about their perceptions and experiences so that I would not be perceived as an
evaluator of the teachers and could better build and maintain safe and trusting relationships with them.

Finally, I maintained my researcher reflexivity to minimize any bias I might have brought to the study and used triangulation to increase its validity (Glesne, 2016).

Summary

The data collected in this study from surveys, focus groups, and follow-up emails helped me explore teachers’ perceptions of the professional-development activities in which they engaged to support their implementation of the NGSS and the effectiveness of the various features of these professional-development activities in supporting the shifts required in teachers’ knowledge and instructional practice to implement the standards fully. They provided valuable teacher insights that may help professional developers capitalize on the affordances of the most effective NGSS professional-development activity features while avoiding the pitfalls of NGSS professional-development activity features that were perceived as less effective. The data also helped to identify teachers’ professional development needs as they shifted their instructional practice to meet the demands of the NGSS.
Chapter 4: Findings

Introduction

This chapter shares the findings of a study conducted in the interpretivist, phenomenological paradigm (Glesne, 2016, p. 7) using a qualitative research approach with a quantitative component in a case study tradition that explored teachers’ perceptions of the professional-development activities in which they engaged to support their implementation of the Next Generation Science Standards (NGSS), and Common Core State Standards for English Language Arts/Literacy that supplement them. The study sought to explore the effectiveness of the various features of these professional-development activities in supporting the shifts required in teachers’ knowledge and instructional practice to implement the standards fully. This study’s goal was to collect and report teachers’ perceptions of the NGSS professional-development activities in which they engaged and their perceptions of the degree to which the features of these professional-development activities provided them with knowledge and skills that supported their implementation of the new content standards.

This study attempted to achieve its purpose and meet its goals by addressing the following questions:

Research Question

What are teachers’ perceptions of the professional-development activities in which they engaged to support their transition to the Next Generation Science Standards and the effectiveness of the various features of these professional-development activities in supporting their implementation of the Next Generation Science Standards and the...
Common Core State Standards for English Language Arts/Literacy that supplement them?

**Sub-Questions**

1. What types of professional-development activities have teachers engaged in to support their implementation of the NGSS and the Common Core State Standards for English Language Arts/Literacy that supplement them?

2. What knowledge and skills do teachers perceive they gained from participation in NGSS professional-development activities that supported their implementation of these content standards in their classrooms?

3. What are the features of professional-development activities that teachers perceive as most helpful for gaining new knowledge and skills to support their implementation of these content standards?

4. What areas for improvement in NGSS professional-development activities do teachers identify to better support their implementation of these content standards?

The findings presented in this chapter seek to shed light on the professional-development perceptions and needs of teachers charged with implementing the NGSS. They have been organized around themes that emerged for each research question to provide valuable insights into teacher perceptions of the effectiveness of various NGSS professional-development activities and may help professional developers capitalize on the affordances of the most effective professional-development activities while avoiding the pitfalls of professional-development activities that teachers perceive as less effective. Additionally, the findings have been organized in a manner that seeks to help identify
changing teacher professional-development needs as teachers shift their knowledge and instructional practice to meet the demands of the NGSS.

**Participants**

The research participants in this study were 23 prekindergarten through 12th-grade teachers working to implement the NGSS in schools within a large urban district in the western United States. The 23 study participants were part of a larger group of 94 teachers who all completed cohort one or cohort two of their district’s STEAM Micro-Credentialing Program during the 2018-2019 or 2019-2020 school years and who were all invited to participate in the study in the spring of 2021. I did not gather specific information about the participating teachers’ educational backgrounds in science and English language arts. However, through their successful completion of the competency-based STEAM Micro-Credentialing Program, which required them to create five artifacts demonstrating the application of their learning in their setting, the 23 teachers who elected to participate have shown that they are working actively to implement the NGSS and Common Core State Standards in English Language Arts/Literacy that supplement them. Table 4.1 summarizes the 23 participants’ grade spans, roles, and primary subject areas.
### Table 4.1

*Study Participants’ Grade Spans, Roles, and Primary Subject Area(s)*

<table>
<thead>
<tr>
<th>n</th>
<th>Grade Span</th>
<th>Role</th>
<th>Primary Subject Area(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Grades PK-2</td>
<td>Classroom Teacher</td>
<td>All Elementary Subjects</td>
</tr>
<tr>
<td>9</td>
<td>Grades 3-5</td>
<td>Classroom Teacher</td>
<td>All Elementary Subjects</td>
</tr>
<tr>
<td>2</td>
<td>Grades PK-5</td>
<td>Instructional Coach</td>
<td>All Elementary Subjects</td>
</tr>
</tbody>
</table>

**Elementary School Participants**

**Middle School Participants**

| 2  | Grades 6-8 | Teacher           | Science                        |
| 1  | Grades 6-8 | Teacher           | Science, Computer Science      |
| 1  | Grades 6-8 | Teacher           | Physical Education             |
| 1  | Grades 6-8 | Teacher           | English Language Arts          |

**High School Participants**

| 2  | Grades 9-12| Teacher | Science |

From this group of 23 survey participants, seven elementary school teachers, one elementary school instructional coach, three middle school teachers, and two high school teachers consented to participate in focus groups and follow-up emails to share their professional-development insights further. While my goal was to ensure representation from elementary, middle, and high schools from teachers who had participated in the widest variety of NGSS professional-development activities and therefore had the potential to provide the deepest insights, because only 13 teachers volunteered for the focus groups, I invited all of them to participate. Table 4.2 provides information about each of the 13 focus group participants, including their pseudonyms used in the findings and their grade span, role, and primary subject area(s).
Table 4.2

Focus Group Participants, Grade Spans, Roles, and Primary Subject Area(s)

<table>
<thead>
<tr>
<th>Pseudonym</th>
<th>Grade Span</th>
<th>Role</th>
<th>Primary Subject Area(s)</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anna</td>
<td>Grades 3-5</td>
<td>Classroom Teacher</td>
<td>All Elementary Subjects</td>
</tr>
<tr>
<td>Audrey</td>
<td>Grades 3-5</td>
<td>Classroom Teacher</td>
<td>All Elementary Subjects</td>
</tr>
<tr>
<td>Eileen</td>
<td>Grades 3-5</td>
<td>Classroom Teacher</td>
<td>All Elementary Subjects</td>
</tr>
<tr>
<td>Mia</td>
<td>Grades 3-5</td>
<td>Classroom Teacher</td>
<td>All Elementary Subjects</td>
</tr>
<tr>
<td>Elementary School Focus Group Two</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jessica</td>
<td>Grades PK-5</td>
<td>Instructional Coach</td>
<td>All Elementary Subjects</td>
</tr>
<tr>
<td>Lucy</td>
<td>Grades 3-5</td>
<td>Classroom Teacher</td>
<td>All Elementary Subjects</td>
</tr>
<tr>
<td>Mark</td>
<td>Grades 3-5</td>
<td>Classroom Teacher</td>
<td>All Elementary Subjects</td>
</tr>
<tr>
<td>Monica</td>
<td>Grades PK-2</td>
<td>Classroom Teacher</td>
<td>All Elementary Subjects</td>
</tr>
<tr>
<td>Middle School Focus Group</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brenda</td>
<td>Grades 6-8</td>
<td>Teacher</td>
<td>Science, Computer Science</td>
</tr>
<tr>
<td>Danna</td>
<td>Grades 6-8</td>
<td>Teacher</td>
<td>Physical Education</td>
</tr>
<tr>
<td>Michelle</td>
<td>Grades 6-8</td>
<td>Teacher</td>
<td>English Language Arts</td>
</tr>
<tr>
<td>High School Focus Group</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ronald</td>
<td>Grades 9-12</td>
<td>Teacher</td>
<td>Science</td>
</tr>
<tr>
<td>Samantha</td>
<td>Grades 9-12</td>
<td>Teacher</td>
<td>Science</td>
</tr>
</tbody>
</table>

Data Collection and Analysis

Data sources for this study included survey responses from 23 teachers who completed a 28-question survey in the spring of 2021, transcripts from four focus groups conducted with 13 teachers in June 2021, and follow-up emails with these focus group teachers from June 2021-2023 while data analysis was occurring.

The closed-ended survey questions involving continuous and categorical scales were quantitatively analyzed to identify trends in the data. I used thematic data analysis to qualitatively analyze the open-ended survey question to identify emerging themes.
Then I also used thematic data analysis to analyze the transcripts from the four focus groups qualitatively. Additionally, teacher responses to my follow-up emails were incorporated into my qualitative analysis.

In conducting my qualitative analysis, I first familiarized myself with the data through preliminary data analysis. I read through each open-ended survey response and focus group transcript to gain a general sense of the data. Next, I segmented the text according to each research question. I then highlighted any significant quotes within each segment that helped to answer each research question and applied descriptive codes to each quote that captured the content of the text. In some cases, multiple codes were applied to a single quote. Once codes were created for the text associated with each research question, I combined similar codes and counted the number of times each code occurred. Finally, I grouped the codes for each research question into themes and totaled the frequency of occurrence for all codes under each theme. Table 4.3 summarizes the codes and themes for research sub-question one; Table 4.4 summarizes the codes and themes for research sub-question two; Table 4.5 summarizes the codes and themes for research sub-question three; and Table 4.6 summarizes the codes and themes for research sub-question four:
Table 4.3

*Codes and Themes for Research Sub-Question One*

Research Sub-Question One: What types of professional-development activities have teachers engaged in to support their implementation of the NGSS and the Common Core State Standards for English Language Arts/Literacy that supplement them?

<table>
<thead>
<tr>
<th>Codes</th>
<th>Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>District sponsored</td>
<td>District-sponsored professional-development opportunities: Central and regional district professional-development opportunities</td>
</tr>
<tr>
<td>Grade level meetings</td>
<td></td>
</tr>
<tr>
<td>Science cadre</td>
<td></td>
</tr>
<tr>
<td>Book study</td>
<td></td>
</tr>
<tr>
<td>School-based PLC</td>
<td></td>
</tr>
<tr>
<td>District sponsored technology</td>
<td></td>
</tr>
<tr>
<td>Curriculum-based professional development</td>
<td>District-sponsored professional-development opportunities: Curriculum vendor professional-development opportunities</td>
</tr>
<tr>
<td>Textbook training</td>
<td></td>
</tr>
<tr>
<td>Institute of higher learning sponsored training</td>
<td>Professional-development opportunities from institutes of higher education</td>
</tr>
</tbody>
</table>
## Table 4.4

**Codes and Themes for Research Sub-Question Two**

Research Sub-Question Two: What knowledge and skills do teachers perceive they gained from participation in NGSS professional-development activities that supported their implementation of these content standards in their classrooms?

<table>
<thead>
<tr>
<th>Codes</th>
<th>Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shift from old practice</td>
<td>Architecture and design of standards: Shifts from old to new standards</td>
</tr>
<tr>
<td>21st-century skills</td>
<td></td>
</tr>
<tr>
<td>Old standards not as flexible</td>
<td></td>
</tr>
<tr>
<td>Standards design</td>
<td>Architecture and design of standards: Backward design and K-12 progression of concepts in the</td>
</tr>
<tr>
<td>Backward design</td>
<td>NGSS</td>
</tr>
<tr>
<td>Progression of concepts</td>
<td></td>
</tr>
<tr>
<td>NGSS standards as movable pieces/flexible</td>
<td>Architecture and design of standards: Performance expectations, foundation boxes, and connection boxes</td>
</tr>
<tr>
<td>Discipline integration</td>
<td>Architecture and design of standards: Integration with other disciplines/connections to Common Core</td>
</tr>
<tr>
<td>Literacy in science</td>
<td></td>
</tr>
<tr>
<td>Connections to Common Core</td>
<td></td>
</tr>
<tr>
<td>Student inquiry</td>
<td>Three dimensions of the NGSS: Science and engineering practices</td>
</tr>
<tr>
<td>Student questioning</td>
<td></td>
</tr>
<tr>
<td>Student discussion</td>
<td></td>
</tr>
<tr>
<td>Students planning and carrying out investigations</td>
<td></td>
</tr>
<tr>
<td>NGSS focus on student performance of practices</td>
<td></td>
</tr>
<tr>
<td>Three dimensions</td>
<td>Three dimensions of the NGSS: Disciplinary core ideas and crosscutting concepts</td>
</tr>
<tr>
<td>crosscutting concepts</td>
<td></td>
</tr>
<tr>
<td>disciplinary core ideas</td>
<td></td>
</tr>
<tr>
<td>Phenomenon based instruction</td>
<td>Phenomenon-based instruction</td>
</tr>
</tbody>
</table>
Table 4.5

**Codes and Themes for Research Sub-Question Three**

Research Sub-Question Three: What are the features of professional-development activities that teachers perceive as most helpful for gaining new knowledge and skills to support their implementation of these content standards?

<table>
<thead>
<tr>
<th>Codes</th>
<th>Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provides something to implement in classroom</td>
<td>Provides something to implement in the classroom with practical steps for implementation</td>
</tr>
<tr>
<td>Practical steps</td>
<td></td>
</tr>
<tr>
<td>Meaningful/purposeful</td>
<td></td>
</tr>
<tr>
<td>Time to dig in</td>
<td>Provides time to process, plan, dig in, and discuss materials: Time to process, plan, and dig in</td>
</tr>
<tr>
<td>Time to work through frustration</td>
<td></td>
</tr>
<tr>
<td>Explore standards</td>
<td></td>
</tr>
<tr>
<td>Time to plan</td>
<td></td>
</tr>
<tr>
<td>Using the textbook</td>
<td></td>
</tr>
<tr>
<td>Time to discuss materials</td>
<td>Provides time to process, plan, dig in, and discuss materials: Time to discuss</td>
</tr>
<tr>
<td>Correct teacher misconceptions</td>
<td></td>
</tr>
<tr>
<td>Follow-up on how things are going</td>
<td></td>
</tr>
<tr>
<td>Using/having critical friends</td>
<td></td>
</tr>
<tr>
<td>Seeing examples of NGSS in action</td>
<td>Provides hands-on opportunities to see examples of NGSS in action as learners</td>
</tr>
<tr>
<td>Hands-on</td>
<td></td>
</tr>
<tr>
<td>Experience as learner</td>
<td></td>
</tr>
<tr>
<td>Balance between learning as a student and teacher</td>
<td></td>
</tr>
<tr>
<td>Professionalism</td>
<td>Facilitator preparation, professionalism, clarity, and ability to break learning down</td>
</tr>
<tr>
<td>Clarity of content</td>
<td></td>
</tr>
<tr>
<td>Preparation</td>
<td></td>
</tr>
<tr>
<td>Treat teachers with respect</td>
<td></td>
</tr>
<tr>
<td>Break learning down</td>
<td></td>
</tr>
<tr>
<td>Feeling like teacher belongs</td>
<td></td>
</tr>
<tr>
<td>Making teachers feel appreciated</td>
<td></td>
</tr>
<tr>
<td>Expert speaker</td>
<td>Expert speakers</td>
</tr>
<tr>
<td>Research-based</td>
<td></td>
</tr>
<tr>
<td>Collaborative lesson and unit design</td>
<td>Provides opportunities for the collaborative design of lessons and units</td>
</tr>
<tr>
<td>Teacher buy-in</td>
<td></td>
</tr>
<tr>
<td>Accountability for creating something</td>
<td></td>
</tr>
<tr>
<td>Collaboration opportunity</td>
<td></td>
</tr>
</tbody>
</table>
Table 4.6

**Codes and Themes for Research Sub-Question Four**

Research Sub-Question Four: What areas for improvement in NGSS professional-development activities do teachers identify to better support their implementation of these content standards?

<table>
<thead>
<tr>
<th>Codes</th>
<th>Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Need practical ideas</td>
<td>Need practical ideas</td>
</tr>
<tr>
<td>Need to be able to take it back to the classroom</td>
<td></td>
</tr>
<tr>
<td>Need materials to support implementation</td>
<td></td>
</tr>
<tr>
<td>Differentiation for new and experienced teachers</td>
<td>Need differentiation for diverse needs and experiences</td>
</tr>
<tr>
<td>Need to consider diverse teacher needs</td>
<td></td>
</tr>
<tr>
<td>Differentiate for prior experiences and needs</td>
<td></td>
</tr>
<tr>
<td>Provide access to all teachers</td>
<td></td>
</tr>
<tr>
<td>Need time for teacher discussion</td>
<td>Need time for discussion</td>
</tr>
<tr>
<td>Level of humility in presenters</td>
<td></td>
</tr>
<tr>
<td>Need expert-led training</td>
<td></td>
</tr>
<tr>
<td>Focused and streamlined</td>
<td></td>
</tr>
</tbody>
</table>

The findings from my data analysis are described in the following sections.

**Findings From Survey**

The survey included questions to measure the 23 teachers’ self-reported familiarity with designing and delivering NGSS instruction, familiarity with the NGSS design and use in planning, the frequency with which they engaged their students in NGSS instruction, their engagement in professional-learning experiences to learn about the NGSS, and an opportunity to describe the most impactful NGSS professional-development activity in which they engaged that caused them to implement something new in their classroom, along with their perception of this activity’s effectiveness.
**Familiarity with Designing and Delivering NGSS Instruction**

Six survey questions were designed to gather information about the respondents’ familiarity with designing and delivering NGSS instruction. From these questions, participants rated themselves as more familiar with the Common Core State Standards for English Language Arts/Literacy ($M = 4.04$) than with the NGSS ($M = 3.91$). This was particularly true for secondary teachers, who reported being more familiar with the Common Core State Standards for English Language Arts/Literacy ($M = 4.00$) than with the NGSS ($M = 3.71$).

As a whole, participants also rated themselves slightly higher for designing ($M = 3.87$) and delivering ($M = 3.78$) instruction that requires students to engage in argument from evidence called for in the Common Core State Standards for English Language Arts/Literacy than they did for designing ($M = 3.70$) and delivering ($M = 3.65$) instruction based on the NGSS. Disaggregating this data by grade span revealed that this was especially true for secondary participants who rated themselves higher for designing ($M = 4.00$) and delivering ($M = 4.00$) instruction called for in the Common Core State Standards for English Language Arts/Literacy than they did for designing ($M = 3.43$) and delivering ($M = 3.57$) instruction based on the NGSS. When I removed the secondary physical education and English language arts teachers from the analysis of secondary data because they were outliers who rated their familiarity with the NGSS much lower than the other secondary teachers, the averages for familiarity with the NGSS ($M = 4.20$) and their use in designing ($M = 3.80$) and delivering ($M = 4.00$) NGSS instruction increased. These outliers make the averages less indicative of the teachers’ actual familiarity with NGSS. Table 4.7 summarizes these findings.
### Table 4.7

**Survey Respondents’ Familiarity with Designing and Delivering NGSS Instruction**

<table>
<thead>
<tr>
<th></th>
<th>1 Not At All/ Developing</th>
<th>2 (4.35)</th>
<th>3 (13.04)</th>
<th>4 (69.57)</th>
<th>5 (13.04)</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>All Teachers</strong></td>
<td>n 0</td>
<td>1</td>
<td>3</td>
<td>16</td>
<td>3</td>
<td>3.91</td>
</tr>
<tr>
<td></td>
<td>% 0</td>
<td>4.35</td>
<td>13.04</td>
<td>69.57</td>
<td>13.04</td>
<td></td>
</tr>
<tr>
<td><strong>Elementary</strong></td>
<td>n 0</td>
<td>0</td>
<td>2</td>
<td>12</td>
<td>2</td>
<td>4.00</td>
</tr>
<tr>
<td></td>
<td>% 0</td>
<td>0</td>
<td>12.50</td>
<td>75.00</td>
<td>12.50</td>
<td></td>
</tr>
<tr>
<td><strong>Secondary</strong></td>
<td>n 0</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>3.71</td>
</tr>
<tr>
<td></td>
<td>% 0</td>
<td>14.29</td>
<td>14.29</td>
<td>57.14</td>
<td>14.29</td>
<td></td>
</tr>
</tbody>
</table>

Please rate your knowledge for **designing** instruction based on the Next Generation Science Standards.

<table>
<thead>
<tr>
<th></th>
<th>1 Not At All/ Developing</th>
<th>2 (8.70)</th>
<th>3 (21.74)</th>
<th>4 (60.87)</th>
<th>5 (8.70)</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>All Teachers</strong></td>
<td>n 0</td>
<td>2</td>
<td>5</td>
<td>14</td>
<td>2</td>
<td>3.70</td>
</tr>
<tr>
<td></td>
<td>% 0</td>
<td>8.70</td>
<td>21.74</td>
<td>60.87</td>
<td>8.70</td>
<td></td>
</tr>
<tr>
<td><strong>Elementary</strong></td>
<td>n 0</td>
<td>0</td>
<td>4</td>
<td>11</td>
<td>1</td>
<td>3.81</td>
</tr>
<tr>
<td></td>
<td>% 0</td>
<td>0</td>
<td>25.00</td>
<td>68.75</td>
<td>6.25</td>
<td></td>
</tr>
<tr>
<td><strong>Secondary</strong></td>
<td>n 0</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>3.43</td>
</tr>
<tr>
<td></td>
<td>% 0</td>
<td>28.57</td>
<td>14.29</td>
<td>42.86</td>
<td>14.29</td>
<td></td>
</tr>
</tbody>
</table>

Please rate your skill **delivering** instruction designed for the Next Generation Science Standards.

<table>
<thead>
<tr>
<th></th>
<th>1 Not At All/ Developing</th>
<th>2 (4.35)</th>
<th>3 (34.78)</th>
<th>4 (52.17)</th>
<th>5 (8.70)</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>All Teachers</strong></td>
<td>n 0</td>
<td>1</td>
<td>8</td>
<td>12</td>
<td>2</td>
<td>3.65</td>
</tr>
<tr>
<td></td>
<td>% 0</td>
<td>4.35</td>
<td>34.78</td>
<td>52.17</td>
<td>8.70</td>
<td></td>
</tr>
<tr>
<td><strong>Elementary</strong></td>
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<td>0</td>
<td>6</td>
<td>9</td>
<td>1</td>
<td>3.69</td>
</tr>
<tr>
<td></td>
<td>% 0</td>
<td>0</td>
<td>37.50</td>
<td>56.25</td>
<td>6.25</td>
<td></td>
</tr>
<tr>
<td><strong>Secondary</strong></td>
<td>n 0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>3.57</td>
</tr>
<tr>
<td></td>
<td>% 0</td>
<td>14.29</td>
<td>28.57</td>
<td>42.86</td>
<td>14.29</td>
<td></td>
</tr>
</tbody>
</table>

Please rate your familiarity with the Common Core State Standards for English Language Arts/Literacy that supplement the Next Generation Science Standards.

<table>
<thead>
<tr>
<th></th>
<th>1 Not At All/ Developing</th>
<th>2 (52.17)</th>
<th>3 (21.74)</th>
<th>4 (52.17)</th>
<th>5 (26.09)</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>All Teachers</strong></td>
<td>n 0</td>
<td>0</td>
<td>5</td>
<td>12</td>
<td>6</td>
<td>4.04</td>
</tr>
<tr>
<td></td>
<td>% 0</td>
<td>0</td>
<td>21.74</td>
<td>52.17</td>
<td>26.09</td>
<td></td>
</tr>
<tr>
<td><strong>Elementary</strong></td>
<td>n 0</td>
<td>0</td>
<td>3</td>
<td>9</td>
<td>4</td>
<td>4.06</td>
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<td></td>
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<td>18.75</td>
<td>56.25</td>
<td>25.00</td>
<td></td>
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<tr>
<td><strong>Secondary</strong></td>
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<td>3</td>
<td>2</td>
<td>4.00</td>
</tr>
<tr>
<td></td>
<td>% 0</td>
<td>0</td>
<td>28.57</td>
<td>42.86</td>
<td>28.57</td>
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</tr>
</tbody>
</table>
Table 4.7 Continued

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<th>M</th>
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<tbody>
<tr>
<td>Not At All/</td>
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<td></td>
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<td>14</td>
<td>3</td>
<td>3.87</td>
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<td>Developing</td>
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<tr>
<td>Advanced</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Please rate your knowledge for designing instruction that requires students to engage in argument from evidence.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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</thead>
<tbody>
<tr>
<td>All Teachers</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>n</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>14</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>%</td>
<td>0</td>
<td>0</td>
<td>26.09</td>
<td>60.87</td>
<td>13.04</td>
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<td>n</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>11</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>%</td>
<td>0</td>
<td>0</td>
<td>25.00</td>
<td>68.75</td>
<td>6.25</td>
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<td>Secondary</td>
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<td>n</td>
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<td>0</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>%</td>
<td>0</td>
<td>0</td>
<td>28.57</td>
<td>42.86</td>
<td>28.57</td>
<td>4.00</td>
</tr>
</tbody>
</table>

Please rate your skill delivering instruction that requires students to engage in argument from evidence.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Teachers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>14</td>
<td>2</td>
<td></td>
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Familiarity with the NGSS Design and Use in Planning

Seven survey questions gathered information about the participants’ familiarity with the NGSS design and use in planning. Across all but one question, elementary teachers reported more familiarity than secondary teachers.

As a whole, participants rated themselves as most knowledgeable in their ability to identify and describe the parts of a Next Generation Science Standard ($M = 4.09$). This was most true for secondary teachers ($M = 3.86$). Additionally, elementary teachers indicated high levels of knowledge in their ability to identify the three dimensions of a Next Generation Science Standard ($M = 4.25$), while secondary teachers indicated high levels of knowledge in being able to identify and describe what crosscutting concepts ($M = 3.71$) look like in the classroom.

Regarding using the standards in planning, participants as a whole were most comfortable developing performance tasks for a single performance expectation or
bundle of performance expectations ($M = 3.96$). When planning lessons using the NGSS, participants as a whole rated themselves equally knowledgeable in their ability to take a current lesson to make it three-dimensional ($M = 3.74$) and in planning a three-dimensional lesson sequence using the standards ($M = 3.74$). These patterns held true for both elementary and secondary teachers. Table 4.8 summarizes these findings.
### Table 4.8

*Survey Respondents’ Familiarity with the NGSS Design and Use in Planning*

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<td>14.29</td>
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<tr>
<td>I can take a current lesson and make it three-dimensional.</td>
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</tr>
<tr>
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<th>4</th>
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<td>0</td>
<td>14.29</td>
<td>71.43</td>
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</table>

I can plan a three-dimensional lesson sequence using the Next Generation Science Standards.

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<th>3</th>
<th>4</th>
<th>5</th>
<th>M</th>
</tr>
</thead>
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<td>28.57</td>
<td>42.86</td>
<td>14.29</td>
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</tbody>
</table>

Engagement of Students in NGSS Instruction

Nine survey questions gathered information about how often participants engaged their students in NGSS instruction aligned to the significant changes they need to make (Table 4.9) to achieve the vision articulated in the Framework on which the Next Generation Science Standards are based (National Research Council, 2015). Overall, the mean scores for engaging their students in NGSS instruction aligned to the vision in the Framework were lower here than in other parts of the survey where participants rated their familiarity with designing and delivering NGSS instruction (Table 4.7) and with the NGSS design and use in planning (Table 4.8).

As a whole, for both elementary and secondary teachers, participants reported most frequently engaging their students in activities that allowed them to learn facts and terminology as needed while developing explanations and designing solutions supported by evidence-based arguments and reasoning ($M = 3.52$). For elementary teachers, having
their students discuss open-ended questions that focus on the strength of the evidence used to generate claims ($M = 3.31$) and having their students read multiple sources, including science-related magazines, journal articles, and web-based resources ($M = 3.31$) were the second most frequently reported activities for engaging their student in NGSS-aligned instruction. For secondary teachers, the second most frequently reported activities for engaging their students in NGSS-aligned instruction were having their students discuss open-ended questions that focus on the strength of the evidence used to generate claims ($M = 3.29$), having their students conduct investigations, solve problems, and engage in discussions with teachers’ guidance ($M = 3.29$), and providing supports so that all students can engage in sophisticated science and engineering practices ($M = 3.29$).

As a whole, they reported less frequently engaging their students in conducting multiple investigations driven by students’ questions with a range of possible outcomes that collectively lead to a deep understanding of established core scientific ideas ($M = 2.26$) and having their students write journals and reports as well as create posters and media presentations that explain and argue ($M = 2.39$). For the secondary teachers, having their students read multiple sources, including science-related magazines, journal articles, and web-based resources ($M = 2.29$) was also infrequent.

Few participants reported engaging their students in NGSS instruction daily, while several reported that it is rare. Table 4.9 summarizes these findings.
Table 4.9

*Survey Respondents’ Engagement of Students in NGSS Instruction*

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<th></th>
<th>Rarely</th>
<th>Monthly</th>
<th>Weekly</th>
<th>Several Times a Week</th>
<th>Daily</th>
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<td>43.75</td>
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<td>4</td>
<td>0</td>
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<tr>
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<td>0</td>
<td>42.86</td>
<td>57.14</td>
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</tr>
</tbody>
</table>

Students learn facts and terminology as needed while developing explanations and designing solutions supported by evidence-based arguments and reasoning.

All Teachers:  
- **n**: 2  
- **%**: 8.70  
- **M**: 3.13  

Elementary:  
- **n**: 1  
- **%**: 6.25  
- **M**: 3.13  

Secondary:  
- **n**: 1  
- **%**: 14.29  
- **M**: 3.14  

Students use systems thinking and modeling to explain phenomena and to give a context for the ideas to be learned.

All Teachers:  
- **n**: 2  
- **%**: 8.70  
- **M**: 3.22  

Elementary:  
- **n**: 1  
- **%**: 6.25  
- **M**: 3.19  

Secondary:  
- **n**: 1  
- **%**: 14.29  
- **M**: 3.29  

Students conduct investigations, solve problems, and engage in discussions with teachers’ guidance.

All Teachers:  
- **n**: 2  
- **%**: 8.70  
- **M**: 3.30  

Elementary:  
- **n**: 2  
- **%**: 12.50  
- **M**: 3.31  

Secondary:  
- **n**: 0  
- **%**: 28.57  
- **M**: 3.29  

Students discuss open-ended questions that focus on the strength of the evidence used to generate claims.

All Teachers:  
- **n**: 2  
- **%**: 8.70  
- **M**: 3.30  

Elementary:  
- **n**: 2  
- **%**: 12.50  
- **M**: 3.31  

Secondary:  
- **n**: 0  
- **%**: 28.57  
- **M**: 3.29
Table 4.9 Continued

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<th>M</th>
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<td>Rarely</td>
<td>Monthly</td>
<td>Weekly</td>
<td>Several Times a Week</td>
<td>Daily</td>
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<td>Students read multiple sources, including science-related magazines, journal articles, and web-based resources.</td>
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<tr>
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<tr>
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<td>39.13</td>
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<td>Students develop summaries of information.</td>
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<td>14.29</td>
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</tr>
<tr>
<td>Students conduct multiple investigations driven by students’ questions with a range of possible outcomes that collectively lead to a deep understanding of established core scientific ideas.</td>
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</tr>
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<td>Students write journals and reports as well as create posters and media presentations that explain and argue.</td>
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I provide supports so that all students can engage in sophisticated science and engineering practices.

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Engagement in Professional-Learning Experiences to Learn About the NGSS

One survey question gathered information about participants’ engagement in professional-learning experiences to learn about the NGSS. For four of the participants (17.39%), the STEAM Micro-Credentialing Program was their only professional-development experience in which they engaged to learn about the NGSS. Three of these teachers volunteered to participate in a focus group, and their frame of reference related to effective NGSS professional-development features was limited to that sole experience. Most of the teachers (60.87%) indicated they engaged in three or more professional-learning experiences to learn about the NGSS in addition to the STEAM Micro-Credentialing Program. Table 4.10 summarizes these findings.

Table 4.10

Survey Respondents’ Engagement in Professional-Learning Experiences to Learn About the NGSS

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Themes From Survey Open-Ended Question

The two most impactful NGSS professional-development activities teachers shared in the survey were those that provided opportunities for the collaborative design of lessons and units and those that provided them with hands-on opportunities to see examples of the NGSS in action as learners.

Provides Opportunities for the Collaborative Design of Lessons and Units

The most common, impactful professional-development activity shared by ten teachers was planning NGSS lessons and units.

An elementary school teacher described a professional-development opportunity where she had to “use all the STEAM standards individually to create a performance task.” She further elaborated, “During the workshop, we were able to take time individually, with guided support, to look at standards and create a performance task that would best demonstrate all aspects of the standards and engage the students in a task.” In her planning during the professional-development activity, she appreciated being provided with a graphic organizer, and she recognized that “It was hard at first. I had a really hard time first seeing how all the pieces of the puzzle fit together. I had to leave the PD activity and digest all that we learned to go back and begin to create a culminating performance task.” This teacher shared that she implemented the performance task in her classroom with her students: "I was motivated to use my performance task to see how students would do and as a reflection of what I could change for the future.” While her students were initially apprehensive, she said, “My students responded well to the implementation of the performance task.”
Another elementary school teacher highlighted a professional-development activity she participated in through a university summer program. The activity required her to create a 5E lesson plan based on the NGSS. In her survey, she explained, “My focus [in planning my lesson] was on plastic pollution. I wanted students to make connections between our behaviors and the impact on the ocean and ocean life.” She further explained, “The variety of materials and activities [I used in my lesson] created an environment where students were excited about learning.” As she described her learning during the professional-development activity, she shared that she was confused at first but found value in the new way of teaching once she implemented it in her classroom:

I was very confused at the beginning. I wasn't clear about what each step looked like in the classroom. I was also nervous to have students working in groups on their own with the different materials. It was a very noisy day. But having tried it, I recognized the value, and it really changed the way that I teach.

In her reflection, this teacher shared, “I have been using the 5E lesson design for science ever since. Students are engaged, involved, and excited about learning.” As a result, she shared that she has increased the amount of science instruction in her classroom and that “One of the biggest skills I learned is how to intentionally plan an engaging lesson that will leave students smiling.”

**Provides Hands-On Opportunities to See Examples of NGSS in Action as Learners**

The second most common, impactful professional-development activity shared by six teachers was engaging in model lessons and activities as learners that provided them with hands-on opportunities to see examples to see the NGSS in action as learners.
A high school teacher shared, “The [professional-development] activities that I have engaged in that have impacted me to want to implement in my classroom have been those in which I have been the student experiencing the activity with my content.” The teacher found it most valuable when “I was placed in my content and grade level. The facilitators provided all the materials and instructions for us to complete the activity [and] we needed to work together to figure it out.” They shared, “There are many skills and knowledge gained from doing these activities,” the first being that “I get to participate in the activity as a student and thus get this perspective of what it feels like.” This was important for this teacher because “I gain the insight of what I would need to do in my classroom to make it work successfully.”

An elementary teacher also shared that she finds engaging in model lessons and activities as a student as her most impactful NGSS learning experience. She gave as an example “a PD where we were investigating: Is it a fruit? We were given various items: bell pepper, oranges, bananas, tomatoes, and sugar snap peas.” This teacher “thoroughly enjoyed the activity because it gave me a different perspective of engaging in science.”

While engaging in professional-development activities that provided time for lesson and unit planning and engaging in model lessons and activities as learners were most impactful for teachers in the survey, additional impactful professional-development features from the survey included listening to expert speakers and spending time unpacking the NGSS.

**Findings From Focus Groups and Follow-up Emails**

Data analysis from the four focus groups and follow-up emails allowed me to clarify and extend the findings from the survey and learn more about the teachers’
perceptions of the science professional-development activities in which they participated and their perceptions of how they supported the shifts in their practice required of the NGSS. The findings are detailed below, organized by research question.

**Findings for Research Sub-Question One**

At the beginning of each focus group, teachers discussed the various activities they engaged in to learn about the NGSS. Teachers in each of the focus groups talked about their professional-development experiences as part of the district’s STEAM Micro-Credentialing Program in a positive way. For example, elementary teacher Mia shared that “it wasn't until the [STEAM Micro-Credentialing Program] that I really got to understand the way everything works so well together,” and “I think that that professional development, the way that it was presented to us, should've been presented to all teachers.”

The subsequent most commonly discussed professional-development activities after the STEAM Micro-Credentialing Program were opportunities provided by their school district, followed by those from institutes of higher education.

**District-Sponsored Professional-Development Opportunities**

Across all focus groups, a primary source for teacher professional-development offerings came from the school district through either centrally or regionally provided options or curriculum vendors for materials adopted by the district.

**Central and Regional District Professional-Development Opportunities.** Two teachers shared that they participated in science teacher professional-development opportunities provided by staff from the district’s central office. As they explained their experiences, convenience was one reason for participating.
In addition to the larger centralized training provided by the district, two teachers shared that they learned about NGSS through opportunities provided by their regional district staff. When describing their experience, convenience and availability were their main reasons for participating.

**Curriculum Vendor Professional-Development Opportunities.** Focus group teachers also indicated receiving district-sponsored professional-development opportunities from curriculum vendors. Elementary teacher Anna discussed attending sessions from STEMscopes (a science curriculum), while elementary teachers Monica and Mark discussed attending curriculum sessions through Amplify (another science curriculum used within the district). Elementary teacher Mark was particularly optimistic about his experience with the Amplify sessions and resources he was provided, stating, “Amplify had great online tools that allowed it to work remotely, and it was fabulous.”

**Professional-Development Opportunities from Institutes of Higher Education**

Two focus group teachers shared that some of their NGSS professional-development experiences were through neighboring institutions of higher education. Elementary teacher Eileen had previously taken math professional-development courses through a nearby university. She loved the professional-development courses so much that she was motivated to participate in a series of science workshops offered by this same university, stating, “I just signed up for it blindly 'cause I just thought, hey, [the nearby university]'s putting on science, it has to be good.” She followed up with, “Oh, man, it really was,” and described how “each year they touched on a different aspect of NGSS.”
Another elementary teacher, Jessica, described participating in one of the district’s science collaboratives, where she worked with a teacher whose school had a close relationship with a nearby university. As a result of this close relationship, she shared that her fellow teacher “just knew all the current PDs, you know, they were going out to [a nearby city] for the weekend, and they just were much more in the know.”

In summary, many of the teachers engaged in NGSS-related professional-development activities beyond the STEAM Micro-Credentialing Program. More often, they opted for district-provided activities, for convenience, but some also participated in activities provided by institutes of higher education.

**Findings for Research Sub-Question Two**

During the focus groups, teachers also shared the knowledge they gained from professional-development activities that supported their implementation of the NGSS. This included information about the architecture and design of the standards, their three dimensions, and their focus on phenomenon-based instruction.

*Architecture and Design of Standards*

The teachers' most commonly discussed area of learning in each focus group was the architecture and design of the NGSS. This included how the new standards differed from the old standards, their backward design and K-12 progression of concepts in the standards, their inclusion of Performance Expectations, Foundation Boxes, and Connection Boxes, and how they integrate with other disciplines and connect to the Common Core.

**Shifts From Old to New Standards.** Teachers in each focus group highlighted how the NGSS differed from the previous science standards, which elementary teacher
Mark described as “sort of just a list of things the kids should know.” High school teachers described the NGSS as more flexible, having movable pieces (related to the three dimensions of disciplinary core ideas, crosscutting concepts, and science and engineering practices) and providing more autonomy than previous standards. High school teacher Ronald recognized that the three dimensions of the standards provided him greater autonomy in his teaching while also making the standards more challenging for him to teach because he needed to ensure his students mastered the content within each of the three dimensions of each standard.

**Backward Design and K-12 Progression of Concepts in the NGSS.** Teachers also stressed the backward design of the standards as part of their professional learning around the standards’ architecture. Elementary teacher Anna shared, “I know that it was written backward. . . or it started with the 12th-grade standards, and then they wrote them for elementary. And so, they had backward mapped them when they wrote them.” Elementary teacher Anna reiterated this point as she contrasted the new standards' design with those that preceded them, sharing, “They essentially just build on each other rather than individual concepts being taught at each grade level.” Reflecting on her experience teaching science in fourth grade, she continued, “I know that in magnets, it used to be in fourth grade, and now it's spread throughout. So, it's not just magnets in fourth grade. We learn concepts, and then they build through.”

Elementary teacher Lucy added to these reflections of the backward design of the standards and added that this design allowed her to engage her students in deeper thinking: “There is a natural progression from K through 12 [that engages students in] higher and deeper levels of thinking, building on what they learned in previous years.”
Performance Expectations, Foundation Boxes, and Connection Boxes.

Another big area of learning for the teachers centered around how the design of the standards was more complex than previous standards and included performance expectations, foundation boxes, and connection boxes.

Elementary teacher Audrey described the design of the standards as “more holistic. You've got the performance tasks [sic], the disciplinary core ideas, the science and engineering practices, so there's just a lot to each standard.” She described the standards as “just so layered and complex and includes so many more ideas and concepts.”

Middle school teacher Brenda shared similar sentiments and spent time reflecting on how intimidating she first found the design of the standards. She shared, “When you first see those standards, they’re extremely colorful and organized; they're very intimidating.” Brenda continued her reflections by sharing that the more she attended professional-development sessions, “it allows you to see each part for what it is, and instead of that one colorful page with all the information of the standard being confusing, it became something to work towards.”

Integration With Other Disciplines/Connections to Common Core. As teachers reflected upon their learning around the architecture and design of the NGSS, several teachers shared how an essential piece of learning was how the standards connected to other disciplines, especially to the Common Core Standards for English Language Arts/Literacy. Elementary teacher Mia shared how she has focused more on literacy during her science instructional time: “In the past, it was science had its own time, and now science is actually our informational reading time.” High school teacher
Ronald also highlighted this connection but shared that this “makes them harder because there certainly is more writing involved.”

This learning and challenge were also underscored by middle school teacher Danna who shared, “I need to keep those standards [Common Core Standards for English Language Arts/Literacy] more in the forefront because there's just so many different things when I'm creating a lesson to think about, right? Because you wanna go interdisciplinary.”

**Three Dimensions of the NGSS**

The teachers' second most commonly discussed area of learning was the three dimensions of the standards. Elementary teacher Lucy described the three dimensions of the NGSS as “three strands that are woven together with the DCIs [disciplinary core ideas], crosscutting concepts and the practices.”

**Science and Engineering Practices.** Of all three NGSS dimensions, focus group teachers spent most of their time discussing their learning about science and engineering practices as supporting their implementation of the NGSS.

Elementary teacher Monica described the science and engineering practices as providing her students with a “more hands-on” experience. Fellow elementary teacher Mia shared that through her learning about, and implementation of, the science and engineering practices, her students “lead the discussion and the exploration.” Mia noted, “NGSS put a lot more emphasis on student discovery and exploration instead of starting with the teacher.”

As elementary teacher Audrey discussed the science and engineering practices, she found their implementation challenging because “Now you're trying to get the kids to
ask questions and then have them experiment and discover on their own some of the answers to those questions. Like building on their own experiments.”

The high school teachers also discussed learning about science and engineering practices and agreed that their implementation was complex. High school teacher Ronald shared that the “NGSS is more skills” and that “they seem more authentic [because students are] really doing science rather than learning about science.” Ronald went on to describe that because of the science and engineering practices, he had to support his students with “designing experiments or writing essays to defend an argument or scientific claim and citing evidence based on a lab, which is certainly more difficult than memorizing a formula or the parts of a cell.” As Ronald described his learning around the science and engineering practices, he recognized that, “the students will do something to collect some data, and then they'll explain their data rather than take a multiple-choice test.”

**Disciplinary Core Ideas and Crosscutting Concepts.** In addition to learning about the science and engineering practices, focus group teachers shared briefly about the crosscutting concepts and disciplinary core ideas that are part of each standard. Elementary teacher Mia highlighted how teaching crosscutting concepts like cause and effect reinforce the teaching of “other skills that we used to only focus on with literacy or with informational reading. Now, we're using the science texts to use all those.”

**Phenomenon-Based Instruction**

Finally, the third most commonly discussed area of learning that supported teachers’ classroom implementation of the NGSS was their learning around the real-world, phenomenon-based instruction the standards require.
Elementary teacher Eileen highlighted, “With NGSS, we're trying to teach the students starting with the phenomena and to ask questions about the phenomena and then try to figure out why this is happening.” Eileen stressed that the focus on phenomena-based inquiry was a significant shift with the NGSS.

In sum, the bulk of the teachers' professional-development experiences focused on learning about the architecture and design of the NGSS, with a focus on how the standards differed from the standards that preceded them, were designed with a K-12 progression of concepts, and consisted of Performance Expectations, Foundation Boxes, and Connection Boxes that supported their integration with other disciplines and the Common Core. The teachers’ experiences also focused heavily on learning about the three dimensions of the standards, with science and engineering practices being the most common focus. While less frequently discussed, phenomenon-based instruction was the area of learning that teachers seemed to be working to implement most in their classrooms as they shifted their instruction to the NGSS.

With these three areas of learning, I sensed that the teachers commonly raised each for different reasons. When discussing the architecture and design of the NGSS, I sensed that not only was this the most frequently covered topic in the teachers’ professional-development experiences, but also something they found, in their words, to be “challenging,” “complex,” and “intimidating,” and something they were still grappling with. Their learning about the standards’ three dimensions, specifically the science and engineering practices, seemed to be the next most frequently discussed because the teachers were challenged with it as they actively tried to provide more hands-on opportunities for their students. Finally, I sensed that phenomenon-based instruction was
the next most frequently discussed area of learning because it was something the teachers
learned that seemed to be more easily implemented in their classrooms.

**Findings for Research Sub-Question Three**

Focus group teachers discussed the professional-development activity features they perceived most helpful for gaining new knowledge and skills to support their implementation of the NGSS. These features, beginning with the most frequently discussed, included: providing something to implement in the classroom with practical steps for implementation; providing time to process, plan, dig in, and discuss materials; providing hands-on opportunities to see examples of NGSS in action as learners; having a facilitator who is prepared, professional, clear, and can break learning down; expert speakers; and providing opportunities for the collaborative design of lessons and units.

**Provides Something to Implement in the Classroom with Practical Steps for Implementation**

Providing teachers with something to implement in their classroom, along with the practical steps for implementation, was the professional-development activity feature most frequently discussed by the focus group teachers.

Elementary teacher Audrey shared that the “most important thing for any PD for teachers is to have something presented that you can actually take back and implement in your own classroom.” She described one of these professional-development experiences during the STEAM Micro-Credentialing Program, where she participated in a model 5E lesson activity that provided her with something to take back to her classroom and use:

It wasn't theoretical. It was here it is; here's something you can actually take back and you can do tomorrow. And I was like, I can actually take this lesson, maybe
not the same exact lesson, but I can totally go back and I can format a lesson just like this, except to whatever standard I'm teaching.

In the middle school focus group, Danna described how her professional-development experience learning Kagan strategies was so impactful because she learned strategies she could use: “They gave several Kagan strategies, just simple strategies.” During this discussion, her fellow middle school focus group participant Michelle emphasized, "We want our professional development to be practical to what we’re doing.”

High school teacher Ronald described how helpful a professional-development session focused on NGSS formative assessment was because he could find the direct application of the learning in his classroom:

What clicked was that I was able to take this idea that they were talking about in the PD, apply it directly to what I was doing in my class, and put my own flavor, my own spin. It wasn't 100% prescriptive. I was able to say, “Okay, well, yeah, I wanna do it this way.”

Ronald’s fellow high school focus group teacher Samantha also highlighted the importance of providing something to implement in the classroom, pointing out that often during professional-development sessions, she would ask herself, “Why do I need this new way of learning or teaching,” and “How can I use or apply it in my classroom? For me, that is one of the big things.”

When I asked Samantha to provide an example of an impactful professional-development experience where she was provided something to implement in the classroom with the practical steps for implementation, she discussed her experience over
several summers with a professional-development series provided by a nearby county office of education. Samantha reported that during the professional-development session, she was provided with strategies and opportunities for considering how she might use them:

    They would teach us strategies. It was a lot of looking at strategies and analyzing what makes a good lesson. And I loved this because they would say, “Okay, this is a strategy. Use it or don't. It's okay.” But at least you know what the strategy is, how to use it, and then, of course, they would give us time to think about where you would use it in your unit.

    For Samantha, this exposure to practical strategies to bring back to her classroom through these professional-development sessions was helpful because the sessions “provided not only thinking time but strategies that I was like, okay, I wanna use this. I actually wanna use this in my classroom today or tomorrow when I go back.” Samantha also articulated that once she had determined for herself that she was going to use a strategy in her classroom, she wanted to be walked through the steps for implementation:

        Okay, how? How can I now do that? Because now I want to, I want to do that. So, you know, now walk me through the steps. Walk me through the steps once I am invested in wanting to know this. So now show me the how.

    Finally, while elementary teacher Anna shared that being provided something to implement in her classroom with practical steps for implementation was important, she also spent time explaining that it was essential to be provided options for how to implement a strategy because it can sometimes be very overwhelming:
I think that some teachers need a guide to tiptoe in. So, I would love that to also be a thing. Give a PD series that isn't overwhelming so that those that are not necessarily ready don't feel like they have to go headfirst [into implementing an NGSS-aligned strategy]. [Instead], they could tiptoe in because I feel like PDs make it feel like it's all or nothing. You either do it all, or you don't do it. And there's this whole gray area that most of us fall into.

**Provides Time to Process, Plan, Dig In, and Discuss Materials**

Providing time for teachers to plan, dig in, and discuss materials was the next most common professional-development activity feature discussed by the focus group teachers.

**Time to Process, Plan, and Dig In.** Teachers frequently expressed their desire to be provided time to process the information they were receiving, dig into the information, resources, and materials, and plan or consider how to implement the new learning in their classroom.

Elementary teacher Mia discussed how during her time in the STEAM Micro-Credentialing Program, “We had time to dig into cross-cutting concepts; we had time to dig into the disciplinary core ideas; we had time to dig into the practices.” She said this time was necessary because “we can't just expect teachers to learn how to do this [implement the three dimensions of NGSS] in one or two PDs a year.” Another elementary teacher, Audrey, agreed with Mia, stating, “In the STEAM Micro-Credentialing Program, I think one of the real benefits of that was the time element. We had time to explore deeply, which you don't get in that two-day PD.”
Elementary teacher Eileen also highlighted the need to provide time to plan and dig in when she discussed some district professional-development sessions she attended to learn how to adapt her current science curricular materials to the expectations of the NGSS. Eileen said she needed time to process because “we get a lot of information, but we don't have time to process it or think about how it's gonna look in the classroom.”

At the secondary level, high school teacher Samantha also emphasized that an essential feature of professional-development activities was the need for time to dig into the standards, sharing, “We do need time to be able to become familiar with [the NGSS], and not only the time for us to look at them, [but to get to a] point where you feel comfortable.” She found value in using time within professional-development sessions to “look at our curriculum map and some things we can do. How can we take what we do and make it actual NGSS?”

During the focus group session with Samantha, high school teacher Ronald shared that when the professional-development time feels rushed and he is not provided the time he needs to process the information, he thinks, "Oh my God, I can't do that. Okay, I'm just gonna go back to the old way.” To Ronald, it was essential to be provided time to understand the content and consider how he would incorporate it into his teaching.

**Time to Discuss.** Teachers also frequently shared their need to be provided time during professional-development sessions to discuss their learning with fellow participants.

Elementary teacher Anna reflected on a professional-development experience where she and a colleague attended the same session with two different facilitators. Anna’s facilitator did not provide time for discussion, while her colleague’s facilitator
did. As a result, Anna shared that her colleague had many new ideas for teaching the new curriculum due to the time provided for discussion, while Anna left her session with few new ideas.

Middle school focus group teachers also echoed the importance of having time to discuss their learning. Middle school teacher Danna shared that after she learns something, she likes to talk to her colleagues and discuss: “Okay, this is what they’re doing. I could ask questions, bounce things off of them, and pick the one that most fits into what I was doing.”

Fellow middle school focus group participant Michelle reflected (when thinking about her NGSS learning) upon the importance of having time to discuss in supporting her understanding:

I know I fought with it [the NGSS]. My brain fought with it every class until finally, it just, like, I can do this, right? And it finally became something that my brain wrapped its head around.

As high school teacher Samantha reflected on how she preferred to use the time provided during professional-development sessions, she shared that she liked to “take the time to actually have discussions. To have like a whole-hour discussion.” For Samantha, time for discussion is necessary because “We got such a rich discussion from [our time together] that we feel so much more connected and invested in the work that we're doing.”
Provides Hands-on Opportunities to See Examples of NGSS in Action as Learners

Providing teachers with hands-on opportunities to see examples of NGSS in action as learners sparked an interest in the focus group teachers to learn and teach and was the next most frequently discussed professional-development activity feature.

When elementary teacher Eileen shared an impactful NGSS professional-development experience at a nearby university, she described that what made the experience impactful was, “They really put us as a learner. We could experience it as a learner first and then talk about it from a teacher’s point of view.” As she further explained her experience, she said, “[During] the first year, it was all about engineering, which was really fun because engineering's building and hands-on. And then every year they touched on something different, with lots of hands-on, and a lot of engagement.” This engagement sparked an interest and motivated Eileen to continue participating in additional professional-development opportunities provided by the university.

The sentiment of providing teachers with hands-on experiences as learners to spark an interest to learn and teach was echoed by elementary teacher Anna when she described a full day professional-development experience where one activity required her to learn about food webs by acting as a student using yarn: “I don't remember what the other activities were except for that yarn activity. And maybe that's because they made us do it.”

Elementary teacher Mark also highlighted the importance of engaging in hands-on activities as a learner by stating, “Until you actually get your hands dirty and start figuring stuff out and playing with it and watching people teach and engaging in some lessons and seeing lessons and trying them out, it feels like it's just a waste of time.” He
emphasized his point by sharing, “If you teach us the way we're not supposed to teach kids, then you're probably hitting the wrong target.”

Several middle school focus group teachers also spoke about seeing NGSS in action through hands-on activities. Middle school teacher Donna shared details of a professional-development session where the presenters provided “a lot of different strategies [where] everyone was engaged. We weren't just sitting there and listening; we actually learned by doing.” And as a result, Donna shared, she was excited to take the strategies back to use with her students. Another middle school teacher in this same focus group, Brenda, shared something similar: "I want it to be engaging. I want to be able to get out of my seat. I might complain about getting out of my seat, but I always sit down being like, okay, that was actually pretty cool."

Elementary teacher Jessica summed up the sentiments of many focus group participants and the importance of providing hands-on opportunities to see examples of NGSS in action as learners when she shared, “It's just ridiculous to train teachers using pedagogy that is outdated and makes no sense. It needs to match our expectations. It needs to be highly thought out [and the presenters need to know they’re] modeling the techniques we would expose our students to.” In this same vein, high school teacher Samantha shared that it is essential to “allow us to experience the why. Maybe do a boring old lesson and then do an interactive, hands-on, new NGSS kind of thing, and show us the why.”
Facilitator Preparation, Professionalism, Clarity, and Ability to Break Learning Down

The fourth most frequent professional-development activity feature shared was having a facilitator who was prepared, professional, clear, and could break learning down.

Elementary teacher Jessica explained that it was essential for the professional-development facilitator “to believe that the development of your teachers develops the students, and it really needs to be high quality.” Jessica explained that for the facilitator to do this, the professional-development experience they provide “needs to be highly thought out.”

Many focus group teachers referenced their experience with facilitators from the STEAM Micro-Credentialing Program as one that was, as middle school teacher Danna said, “very organized, and they broke things down very well.” Another elementary teacher, Mia, agreed, sharing, “Everything just started with one point connected to the next point, and it just all made sense.” Mia shared that she “really liked the way that [the facilitators] did that and wished that it would've been done to everyone [in] PDs set at school sites.”

Elementary teacher Eileen agreed that the facilitator’s level of preparation was essential for her learning. Like Jessica and Mia, she saw the facilitators from the STEAM Micro-Credentialing Program as “very thoughtful and purposeful,” which supported her learning. Eileen shared, “I could really see every single component; every single course and module was so well designed and thought out. Every activity was meaningful; there was a purpose.” This was in contrast to other professional-development experiences she discussed, where “we usually go in and out a couple of hours, and that's it.”
STEAM Micro-Credentialing Program, Eileen highlighted that the facilitators created “a continuum and built upon it all year long.” As a result of the facilitators’ preparation, clarity, and ability to break things down, Eileen stated, “The learning was greater because of that.”

Middle school teacher Brenda also shared that she learns best in professional-development sessions where the facilitator is organized and breaks the learning down into chunks. According to Brenda, “If I'm being taught in an unorganized way, I'm gonna be confused, and my brain is gonna start shutting down to the learning.”

Mark, Michelle, and Eileen all spoke about how it was important for the facilitator to treat teachers like professionals. Michelle stated, “Treating us like professionals makes such a huge impression on us. It makes a difference. It's like it just makes you feel like you're appreciated.” And this appreciation, said Michelle, helped her learn.

As high school teacher Samantha reflected on the facilitators from her professional-development experiences, she shared that it was vital for them to know that teachers care and want to get better:

We're teachers. And you know, everywhere, everyone says it, not because of what we get paid but because we care. So, remember that, remember that we care. Remember that we do want to get better, and we do want to do better for our students, but we don't like to be treated as a token, where we have to comply with your specific checkmarks and check-off for whatever you feel are required.
**Expert Speakers**

Having expert speakers present during their professional-development sessions was a way to spark teachers’ interest to learn and teach. It was the next most commonly discussed helpful professional-development activity feature.

Elementary teacher Mia described a STEAM Micro-Credentialing session where the speaker “brought in this whole excitement and then brought in experiments, so we're like, ‘Oh, that is so cool!’” Elementary teacher Mark described this same expert speaker and how he also sparked an interest in Mark during what Mark described as “one of the most impactful PDs I've participated in ever in teaching”:

The presentation that he gave grabbed me; he interested me. The stuff he presented, for some reason, felt relevant, probably because he engaged me in it. I felt like if we had PDs like that throughout the district, you'd have teachers who were far more active in furthering their skillset because I was motivated to go back like, I'm gonna show my kids stuff too. Like, ‘How does this work?’ Just get their brains going.

As Mark shared further, he described how strongly the expert speaker engaged him and motivated him to try something new in his classroom:

He drove home the idea, whether it was his intent or not, that getting my kids to engage through stuff that's just gonna catch them. He knows that it works for teachers. And I think that's the thing that drove me to say, “Gosh, this is the kind of thing I wanna try and do too in class, to teach the way he made that presentation.”
Elementary teacher Jessica also shared how this same expert speaker sparked an interest in her:

He was phenomenal. He had just taken materials from the second grade [science] kit and presented it in such a way that was extremely expansive and engaging. So, the takeaway for me was that it wasn't really anything that I had to go too far to get. He made it just so engaging using what's right there in front of us.

In a follow-up email, I asked Jessica more about what she thought it was about outside expert speakers like the one she described during the focus group, which makes them much more engaging and able to spark an interest in teachers to learn and teach in a way that other facilitators cannot. Jessica added, "It is always refreshing to hear from regional experts because they provide a unique perspective because their lens tends to be broader.” Jessica also felt that expert speakers validated initiatives in the district: "When you discover that your ideas are in sync with that of others beyond the local level, it is very validating in creating teacher agency.” So, to Jessica, the expert speakers brought in new perspectives from outside of the district and served to validate the work she was doing.

High school teacher Samantha also described an expert speaker's impact on her while she participated in a literacy activity. In the graphic organizer activity she described, Samantha highlighted the expert speaker’s ability to have her look at the content differently, stressing how the speaker’s delivery made so much sense to her. Samantha shared that her experience with the expert speaker was so transformative because “not only was the speaker so impactful in how she presented the information,
[because] I was like totally into listening to everything she said and wanted to write everything down, but I also felt connected to it as a student.”

**Provides Opportunities for the Collaborative Design of Lessons and Units**

The final most commonly discussed professional-development activity feature was being provided opportunities for the collaborative design of lessons and units.

Elementary teacher Lucy reflected on one of these collaborative experiences in the STEAM Micro-Credentialing Program, mentioning, “There was a lot of content, but the final product [was to design] a lesson based around NGSS. So, you know, that helped me reinforce what I had learned again.”

Middle school teacher Michelle shared a similar sentiment, where she also found professional-development time provided through the STEAM Micro-Credentialing Program to collaboratively design NGSS-aligned lessons and units valuable:

When we had to create a multidisciplinary lesson for the micro-credential, where it was like, okay, where's the math? Where's the science? Where's this? Where's that? The willingness of the five of us on that team to work together and make that happen was an exciting prospect.

Michelle explained that what made the collaborative planning so effective was that “everyone was committed to doing it, and that was an awesome part of it of all.”

In summary, teachers identified several features of professional-development activities that helped them gain knowledge and skills to implement the NGSS. They found it most helpful to be provided with something to implement in their classroom and time to process and discuss what they learned. They also found it valuable to engage in hands-on opportunities to see examples of NGSS in action as learners and highlighted the
importance of engaging in professional-development activities that were facilitated by a presenter who was prepared and clear. The teachers also shared that hearing from expert speakers and engaging in the collaborative design of lessons and units supported their learning and implementation of the standards.

**Findings for Research Sub-Question Four**

Focus group teachers identified several areas for improvement in NGSS professional-development activities to better support their implementation of the content standards. Areas for improvement, beginning with the most frequently discussed, included: needing practical ideas; needing differentiation for diverse needs and experiences; needing time for discussion; and needing high-quality, modest facilitators.

**Need Practical Ideas**

The most commonly discussed area for improvement identified by the teachers was a need for more practical ideas from their professional development activities.

Many teachers, including elementary teacher Anna, shared that facilitators “never gave us any ideas,” which made the professional-development experience ineffective for her. Fellow elementary focus group teacher Audrey shared a similar concern when she couldn’t take her learning back to her classroom because “they don't provide you with either a strategy or a lesson or something that you can take back to your classroom.” Additionally, Audrey shared that even if a practical idea is provided, “it's not always something I feel like I can use in my setting.” Fellow elementary focus group teacher Mark echoed these sentiments: "The hard part is finding PD that actually makes you feel like you've learned something and that you can go home with something [to use in your classroom]."
Need Differentiation for Diverse Needs and Experiences

The next most common need identified by the teachers was the need for differentiation which accounts for the diverse needs and experiences of the teachers.

Said elementary teacher Mark, “When I sit through a PD where I’m getting a general picture of something, it's not as useful as if I'm able to focus on what I need.” Elementary teacher Audrey, who teaches special-education students, shared this sentiment: "There's no consideration for different groups [in NGSS professional-development activities]. There's not much consideration for diversity or our special-needs students.” In both cases, the teachers wanted strategies that could be used with their specific grade level, with their particular populations of students, and with the science content they were currently teaching.

Mark reflected on the lack of differentiation within NGSS professional-development opportunities by sharing, “I think many times it's the state's mandated this. We have to follow this protocol. We have to have this.” Mark believes these mandates have resulted in professional-development activities for teachers where “We have to have these sorts of narrated, follow-a-script PDs.” And as a result, Mark shared, “It's beating a dead horse. It's not gonna affect instruction.”

In contrast to the “one-size-fits-all,” undifferentiated professional-development opportunities Mark described, he shared a more impactful experience where he learned to facilitate small-group discussions in his classroom. In that activity, the facilitators allowed participants to work in small groups to practice the discussion protocols. Shared Mark, “The downside of [this type of professional-development activity] is they take a
long time. But the upside is they’re far more useful than the sort of top-down, one-size-fits-all, meet-a-state mandate training.”

*Need Time for Discussion*

Not only was time to discuss their learning one of the professional-development activities that teachers perceived as helping support their NGSS implementation, but it was also the next most commonly discussed area for improvement in NGSS professional-development activities.

Several of the teachers described professional-development activities where a lack of time for discussion hampered their implementation. High school teacher Samantha shared her experience with professional-development sessions that move too quickly, do not provide discussion time, and as a result, prevent her from figuring out how to apply her learning in the classroom:

They [the facilitators] go through it so quickly, they show you what it is, they go through it with you, and then we move on to something else. I don't get that brainstorming time where it's like, oh, okay, I can see it. I can see how I can use it in my classroom.

Samantha’s most extensive critique was that “it's too quick or way too general, and I don't get to figure out how to use it in my classroom.”

*Need High-Quality, Modest Facilitators*

Having more high-quality facilitators with humility was discussed by several of the focus group teachers, and the next most commonly discussed area of improvement they identified.
Elementary teacher Eileen shared that she had been designated as a lead science teacher at her school. As a result, she was asked to attend science professional-development sessions and to bring the information back to present at her school. Eileen shared, “I'm not an expert. I can't help all the grade-level teachers. I could only maybe possibly assist my grade level. So, it was just not an effective or efficient way to disseminate information to the whole staff or all the teachers in [the district].” Elementary Monica shared a similar experience and added, “I would like PDs to be taught by people with expertise.”

Elementary teacher Anna went into great depth regarding the importance of having modest facilitators. Anna shared that she often felt like her NGSS professional-development facilitators acted as if they were better than or above her. She stated, “There's a level of humility that presenters need to have,” and, “I don’t like when people feel that they're above me.” As Anna further discussed the need for improved facilitators, she shared how important it was for them to be humble and empathetic:

I think teachers are very hard to teach. I think that we're a rough group sometimes. I just need a level of humility that's like, okay, I understand what your job is, and this is how we can work together to achieve your goal or this goal that we're talking about.

When asked what this more modest facilitator might do, Anna shared that they would use a “calm voice,” be “somebody that understands,” and say things like, "I understand time can be a constraint. This is my suggestion," instead of something like, "Why aren't you doing this?" For Anna, she felt it was important for the facilitator to engage in more of a conversational way rather than feeling like she was being talked at.
Anna shared that she stops listening to facilitators who are not modest: “You know, [when I’m] talked at rather than conversational, that's a turn-off. Like, I'm done. I actually won't probably listen at that point.”

In sum, the teachers identified several areas for improvement in professional-development activities they deemed most important to supporting their implementation of the standards. The teachers perceived a lack of practical ideas they could take back and use in their classrooms through professional-development experiences that were differentiated to account for their diverse needs and experiences as an area of improvement. They also indicated that current professional-development experiences do not provide them with ample time for discussion as part of their learning so they could take back and implement what they learned. An unexpected criticism of professional-development experiences and area for improvement that surfaced from the teachers was that some of their prior professional-development experiences were led by facilitators who were not high-quality or modest, and as a result, their learning was not supported.

**Summary**

The findings in this study from the survey, focus groups, and follow-up emails revealed several themes related to teachers’ perceptions of the professional-development activities in which they engaged to support their implementation of the NGSS and the effectiveness of the various features of these professional-development activities in supporting the shifts required in teachers’ knowledge and instructional practice to implement the standards fully.

Teachers most frequently engaged in professional-development activities through district-sponsored opportunities with the central and regional district offices, most
commonly due to the convenience of these offerings. This was followed by professional-
development opportunities provided by curriculum vendors for the materials they were
using. They also participated in professional-development opportunities with institutes of
higher education. Through their engagement in these professional-development activities,
teachers learned about the architecture and design of the NGSS, the three dimensions of
the standards, and the standards’ focus on phenomenon-based instruction.

The findings revealed several critical professional-development activity features
that supported teachers in fully implementing the standards. The most helpful feature, and
also an area for improvement, was providing teachers with something practical to use in
their classroom along with the steps for its implementation. Time to process and discuss
their learning was also a helpful professional-development activity feature and an area of
improvement expressed by the teachers.

Other helpful professional-development activity features included providing
teachers with hands-on opportunities to see examples of NGSS in action as learners and
having a prepared, professional, clear facilitator who could break the learning down for
the teachers. The quality of the facilitator was so vital that it was a commonly discussed
area for improvement, with teachers desiring high-quality, modest facilitators. Along
these same lines, study participants also found learning from expert speakers during their
professional-development experiences was effective.

Finally, being provided opportunities for the collaborative design of lessons and
units were perceived by the teachers as an effective professional-development activity
feature, while providing differentiation for their diverse needs and experiences was noted
as an area for improvement for supporting the shifts in their knowledge and instructional practice to implement the standards fully.

Chapter Five will discuss these findings and their implications, along with opportunities for further research.
Chapter 5: Discussion and Conclusions

Introduction

This chapter discusses the findings and implications of a study that explored teachers’ perceptions of the professional-development activities they engaged in to support their implementation of the Next Generation Science Standards (NGSS) and Common Core State Standards for English Language Arts/Literacy that supplement them. It begins with a summary of the study, including a brief overview of its problem, purpose, research questions, methodology, theoretical framework, and major findings related to answering the research questions.

It continues with a discussion that provides an in-depth interpretation, analysis, and synthesis of the study’s findings connected to its larger body of literature and theoretical framework. The discussion also includes a reflection on this study’s contributions, limitations, and generalizability to the field.

From there, it discusses the study’s implications for policy and practice and includes recommendations for change in educational policy and practice based on the findings.

Finally, the chapter ends with future research recommendations that include a description of topics that may need closer examination.

Summary of the Study

Overview of Problem

Ambitious efforts are underway to implement a new vision for science education by implementing the Next Generation Science Standards (NGSS) (NGSS Lead States, 2013a). While the authors of the science Framework upon which the science standards
were based indicated there is a need for the professional-development experiences of teachers to change for them to implement the new standards (National Research Council, 2012, p. 305), current research provides only broad guidelines for the design of professional-development experiences, and include only minimal information about the professional-development needs of science teachers.

**Overview of Purpose**

The purpose of this study was to explore teachers’ perceptions of the professional-development activities in which they engaged to support their implementation of the Next Generation Science Standards and Common Core State Standards for English Language Arts/Literacy that supplement them and the effectiveness of these activities in supporting the shifts required in their instructional practice to implement the standards fully. The findings of this study provided valuable insights into teacher perceptions of the effectiveness of various NGSS professional-development activities that could help professional developers capitalize on the affordances of the most effective NGSS professional-development activities while avoiding the pitfalls of NGSS professional-development activities perceived as less effective. The findings of this study also helped identify teachers’ professional-development needs as they shift their knowledge and instructional practice to meet the demands of the NGSS.
**Research Questions**

In an effort to fill the gap in the research, the following research questions guided this study:

**Research Question**

What are teachers’ perceptions of the professional-development activities in which they engaged to support their transition to the Next Generation Science Standards and the effectiveness of the various features of these professional-development activities in supporting their implementation of the Next Generation Science Standards and the Common Core State Standards for English Language Arts/Literacy that supplement them?

**Sub-Questions**

1. What types of professional-development activities have teachers engaged in to support their implementation of the NGSS and the Common Core State Standards for English Language Arts/Literacy that supplement them?

2. What knowledge and skills do teachers perceive they gained from participation in NGSS professional-development activities that supported their implementation of these content standards in their classrooms?

3. What are the features of professional-development activities that teachers perceive as most helpful for gaining new knowledge and skills to support their implementation of these content standards?

4. What areas for improvement in NGSS professional-development activities do teachers identify to better support their implementation of these content standards?
Methodology Overview

This study was conducted in the interpretivist, phenomenological paradigm (Glesne, 2016, p. 7) using a qualitative research approach with a quantitative component in a case study tradition (Creswell, 2015; Durdella, 2019) with a quantitative component. Research participants included 23 prekindergarten through 12th-grade teachers working to implement the NGSS in a large urban school district in the western United States. The teachers had participated in various professional-development opportunities to learn about the NGSS and completed their district’s STEAM Micro-Credentialing Program.

Data were gathered through a survey containing closed- and open-ended questions, focus groups, and follow-up emails.

Closed-ended questions from the survey were quantitatively analyzed, while answers to the open-ended survey question, focus group questions, and follow-up emails were qualitatively analyzed using preliminary data analysis, thematic data analysis, and interpretation of data.

Theoretical Framework Overview

The theoretical framework for this study was grounded in Guskey’s (1986, 2002) four-step model for teacher change that posits a sequence of four events teachers must go through to create enduring change in their professional practice, beliefs and attitudes, and student learning outcomes towards an articulated goal. Because effective professional-development experiences are the first change event in Guskey’s model, Guskey contends his model can help guide the creation of teacher professional-development programs that are more effective (2002, p. 382). Additionally, research regarding what makes teacher
professional-development experiences most effective also informed the study’s theoretical framework (Darling-Hammond et al., 2017; Garet et al., 2001; Supovitz & Turner, 2000; and Wilson, 2013). While each set of these professional-development features and elements is slightly different, some commonalities include having the professional-development experiences (a) be content-focused; (b) be coherent; (c) be collaborative; and (d) be focused on active learning.

Connecting these features and elements of effective professional-development experiences for teachers to Guskey’s theoretical framework grounded this study as I considered the features of effective professional-development activities that serve as the inputs into the first event in Guskey’s model of teacher change: professional-development programs.

**Summary of Major Findings**

Data analysis from the survey, focus groups, and follow-up emails revealed several themes related to the study’s main research question regarding teachers’ perceptions of the effectiveness of professional-development activities in which they engaged to support their transition to the NGSS, supported by themes from each of the research sub-questions.

**Main Research Question**

The main research question asked, “What are teachers’ perceptions of the professional-development activities in which they engaged to support their transition to the Next Generation Science Standards and the effectiveness of the various features of these professional-development activities in supporting their implementation of the Next Generation Science Standards and the Common Core State Standards for English
Language Arts/Literacy that supplement them?” This main research question was broken down into four sub-questions to learn more about the types of professional-development activities in which teachers engaged, the knowledge and skills they gained from these professional development activities, their perception of the most helpful professional-development activities for gaining new knowledge and skills related to the NGSS, and their recommendations for areas of improvement in NGSS professional-development activities to support the implementation of the standards better.

**Research Sub-Question One**

Research sub-question one asked, “What types of professional-development activities have teachers engaged in to support their implementation of the NGSS and the Common Core State Standards for English Language Arts/Literacy that supplement them?” Data analysis revealed that many of the teachers engaged in NGSS-related professional-development activities beyond the STEAM Micro-Credentialing Program, including those from their district and local institutes of higher education.

**Research Sub-Question Two**

Research sub-question two asked, “What knowledge and skills do teachers perceive they gained from participation in NGSS professional-development activities that supported their implementation of these content standards in their classrooms?” Data analysis found that most of the teachers' professional-development experiences focused on learning about the architecture and design of the NGSS, with learning about the three dimensions of the standards and their emphasis on phenomenon-based instruction as two other common areas of learning.
\textit{Research Sub-Question Three}

Research sub-question three asked, “What are the features of professional-development activities that teachers perceive as most helpful for gaining new knowledge and skills to support their implementation of these content standards?” Teachers found it most helpful to be provided with something to implement in their classroom and time to process and discuss what they learned. They also found engaging in hands-on opportunities to see examples of NGSS in action as learners valuable. They highlighted the importance of engaging in professional-development activities facilitated by prepared and clear presenters. Hearing from expert speakers and engaging in the collaborative design of lessons and units also supported their learning and implementation of the standards.

\textit{Research Sub-Question Four}

Research sub-question four asked, “What areas for improvement in NGSS professional-development activities do teachers identify to better support their implementation of these content standards?” The teachers identified receiving practical ideas to take back and use, delivered through differentiated professional-development experiences, as important. They also highlighted their need for ample discussion during their learning and their desire to be taught by high-quality, modest facilitators.

The findings related and all of the research questions are interpreted, analyzed, and related to the larger body of literature and this study’s theoretical framework in the following discussion section.
Discussion

Because effective professional-development experiences are the first change event in Guskey’s (Guskey, 1986, 2002) four-step model for teacher change in the theoretical framework upon which this study was based, this discussion section will focus on discussing what teachers perceived as features of the most effective professional-development activities as well as their recommendations for areas of improvement in NGSS professional-development activities to support their implementation of the standards better.

Using Guskey’s model, for change in teacher practice to occur, science teachers must leave their professional-development experiences with instructional practices they can enact in their classrooms so they can see the positive impact on students’ learning. This positive impact will lead to an enduring change in their beliefs and attitudes and a fuller implementation of the NGSS.

Types of NGSS Professional Development

Two themes emerged regarding the types of NGSS professional development teachers engaged in.

District-Sponsored Professional-Development Opportunities

The most commonly discussed theme indicated that teachers engaged in district-sponsored professional development opportunities provided by either the central office, regional office, or curriculum vendors and cited convenience as a factor for their participation.
Professional-Development Opportunities from Institutes of Higher Education

The next most common theme indicated that teachers received some of their learning about the NGSS from institutes of higher education, including local colleges and universities. Teachers choose these professional-development options based on the college or university’s reputation or convenience in terms of location.

These findings provide insight into where the teachers received their professional learning outside of the STEAM Micro-Credentialing Program and why they chose it.

Knowledge Gained About NGSS from Professional-Development Activities to Support Implementation

Three themes emerged regarding the knowledge gained about NGSS from professional-development activities to support implementation.

Architecture and Design of Standards

The first theme indicated that the most frequently discussed area of learning about the NGSS that supported teachers’ implementation was focused on the architecture of the standards. This included how they differed from the science standards that preceded them; how they were designed so topics progress from kindergarten through grade 12; how they consist of performance expectations, foundation boxes, and connection boxes; and how they connect to the Common Core. These areas of learning connect to changes in the new standards meant to address several weaknesses in K-12 science education highlighted by the authors of the science Framework upon which they were based (National Research Council, 2012, p. 1). Specifically, science education before the Framework (a) was not systemically organized across multiple years of school,
(b) focused more on breadth and discrete facts rather than depth, and (d) did not provide
students with engaging opportunities that would allow them to experience how science is
done.

Three Dimensions of the NGSS

The second theme indicated that the next most commonly discussed area of
learning that supported the teachers’ implementation of the standards was their three
dimensions (science and engineering practices, crosscutting concepts, and disciplinary
core ideas). The science Framework stresses that all three dimensions must be integrated
into curriculum, instruction, and assessment to support students’ meaningful learning of
science (National Research Council, 2012, p. 2), so it is helpful to see that teachers
gained this knowledge about the three dimensions in the professional-development
activities they experienced. Some science and engineering practices, such as using
models, constructing explanations, and engaging in argument from evidence, require
intensive student discussion, which is a significant shift from previous science standards
(Cheuk, 2016; Penuel et al., 2015) and something the teachers reported as more complex.

Phenomenon-Based Instruction

The next theme indicated that the third most commonly discussed learning area
from professional-development activities that supported teachers’ implementation of the
standards was the focus on phenomenon-based instruction. The NGSS and Framework on
which they are based focus on having students build progressively more sophisticated
explanations of scientific phenomena (National Research Council, 2012), and the
Framework states that: “The goal for students is to construct logically coherent
explanations of phenomena that incorporate their current understanding of science, or a
model that represents it, and are consistent with available evidence” (p. 67). Through their professional-development experiences, teachers indicated that they were frequently teaching their students starting with a real-world phenomenon that allowed them to ask questions about the phenomena and then try to figure out and explain what was happening in the phenomenon.

**Helpful Professional-Development Activity Features**

Six themes emerged regarding what participants perceived as the most helpful professional-development activity features for supporting their learning to implement the standards.

*Providing Something to Implement in the Classroom with Practical Steps for Implementation*

The most frequently discussed theme identified teachers’ desire for something they could implement in the classroom and the practical steps they should follow for implementation. The findings revealed that it was important for teachers to leave the professional-development experience with a practical and useful strategy or resource they could use in their classroom. Along with the new strategy, teachers appreciated the steps for implementing it and the time for considering where and how they would use it in their teaching. While teachers very much wanted to be provided with something to implement, it was interesting to hear them discuss the idea of “tiptoeing” into their use of a strategy rather than feeling like they had to dive in headfirst, as if the use of the strategy were all or none.

Leaving the professional-development experience with something practical to implement in their classrooms aligns with the research of Garet et al. (2001) and Supovitz
and Turner (2000), who found that the kind of professional development that impacted teacher knowledge and instruction gave them specific ideas for engaging in student-centered teaching.

**Providing Time to Process, Plan, Dig In, and Discuss Materials**

The next most commonly discussed theme that emerged was providing time for teachers to process, plan, dig in, and discuss materials. The findings revealed that teachers appreciated time during professional-development opportunities to dig into not only the content of the learning but also into whatever materials they received—the time provided not only an opportunity for the teachers to understand the content and materials better but also to consider where they might fit into their instruction and how they might be used. The time for discussing their learning and the materials they received also allowed them to ask questions and more deeply engage with fellow participants and the facilitator. This theme aligns with the work of Pruitt (2015a), who stresses that helping teachers understand the science and engineering practices in the standards takes time, and he recommends that educators engage in discussion about the new standards to stimulate their greater understanding.

**Hands-on Opportunities to See Examples of NGSS in Action as Learners**

The next most frequent theme regarding what participants perceived as the most helpful professional-development activity feature was providing teachers with hands-on opportunities to see NGSS in action as learners.

This theme is in alignment with research from Garet et al. (2001), who found that professional-development experiences are effective when they include active learning, and Wilson (2013), who identified that this active learning should closely resemble what
teachers are meant to practice in their classrooms. It is also in concurrence with the work of Darling-Hammond et al. (2017, p.1), who found that incorporating active learning that used adult learning theory and models of effective classroom practice demonstrated a positive link between teacher professional development, the teacher’s teaching practices, and improved student outcomes.

Having a Facilitator Who Is Prepared, Professional, Clear, and Can Break Things Down

The fourth most frequent theme that emerged was having a prepared, professional, clear facilitator who could break things down. The findings revealed that the facilitator’s role in the professional-development experience is critical to the teachers’ learning. They were clear that the facilitator must not only know the content of what they are teaching but must present it in a clear and well-thought-out way. When facilitators failed to meet the mark, teachers reported feeling confused, not learning, and shutting down. The importance teachers place on the role of the facilitator was an interesting and unexpected finding from this study not seen in the literature regarding effective professional-development activity features.

Expert Speakers

The next most frequent theme that emerged from the data regarding what participants perceived as most helpful was hearing from expert speakers from the field. While not anticipated from the literature, for the teachers, expert speakers supported their learning because they sparked their interest to learn and teach science by bringing excitement, expertise, and new outside perspectives that were motivational.
Providing Opportunities for the Collaborative Design of Lessons and Units

The sixth most frequent theme that emerged was providing opportunities for the collaborative design of lessons and units. The findings revealed that lesson and unit creation helped teachers better understand the standards, reinforced their learning, and helped them see how the many pieces of the NGSS fit together. Lesson and unit creation also provided teachers with something practical they could try and implement in their classrooms. This finding aligns with the work of Darling-Hammond et al. (2017), who found that supporting collaboration was one of the common effective professional-development features within the 35 professional-development studies she examined (p. 1). This theme is also in concurrence with research by Pruitt (2015a), who recommends that educators engage in curriculum design, task design, and intense discussion with the new standards to stimulate their greater understanding.

Areas for Professional-Development Improvement

Four themes emerged regarding recommendations for areas of improvement in NGSS professional-development activities to support better implementation of the standards.

Needing practical ideas

The most frequent theme that emerged was the teachers’ need for practical ideas. The findings revealed that many teachers attended professional-development experiences where they perceived not receiving practical ideas for things they could bring back and use in their classrooms. Not only did the teachers want to receive practical ideas, but they also wanted to envision using and applying the strategies from the professional-development session in their specific role and content area.
Needing Differentiation for Diverse Needs and Experiences

The next most common theme that emerged was needing differentiation for diverse teacher needs and prior teaching experiences. The findings showed that professional-development experiences were most impactful when they focused on what the teachers needed rather than on generalities that would not result in classroom implementation or affect instruction.

These findings align with the findings of Huberman (2018), Rotherham et al. (2008), and Zhang et al. (2015), who argue that we know very little about what teachers’ professional-development needs are. As a result, the professional-development opportunities they are offered often fail because the learning is frequently neither personalized nor aligned to their needs. These authors stress the importance of understanding the needs of teachers to align our professional-development efforts better. Huberman (2018) points out that although we have emphasized personalizing learning for students based on their individualized needs, this same emphasis has not been placed on teachers, leading to ineffective professional-development experiences that fail to support teacher progress.

Needing Time for Discussion

The next most-frequent theme providing recommendations for areas of improvement in NGSS professional-development activities was teachers’ need for more time for discussion. The findings showed that teachers needed time to discuss their learning and implementation of ideas and strategies they learned. They also needed time to share and discuss their questions with each other and the facilitator.
**Needing High-Quality, Modest Facilitators**

The fourth most frequent theme that emerged was needing high-quality, modest facilitators. The findings showed that teachers were sometimes asked to serve as professional-development facilitators and only sometimes felt adequately prepared for this role. Teachers also indicated that sometimes facilitators were far removed from the classroom and would think they were somehow better than the teachers they served. For teachers, it was essential to feel as though they were part of a conversation rather than being talked down to.

**Emerging Themes**

While several of the themes from my findings aligned with the larger body of literature regarding effective professional-development features and this study’s theoretical framework, two new themes emerged.

First, having a facilitator who was prepared, professional, clear, and could break things down was perceived as one of the most helpful professional-development activity features, while the need for high-quality, modest facilitators was a recommended area of improvement in NGSS professional-development activities. The NGSS place new challenging demands on teachers to design and deliver phenomenon-based, three-dimensional learning experiences that support their students in meeting the performance expectations for each standard. With NGSS, teachers must not only learn new things themselves but must also teach in new ways, and study participants acknowledged that this was challenging. This finding highlights not only the importance of ensuring professional-learning experiences contain helpful professional-development activity features but also that these features must be delivered by a facilitator who is both
knowledgeable and empathetic to the needs of the teachers and can make them feel safe and supported rather than judged and ineffective, as they become more vulnerable in learning and trying new things.

The second new theme that emerged was related to the importance of providing teachers with something to implement in the classroom with practical steps for implementation. While teachers wanted to be provided with something to implement in their classrooms, they often felt that using a new strategy needed to be “all or none.” In their minds, they either needed to use all of a new strategy or none of it at all, so the idea of “tiptoeing” into their use of a strategy was necessary. As previously noted, the NGSS place challenging demands on teachers to learn and teach in new ways. This makes it crucial to present them with new strategies and practical steps for implementation in manageable pieces so they can more easily work towards a fuller implementation of the NGSS.

Figure 5.1 highlights these two new emerging themes, along with the other themes, and how my findings generally align with and build upon the existing research base about effective professional-development experiences.

When considering all of this study’s findings in light of its theoretical framework grounded in Guskey’s model of teacher change (1986, 2002), these two new findings highlight the importance of making sure that during their professional-development experiences, teachers are provided with something to implement in their classroom with the practical steps for implementation, and that their professional-development experiences are facilitated by facilitators who are prepared, professional, clear, and can break things down. As Guskey points out, teachers must experience success in improving
student learning outcomes when implementing a new strategy for their beliefs and attitudes to change. Outside of these two new findings, this study’s other findings provide additional support to existing research that highlights the need for professional-development opportunities that (a) provide time for teachers to process, plan, dig in, and discuss materials; (b) provide hands-on opportunities to see examples of NGSS in action as learners; and (c) provide opportunities for the collaborative design of lessons and units.

I believe the two new findings (having a facilitator who is prepared, professional, clear, and can break things down; providing something to implement in the classroom with practical steps for implementation) emerged in this study but not in prior literature because when considering the significant shifts required in teachers’ knowledge and instructional practice to implement the NGSS, teachers must move away from science education that involves rote memorization of facts and terminology, posing questions with only one right answer, and pre-planned “cookbook” laboratories and towards facts and terminology being learned as needed while developing explanations and designing solutions supported by evidence-based arguments and reasoning, students discussing open-ended questions that focus on the strength of the evidence used to generate claims, and students conducting multiple investigations driven by their questions with a range of possible outcomes. This more rigorous three-dimensional model of science instruction, with a heavy emphasis on engaging their students in hands-on, inquiry-based science and engineering practices, is a significant shift from the pedagogy of previous science standards. Moving towards this new three-dimensional model requires teachers to make significant changes to their practice and take new risks in their teaching, so a clear and empathetic facilitator who can make them feel safe and support their learning is
important. And, because they are being asked to teach in a way that is often new to them, the clear, step-by-step provision of practical strategies they can implement in their classroom supports them as they shift their practice.

Considering Guskey’s model for teacher change and this study’s theoretical change further, while it is important for science teachers to leave their NGSS professional-development experiences with something to implement in their classroom so they can experience success in improving student learning outcomes, it is important to remember that Guskey also points out (1986, pp. 9-10) that during the teachers’ process of change, they need to receive regular feedback on student learning progress. This could be done through coaching and continued support after their initial professional-development experience. While these additional elements of coaching and continued support were not within the scope of this study, they would be an important area for further research.
Figure 5.1

Existing Research Base of Effective Professional-Development Characteristics, Features, and Components With Findings From This Study

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<td></td>
<td>4. Coherence</td>
<td>5. Integrated into school life (coherence)</td>
<td>6. Providing coaching and expert support</td>
<td>4. Deepen content skills and subject-matter knowledge</td>
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<td>5. Sufficient duration</td>
<td>6. Collective participation</td>
<td>7. Offering opportunities for feedback and reflection</td>
<td>5. Grounded in professional development standards</td>
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|                     |                     | Six Structural Components: |                     |
|                     |                     | 2. Providing Time to Process, Plan, Dig In, and Discuss Materials |                     |
|                     | Six Helpful Activity Features: | 3. Hands-on Opportunities to See Examples of NGSS in Action as Learners |                     |
|                     |                     | 4. Providing Opportunities for the Collaborative Design of Lessons and Units |                     |

Note. Similarities between findings of each researcher are highlighted in the same color across columns. New themes emerging from this study are highlighted in purple.
Limitations and Generalizability

This study had several limitations that impacted the generalizability of its findings to a broader population and other settings and conditions.

Limitations included the study's small sample size of teachers from a large district where the average teacher had been teaching in the district for 15 years. This small sample size might have limited the study because my findings only include the voices of this small group and exclude the many other voices of teachers also working to implement the NGSS within the large district under study. Their voices do not necessarily represent the voices of all teachers within the district or nation working to implement the NGSS, nor the length of time teachers have been teaching in the district. Additionally, because the study only investigated teacher perceptions of the effectiveness of various professional-development activities and did not measure the changes in their knowledge, practices, or student outcomes through observations or lesson plan reviews, it was impossible to determine whether or not the various professional-development activity features they perceived as effective are. Finally, because the study consisted of participants from the same large district who shared the common experience of participating in the year-long STEAM Micro-Credentialing Program, they may have been pressured to draw from their STEAM Micro-Credentialing experience for their ideas about effectiveness to please me as the researcher.

Despite these limitations, the understanding and knowledge gained from the study might be transferable to similar contexts and settings. The expectations of the NGSS are the same for all teachers in the United States charged with implementing them and place the same new demands on all teachers as they shift their practice. Given this, the
perceptions of the small group of teachers in this study provide insight to science teacher professional developers so they can consider what was found as the most effective professional-development activity features and avoid those perceived as less effective.

Beyond science teachers, I am confident that the findings of this study will apply to teachers in other disciplines, most specifically teachers of English language arts/literacy, mathematics, and visual and performing arts. This is because the teachers in this study all identified themselves as STEAM teachers. So, in addition to implementing the NGSS, they were also working to design and deliver instruction that incorporated the standards and practices of each STEAM discipline.

Furthermore, when considering the shifts in knowledge and instructional practice science teachers must undergo to implement the NGSS, there is considerable overlap between the NGSS and the standards for these other disciplines. As previously noted in Chapter Two, Cheuk (2016) highlighted how the student practices and capacities found in the CCSS for Mathematics, CCSS for ELA and Literacy in History/Social Studies, Science, and Technical Subjects, and the NGSS (p. 94) work in tandem and there are several areas of overlap between the standards that focus on the student discourse practice of argumentation with evidence that is shared across the disciplines. Therefore, the findings from this study will likely apply to teachers in these other subject areas as well.

**Implications for Policy and Practice**

Findings from this study revealed teachers’ perceptions of the professional-development activities in which they engaged to support their implementation of the Next Generation Science Standards (NGSS) and Common Core State Standards for English
Language Arts/Literacy that supplement them and the effectiveness of these activities in supporting the shifts required in teachers’ instructional practice to implement the standards fully. These findings help fill the gap between what is already known about effective professional-development practices and the additional evidence about approaches to professional development for K-12 teachers across grade levels and science disciplines proposed by the authors of the Framework upon which the standards are based (National Research Council, 2012, p. 257). The findings provide valuable insights into teacher perceptions of the effectiveness of various NGSS professional-development activities that may help professional developers capitalize on the affordances of the most effective NGSS professional-development activities while avoiding the pitfalls of NGSS professional-development activities perceived as less effective. This study's findings also help identify teachers’ professional-development needs as they shift their knowledge and instructional practice to meet the demands of the NGSS.

**Ensure Professional-Development Activities Provide Teachers with Practical Ideas and Strategies to Implement in the Classroom with Practical Steps for Implementation**

Professional-development activities for teachers working to implement the NGSS should provide them with practical ideas and strategies to implement in their classroom with practical steps for implementation.

Providing teachers with practical ideas and strategies can be done most effectively by engaging the teachers in hands-on opportunities to see the NGSS in action while engaging in model lessons and activities as learners. Their engagement in these hands-on activities will provide them with practical ideas and strategies and spark an interest in
them to learn and teach science. While they experience these hands-on opportunities as learners, they should be provided with practical steps for implementing the same ideas and strategies they are experiencing in their classrooms. Additionally, to mitigate the “all or none” approach to strategy implementation that teachers disliked, it is crucial to present the new strategies and practical steps for implementation in manageable pieces so teachers can more easily “tiptoe” into their use.

Teachers can also gain practical ideas and strategies for implementing the NGSS in their classrooms, along with practical steps for implementation, through spending professional-development time designing lessons and units. Designing lessons and units allows teachers to consider how and where they might implement ideas and strategies gained during the professional-development session in their classroom.

The implications for practice of this recommendation are that developers of NGSS professional development should focus their design on providing teachers with practical ideas and strategies to implement in the classroom with practical steps for implementation through engaging teachers in hands-on opportunities to see the NGSS in action while engaging in model lessons and activities as learners or through the design of lessons and units. This is in contrast to professional-development sessions that focus only on the architecture and design of the standards. Additionally, teachers should be provided with follow-up time to discuss how their implementation of the ideas, strategies, lessons, and units went in their classroom so they can continue to refine their practice.

**Provide Time During Professional-Development Activities for Teachers to Discuss**

Teachers should be provided with time during professional-development activities for discussion. Discussion time helps the teachers because it allows them to process the
new information presented; plan for how they might use the ideas, strategies, and learning in their classroom; and dig into and explore any materials provided during the professional-development session.

The implications for practice of this recommendation are that developers of professional development for teachers implementing the NGSS must ensure they provide ample time and space during their professional-development sessions for teacher discussion. If the time for discussion is not provided, teachers are less likely to implement their learning from the session, slowing their transition to the NGSS.

*Provide Differentiated Professional-Development Experiences*

Teachers implementing the NGSS should be provided with professional-development experiences that are differentiated for their prior teaching experiences and should focus on what they need in their classrooms rather than on generalities. Their needs can differ based on their years of teaching, their grade levels, the student populations they serve, and where they are in their understanding and implementation of the NGSS.

The implications for practice of this recommendation are that professional-development developers must move away from “one-size-fits-all” professional-development models where all participants learn the same thing at the same time and in the same way and offer more personalized learning experiences aligned with teachers’ needs. Doing this will require developers of professional-development opportunities to take the time to understand teachers’ needs more deeply so that the professional-development can be differentiated accordingly.
Considering the need for differentiation and the specific needs of the sample of teachers in this study as a whole and their engagement of students in NGSS instruction, the survey found a need for both elementary and secondary teachers to learn more about the types of NGSS-aligned instruction they reported engaging their students in the least: (a) learning how to engage students in conducting multiple investigations driven by students’ questions with a range of possible outcomes that collectively lead to a deep understanding of established core scientific ideas, and (b) learning how to engage students in writing journals and reports as well as creating posters and media presentations that explain and argue. Considering the survey results from the sample of secondary teachers specifically, learning how to engage students in reading multiple sources, including science-related magazines, journal articles, and web-based resources, was another identified area for additional professional learning.

The survey revealed additional areas for differentiation and specific needs when desegregating between elementary and secondary teachers. In terms of familiarity with designing and delivering NGSS instruction, overall, elementary teachers reported being more familiar than secondary teachers with the NGSS.

This finding was initially surprising because the elementary teachers were non-science specialists responsible for teaching all elementary subjects, while the secondary teachers were science specialists, except for one physical education and one English language arts teacher implementing NGSS as part of their school’s STEAM program. When I removed the physical education and English language arts teachers from the analysis of secondary data because they were outliers who rated their familiarity with the NGSS much lower than the other secondary teachers, the data showed secondary teachers
being slightly more familiar with the NGSS ($M = 4.20$) than elementary teachers ($M = 4.00$). Without these two outliers, the data also revealed secondary teachers being slightly more familiar with designing ($M = 3.80$) and delivering ($M = 4.00$) NGSS instruction than elementary teachers in designing ($M = 3.81$) and delivering ($M = 3.69$) NGSS instruction. These outliers, along with self-reporting rather than more objective measures of familiarity, make the initial findings less surprising and the averages less indicative of the teachers’ actual familiarity with NGSS.

Still, had the facilitators of the professional-development experiences this sample of teachers engaged in known their specific needs and how they were different for elementary and secondary teachers working to implement the NGSS, they could have planned their professional-development experiences to align more specifically to them.

Similarly, developers of professional-development experiences for other science teachers might consider giving a survey similar to that used in this study before planning professional-development activities to learn about the areas of need and weaknesses of the teachers they were preparing for and plan accordingly. In addition to accounting for the areas of need identified by such a survey, the professional development experiences they provide could then also be differentiated so that they accounted for differences in the teachers’ years of teaching, their grade levels, and the student populations they served by offering different paths for teachers to understand the content.

For example, as noted in Chapter Three, the average teacher in the district under study had been teaching there for 15 years, so their science professional-development needs are likely different from those of teachers in a district with less experience, who might be focusing more on classroom management or other areas common to newer
teachers. As another example, when considering the student populations teachers serve, with the increasing number of dual language education programs, dual language teachers must deliver instruction in both English and the target languages while supporting science content mastery and development of two languages, so their professional-development experiences must be differentiated for this.

Differentiating the professional development opportunities can take many forms but might include opportunities for a more blended learning approach, where teachers engage in some learning together about the topic in person and then are given the opportunity to continue their learning in a more self-directed fashion using digital online platforms where they can control the pacing, time, and place of their extended learning as they complete tasks that allow them to apply their learning in their setting.

*Ensure Facilitators Are Humble, Prepared, Professional, Clear, and Can Break Things Down*

The professional-development facilitator has a significant impact on the learning outcomes for teachers. For this reason, NGSS professional-development sessions should be delivered by humble, prepared, professional, and clear facilitators who can break things down.

The implications for practice of this recommendation are that in addition to having deep content knowledge, professional-development facilitators must be carefully selected and prepared to deliver professional learning with high humility and professionalism. They should seek to be empathetic to the teachers they serve and teach them in ways that model what is expected for students. They must convey information in a way that makes sense to teachers regarding the science and classroom contexts.
Recommendations for Future Research

This study explored teachers’ perceptions of the professional-development activities in which they engaged to support their implementation of the Next Generation Science Standards (NGSS) and Common Core State Standards for English Language Arts/Literacy that supplement them to provide recommendations that may help professional developers capitalize on the affordances of the most effective professional-development activities while avoiding the pitfalls of professional-development activities that teachers perceived as less effective. In addition to providing recommendations for practice, this study has revealed four areas that may need closer examination.

First, because the study focused on the perceptions of only a small population of teachers from the specialized STEAM Micro-Credentialing Program within a large urban district, it would be helpful to explore the perceptions of a larger sample of teachers from the district, including those who are also working to implement the NGSS but who have not participated in its STEAM Micro-Credentialing Program. The teachers from the STEAM Micro-Credentialing Program were highly motivated to implement the standards, so it would be helpful to see if their professional-development needs are similar to a population of possibly less-motivated teachers. Additionally, the authors of the Framework upon which the standards are based (National Research Council, 2012, p. 257) expressed the need for additional evidence about approaches to professional development for K-12 teachers across grade levels. While my participant sample spanned from prekindergarten through 12th grade, it was disproportionally weighted towards elementary teachers for both the survey and focus groups. Because of this, including more secondary teachers in additional research would be beneficial to see if its findings
hold. At the secondary level, the NGSS provide an option for a more integrated approach to teaching science, integrating the physical, life, and earth and space science standards. As a result, in addition to shifting their practice to meet the demands of the NGSS, secondary teachers must also deepen their science content knowledge to support this more integrated approach, which could impact their needs and desires for the form and features of their professional-development activities.

A second recommendation for future research is to examine the most impactful strategies for differentiating professional-development experiences for science teachers. As professional-development developers move away from one-size-fits-all professional-development models where all participants learn the same thing at the same time and in the same way and provide more personalized learning experiences aligned with teachers’ needs, understanding these differentiation strategies is essential. Understanding how large school districts effectively determine the personalized needs of their science teachers would be helpful. Additionally, learning how districts use their often-limited budgets and time constraints to provide differentiated professional-development experiences would be a helpful contribution to the field.

The idea of “tiptoeing” into the use of NGSS-aligned strategies so teachers do not feel like they need to dive headfirst into their full use and, as a result, are more likely to try new strategies is a third recommendation for future research. This study did not examine how to break NGSS-aligned teaching strategies into more manageable pieces along a continuum of implementation that teachers might use to align their instruction to the NGSS fully. Therefore, this future research would be a valuable contribution.
A final recommendation for future research is to examine the role of the facilitator in science teachers’ professional-development experiences more closely. This study found that expert speakers could spark an interest in teachers to learn and teach science and that facilitators who were prepared, professional, clear, and could break learning down were both something that helped them learn and an area for NGSS professional-development improvement. Given this, understanding how to select and prepare professional-development facilitators effectively is critical to a professional-development session’s success, so additional research in this area would add to the research base regarding the effective facilitation and facilitators needed to implement the NGSS successfully.

**Concluding Statement**

The Next Generation Science Standards (NGSS) generate new expectations for teachers’ classroom behaviors and place new demands on teachers that require changes in their knowledge and instructional practice. Empowering teachers to teach the new science standards requires effective professional-development opportunities that deepen their understanding of the standards and provide them with effective strategies for their implementation.

Current research provides broad guidelines for designing professional-development experiences and provides minimal information about the professional-development needs of science teachers. Moreover, the authors of the national Framework (National Research Council, 2012) on which the new science standards are based indicated that the professional development of teachers needs to change to support the implementation of new science standards (p. 256), so there is a need to expand the
research base and recommendations from their 1996 *National Science Education Standards (NSES)* (National Research Council, 1996).

In that spirit, this study sought to shed additional light on the professional-development perceptions and needs of science teachers charged with implementing the NGSS. The findings help fill the gap between what is already known about effective professional-development practices and the additional evidence about approaches to professional development for K-12 teachers across grade levels and science disciplines proposed by the authors of the Framework upon which the standards were based (National Research Council, 2012, p. 257).

This study’s findings concluded that (a) Ensuring professional-development activities provide teachers with practical ideas and strategies to implement in the classroom with practical steps for implementation, (b) Providing time during professional-development activities for teachers to discuss, (c) Providing differentiated professional-development experiences, and (d) Ensuring facilitators are humble, prepared, professional, clear, and can break things down, are helpful professional-development activity features that best support teachers’ implementation of the NGSS. These recommendations may help professional developers capitalize on the affordances of the most effective NGSS professional-development activities while avoiding the pitfalls of NGSS professional-development activities that are perceived as less effective.

Given these findings, I will use several key takeaways as I plan and deliver NGSS-focused professional-development opportunities for the teachers I serve. First, I will ensure that I take the time to understand the needs and experiences of my teachers more deeply before designing professional-learning experiences for them. This will allow
me to differentiate their learning to meet their needs better. As the teachers engage in these differentiated learning experiences, I will ensure that I provide ample time for the teachers to discuss their learning and how it can be implemented in their settings.

Additionally, I will ensure that my teachers leave each professional-development experience with new strategies and practical steps for implementation in manageable pieces. While doing this, I will avoid the “all or none” approach to strategy implementation the teachers disliked and instead work to support the idea of “tiptoeing” into their use of new strategies.

Finally, because shifting their knowledge and instructional practice to the NGSS requires teachers to become more vulnerable in learning and trying new things, I will ensure that I work to deliver professional-development experiences by being not only knowledgeable, prepared, and professional but also humble and empathetic to the needs of the teachers so they feel safe and supported as they achieve the vision of the NGSS.
References


doi:10.3102/0034654311413609


doi:10.1177/0031721715575299


Appendix A: Research Invitation

Dear [Name of Invited Teacher],

I am writing to invite you to participate in a dissertation study that is being conducted by Michael Beiersdorf, Coordinator of the Micro-Credentialing Program, who is also a doctoral candidate at California State University, Northridge. His study explores teachers’ perceptions of the professional-development activities in which they engaged to support their implementation of the Next Generation Science Standards (NGSS), and Common Core State Standards for English Language Arts/Literacy that Supplement them, and the effectiveness of these activities in supporting the shifts required in their instructional practice to fully implement the standards. As part of his study, he is administering a professional-development survey to teachers who participated in either the 2018-2019 or 2019-2020 cohort of the STEAM Micro-Credentialing Program to obtain information about their NGSS professional-development learning experiences.

The professional-development survey should not take more than 15 minutes to complete.

Additionally, after completing the professional-development survey, you will be invited to participate in an optional follow-up 90-minute focus group with a small group of other teachers to further discuss your NGSS professional-development experiences. If you choose to participate in the optional focus group, you may also be invited for an individual follow-up interview for Michael to learn more about your experiences. This optional interview would be no more than 30 minutes in length.

All your responses to the questions from the professional-development survey, optional focus group, and optional interview used in Michael’s dissertation will be confidential, and your name and other identifiable information will not appear in the
study. Participation in this study is voluntary, and your decision to participate or not participate will not affect your standing within the Micro-Credentialing Program, at your school, or within the District. Finally, information revealed by your participation in this study will not be used in any way that impacts your employment or the evaluation of your work.

Please note that all study related activities must be completed outside of your regular paid work day and that no compensation nor National Board hours will be provided.

If you would like to participate in Michael’s study, please click on this link (insert link to Qualtrics teacher survey here) to learn more about the study, provide your informed consent, and take the 15-minute professional-development survey.

Thank you,

[Redacted]

Sent on Behalf of:

Michael Beiersdorf
California State University, Northridge
Department of Educational Leadership and Policy Studies (ELPS)
18111 Nordhoff St.
Northridge, CA 91330-8222
Michael.Beiersdorf.43@my.csun.edu
Appendix B: Human Research Participant Consent

California State University, Northridge

CONSENT TO ACT AS A HUMAN RESEARCH PARTICIPANT

Teacher Perceptions of Next Generation Science Standards Professional Development Effectiveness

You are being asked to participate in a research study titled *Teacher Perceptions of Next Generation Science Standards Professional Development Effectiveness*, a study conducted by Michael Beiersdorf as part of the requirements for the Ed.D. degree in K-12 Educational Leadership. Participation in this study is completely voluntary. Please read the information below and ask questions about anything that you do not understand before deciding if you want to participate. A researcher listed below will be available to answer your questions.

**RESEARCH TEAM**

**Researcher:**
Michael Todd Beiersdorf
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18111 Nordhoff St.
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**PURPOSE OF STUDY**
The purpose of this study is to explore teachers’ perceptions of the professional-development activities in which they engaged to support their implementation of the Next Generation Science Standards (NGSS), and Common Core State Standards for English Language Arts/Literacy that supplement them, and the effectiveness of these activities in supporting the shifts required in teachers’ instructional practice to fully implement the standards.
SUBJECTS

Inclusion Requirements
You are eligible to participate in this study if you were a participating teacher in the 2018-2019 or 2019-2020 cohort of the [Redacted] STEAM Micro-Credentialing Program.

Exclusion Requirements
You are not eligible to participate in this study if you were not a classroom teacher while you participated in the 2018-2019 or 2019-2020 cohort of the [Redacted] STEAM Micro-Credentialing Program.

Time Commitment
This study will involve from 15 – 135 minutes of your time during the 2020-2021 school year.

PROCEDURES
The following procedures will occur: After you have completed the online survey for this study, you have the option of volunteering to participate in a 90-minute focus group conducted via Zoom where you will be invited to discuss your NGSS professional-development experiences. After the focus group, you may be asked to participate in a shorter follow-up interview of less than 30-minutes via phone to share additional information about your professional development experiences. Before you choose to participate in the focus group and follow-up individual interview, you will be asked to review this consent form and provide a signature that indicates your consent to participate in the focus group and follow-up individual interview.

RISKS AND DISCOMFORTS
This study involves no more than minimal risk. There are no known harms or discomforts associated with this study beyond those encountered in normal daily life.

There could be possible employment repercussions if identifiable data are released. To minimize this risk, identifiable information from the surveys, focus groups, interviews, and audio files will be stored on a password-protected computer. Identifiable information will be removed and replaced with pseudonyms or disguised in any reporting. Pseudonyms will be used for participant and school names, while personal characteristics, situations, and any other information where the reader might be able to determine who a participant is will be disguised. The sequestering and anonymizing of participant data will provide some assurances that employment repercussions will be minimized. Additionally, any information derived from this research project that personally identifies participants will not be voluntarily released or disclosed without separate consent, except as specifically required by law. Publications and/or presentations that result from this study will not include identifiable information. Additionally, no
images or audio resulting from this study will be published, copyrighted, distributed, or displayed.

There are additional minimal social risks because data for the focus groups will be gathered in a social setting via Zoom. To minimize these risks, the focus groups will be held via a non-District Zoom account. Additionally, information you share will remain confidential with the researcher and your name and other personal information will not be used in the study. Other focus group participants will be asked not to reveal to anyone who was in the focus group nor what was shared.

**BENEFITS**

**Subject Benefits**
The possible benefits you may experience from the procedures described in this study include an opportunity to reflect upon your NGSS professional-development experiences.

**Benefits to Others or Society**
The possible benefits may contribute to a better understanding of NGSS professional-development experiences for teachers in [Redacted] and beyond.

**ALTERNATIVES TO PARTICIPATION**
The only alternative to participation in this study is not to participate.

**COMPENSATION, COSTS AND REIMBURSEMENT**

**Compensation for Participation**
You will not be paid for your participation in this research study.

**Costs**
There is no cost to you for participation in this study.

**Reimbursement**
You will not be reimbursed for any out of pocket expenses, such as parking or transportation fees.

**WITHDRAWAL OR TERMINATION FROM THE STUDY AND CONSEQUENCES**
You are free to withdraw from this study at any time. **If you decide to withdraw from this study you should notify the research team immediately.** The research team may also end your participation in this study if you do not follow instructions, miss scheduled visits, or if your safety and welfare are at risk.
CONFIDENTIALITY

Subject Identifiable Data
All identifiable information that will be collected about you will be removed and replaced with a code. A list linking the code and your identifiable information will be kept separate from the research data.

Data Storage
All research data will be stored on laptop computers that are password protected.

Audio and recordings will also be stored on a laptop computer that is password protected and transcribed. The recordings will be retained with the other research data.

Data Access
The researcher and faculty advisor named on the first page of this form will have access to your study records. Any information derived from this research project that personally identifies you will not be voluntarily released or disclosed without your separate consent, except as specifically required by law. Publications and/or presentations that result from this study will not include identifiable information about you.

Data Retention
The researchers intend to keep the research data for at least 3 years after the completion of research and then it will be destroyed.

Mandated Reporting
Under California law, the researchers are required to report known or reasonably suspected incidents of abuse or neglect of a child, dependent adult or elder, including, but not limited to, physical, sexual, emotional, and financial abuse or neglect. If any researcher has or is given such information in the course of conducting this study, they may be required to report it to the authorities.

IF YOU HAVE QUESTIONS
If you have any comments, concerns, or questions regarding the conduct of this research please contact the research team listed on the first page of this form.

If you have concerns or complaints about the research study, research team, or questions about your rights as a research participant, please contact the Research and Sponsored Programs office, 18111 Nordhoff Street, California State University, Northridge, Northridge, CA 91330-8232, by phone at (818) 677-2901 or email at irb@csun.edu.
VOLUNTARY PARTICIPATION STATEMENT
(For Focus Group and Interview Participants Only)
You should not sign this form unless you have read it and been given a copy of it to keep. Participation in this study is voluntary. You may refuse to answer any question or discontinue your involvement at any time without penalty or loss of benefits to which you might otherwise be entitled. Your decision will not affect your relationship with California State University, Northridge. Your signature below indicates that you have read the information in this consent form and have had a chance to ask any questions that you have about the study.

I agree to participate in the study.

___ I agree to be audio recorded
___ I do not wish to be audio recorded

Participant Signature __________________________ Date __________________________

Printed Name of Participant __________________________

Researcher Signature __________________________ Date __________________________

Printed Name of Researcher __________________________
Appendix C: NGSS Survey (Delivered via a Qualtrics Survey)

Introduction

Thank you for your participation in this professional-development survey which explores your perceptions of the professional-development activities in which you engaged to support your implementation of the Next Generation Science Standards (NGSS) and Common Core State Standards for English Language Arts/Literacy that supplement the NGSS, and the effectiveness of various features of these professional development activities in supporting the shifts that are required in your knowledge and instructional practice to fully implement the standards.

This professional-development survey should take about 15 minutes to complete and the information collected is intended to inform creators of NGSS professional-development programs about the effectiveness of various professional-development activity features. Additionally, after completing this professional-development survey you will be invited to volunteer to participate in a follow-up 90-minute focus group with a small group of teachers to further discuss your NGSS professional-development experiences. In some cases, the optional focus group might be followed-up with a short interview of 30 minutes or less.

Any of your responses to the professional-development survey questions used in my dissertation will be confidential, and your name and any other identifying information will not appear in the study.
Survey Questions

1. What is your primary role?
   a. Classroom Teacher
   b. Out-of-Classroom Teacher
   c. School Site or District Coach, Advisor, Expert, Specialist, Coordinator, or Director
   d. School Site Principal or Assistant Principal

2. Which grade(s) do you teach or support? (Please check all that apply)
   a. Grades PK-2
   b. Grades 3-5
   c. Middle School (Grades 6-8)
   d. High School (Grades 9-12)
3. Which subject(s) do you teach? (Please check all that apply)
   a. Math
   b. English Language Arts
   c. Science
   d. History/Social Studies
   e. Physical Education
   f. Visual and Performing Arts
   g. Computer Science
   h. Foreign Language
   i. Other (Please list):

4. Please rate your familiarity with the Next Generation Science Standards.
   (Not Familiar at All) 1  2  3  4  5 (Extremely Familiar)

5. Please rate your knowledge for designing instruction based on the Next Generation Science Standards.
   (Not Knowledgeable at All) 1  2  3  4  5 (Extremely Knowledgeable)

6. Please rate your skill delivering instruction designed for the Next Generation Science Standards.
   (Developing) 1  2  3  4  5 (Advanced)
7. Please rate your familiarity with the Common Core State Standards for English Language Arts/Literacy that supplement the Next Generation Science Standards.
   (Not Familiar at All) 1  2  3  4  5 (Extremely Familiar)

8. Please rate your knowledge for **designing** instruction that requires students to engage in argument from evidence.
   (Not Knowledgeable at All) 1  2  3  4  5 (Extremely Knowledgeable)

9. Please rate your skill **delivering** instruction that requires students to engage in argument from evidence.
   (Developing) 1  2  3  4  5 (Advanced)

Please rate your knowledge of the following:

10. I can identify and describe the parts of a Next Generation Science Standard
    (Not Knowledgeable at All) 1  2  3  4  5 (Extremely Knowledgeable)

11. I can identify the three-dimensions of the Next Generation Science Standards
    (Not Knowledgeable at All) 1  2  3  4  5 (Extremely Knowledgeable)
12. I can identify the science and engineering practices and describe what they look like in the classroom

(Not Knowledgeable at All)1  2  3  4  5(Extremely Knowledgeable)

13. I can identify the crosscutting concepts and describe what they look like in the classroom

(Not Knowledgeable at All)1  2  3  4  5(Extremely Knowledgeable)

14. I can take a current lesson and make it three-dimensional

(Not Knowledgeable at All)1  2  3  4  5(Extremely Knowledgeable)

15. I can develop a performance task for a performance expectation or bundle of performance expectations

(Not Knowledgeable at All)1  2  3  4  5(Extremely Knowledgeable)

16. I can plan a three-dimensional lesson sequence using the Next Generation Science Standards

(Not Knowledgeable at All)1  2  3  4  5(Extremely Knowledgeable)
For the following expectations of the NGSS, think about how often you engage your students in each activity:

17. Students learn facts and terminology as needed while developing explanations and designing solutions supported by evidence-based arguments and reasoning
   a. Daily
   b. Several Times a Week
   c. Weekly
   d. Monthly
   e. Rarely

18. Students use systems thinking and modeling to explain phenomena and to give a context for the ideas to be learned
   a. Daily
   b. Several Times a Week
   c. Weekly
   d. Monthly
   e. Rarely
19. Students conduct investigations, solve problems, and engage in discussions with teachers’ guidance

   a. Daily
   b. Several Times a Week
   c. Weekly
   d. Monthly
   e. Rarely

20. Students discuss open-ended questions that focus on the strength of the evidence used to generate claims

   a. Daily
   b. Several Times a Week
   c. Weekly
   d. Monthly
   e. Rarely

21. Students read multiple sources, including science-related magazines, journal articles, and web-based resources

   a. Daily
   b. Several Times a Week
   c. Weekly
   d. Monthly
   e. Rarely
22. Students develop summaries of information
   a. Daily
   b. Several Times a Week
   c. Weekly
   d. Monthly
   e. Rarely

23. Students conduct multiple investigations driven by students’ questions with a range of possible outcomes that collectively lead to a deep understanding of established core scientific ideas
   a. Daily
   b. Several Times a Week
   c. Weekly
   d. Monthly
   e. Rarely
24. Students write journals and reports as well as create posters and media presentations that explain and argue
   a. Daily
   b. Several Times a Week
   c. Weekly
   d. Monthly
   e. Rarely

25. I provide supports so that all students can engage in sophisticated science and engineering practices
   a. Daily
   b. Several Times a Week
   c. Weekly
   d. Monthly
   e. Rarely
26. In addition to the STEAM Micro-Credentialing Program during the 2018-2019 school year, how many additional NGSS-focused or Common Core State Standards for English Language Arts/Literacy focused professional-development experiences have you engaged in to learn about the Next Generation Science Standards? (Consider traditional workshops and professional-development sessions, conferences, college courses, fellowship programs, etc.):

a. I have only participated in only the STEAM Micro-Credentialing Program to learn about the Next Generation Science Standards

b. I have participated in 1-2 professional-learning experiences in addition to the STEAM Micro-Credentialing Program to learn about the Next Generation Science Standards

c. I have participated in 3-4 professional-learning experiences in addition to the STEAM Micro-Credentialing Program to learn about the Next Generation Science Standards

d. I have participated in 5 or more professional-learning experiences in addition to the STEAM Micro-Credentialing Program to learn about the Next Generation Science Standards
27. Reflecting on all your NGSS professional-development experiences, please consider the **most impactful** NGSS professional-development activity within one of these experiences that caused you to implement something new in your classroom. For this most impactful professional-development activity, please provide the following information:

a. Please describe the professional-development activity in which you engaged:
   
i. What did you do in the activity,
   
ii. how did you do it,
   
iii. why did you do it?
   
iv. What knowledge and skills did you learn from this activity?
   
v. What were your feelings about this professional-development activity?

b. What did you implement in your classroom as a result of this professional-development activity?

c. What motivated you to continue using (or eventually abandoning) the implementation of what you learned?

d. How did your students respond to your implementation of what you learned?

e. Did you modify the implementation of what you learned in any way? If so why? If not, why not?
Conclusion

Thank you for your willingness to complete this professional-development survey and provide valuable information about your experiences with the Next Generation Science Standards. I would like to invite you to an additional opportunity to share more of your thoughts about the Next Generation Science Standards and science professional-development activities with a small group of your colleagues during a small 90-minute focus group session.

28. Would you be willing to participate in a 90-minute focus group to discuss your professional-development learning experiences with a small group of teachers?
   a. Yes, I would be interested in participating in a focus group:
      i. Your First Name:
      ii. Your Last Name:
      iii. [Redacted] Email Address:
      iv. Personal, non-[Redacted] Email Address
   b. No, I am not able to participate in a focus group at this time
Appendix D: Focus Group Interview Protocol

**Research Question.** What are teachers’ perceptions of the professional-development activities in which they engaged to support their transition to the Next Generation Science Standards and the effectiveness of the various features of these professional-development activities in supporting their implementation of the Next Generation Science Standards and the Common Core State Standards for English Language Arts/Literacy that supplement them?

**Sub-Questions.**

1. What types of professional-development activities have teachers engaged in to support their implementation of the NGSS and the Common Core State Standards for English Language Arts/Literacy that supplement them?

2. What knowledge and skills do teachers perceive they gained from participation in NGSS professional-development activities that supported their implementation of these content standards in their classrooms?

3. What are the features of professional-development activities that teachers perceive as most helpful for gaining new knowledge and skills to support their implementation of these content standards?

4. What areas for improvement in NGSS professional-development activities do teachers identify to better support their implementation of these content standards?
Focus Group Introduction:

Welcome, and thank you for being here today to participate in this focus group. The purpose of this focus group is to learn more about your professional-development experiences with the Next Generation Science Standards and the Common Core State Standards for English Language Arts/Literacy that supplement them. I will guide our focus group today by asking the group 10 questions. There are no right or wrong answers and you can feel free to respond to both my questions and the comments of your colleagues.

Before we begin I would like to remind you that our conversation today will be recorded so that I can capture everyone’s comments and answers. Also, this focus group is anonymous and confidential. This means that I will not use your names in my dissertation nor will I disclose who was in this group and what they said. I ask that each of you also not share who is in this focus group nor what they shared outside of this room today. Finally, I will not use information revealed by your participation in this study in any way that impacts your employment or evaluation of your work.

Focus Group Interview Questions:

Warm-up:

- Please tell us your name, how long you have been teaching, and how long you have been teaching at your current school.
1. What do you know about the NGSS?
   a. How are they different from previous science standards?
   b. What is their relationship to the Common Core State Standards for English Language Arts/Literacy?
   c. What are some changes you’ve made to your instruction as a result of these new standards?

2. On a scale of 1-10, where are you in your classroom implementation of NGSS (1 = have not started implementing, 10 = full implementation)?
   a. What challenges have you experienced in implementing the NGSS?
   b. What has prevented you from being a “10”?
   c. What support or resources do you need to become a “10”?
   d. What challenges do you foresee as you move towards greater implementation?

3. What types of NGSS professional-development activities have you engaged in to learn about the NGSS?
   a. How did you feel about the effectiveness of these professional-development activities?
   b. As you think specifically about what made the activities effective or ineffective in supporting your learning, what do you see?
4. If one of the NGSS professional-development activities you participated in was particularly helpful in supporting your implementation of a new classroom practice, can you describe specifically what you did in the professional-development activity?
   a. What did you learn?
   b. How did you use what you learned in your classroom? What new practice did you implement?
   c. After you tried what you learned in your classroom, what motivated you to continue using, or abandon, the new practice?
   d. How did your students respond to your implementation of this new practice?
      i. Did their reaction to the new practice motivate you to keep using, modify, or abandon the new practice you implemented?
   e. What was it specifically about the activity that was helpful in supporting your learning and changing your practice? For example, how long did it last, what was the content, who did you participate with, and what did you do?
5. If one of the NGSS professional-development activities you participated in was not particularly helpful, can you describe specifically what you did in the activity?
   
a. What was the activity trying to help you learn?
   
b. What was challenging about the content you were trying to learn?
   
c. What was it specifically about the activity that was not helpful in supporting your learning or changing your practice?

6. You have my complete attention. As I plan new NGSS professional-development activities for next year, what do you want me to know or do?
   
a. What would you really like to learn most?
   
b. How would you want the activities designed so that you could learn the best?
   
c. What should I avoid?

7. Imagine you had a magic wand that you could use to improve the existing professional-development experiences currently available to you so that they better supported you in implementing the NGSS.
   
a. How would you use your magic wand to improve science professional development?
   
b. What would you most want to learn?
   
c. Why did you choose these areas for improvement and learning?
8. What experiences have you had with NGSS professional development that was delivered outside of the district?
   a. What did you learn?
   b. How did your practice change as a result?
      i. What do you think caused your practice to change?
   c. What do you think about the effectiveness of these professional-development activities in supporting your learning?
   d. What made them effective or ineffective?
   e. How important do you think it is for a teacher to have both district-run and outside PD?

9. Is there anything else you would like to tell district leaders regarding teacher professional-development support for NGSS implementation?

10. Is there anything else you would like to add?
Appendix E: Follow-Up Email Protocol

**Research Question.** What are teachers’ perceptions of the professional-development activities in which they engaged to support their transition to the Next Generation Science Standards and the effectiveness of the various features of these professional-development activities in supporting their implementation of the Next Generation Science Standards and the Common Core State Standards for English Language Arts/Literacy that supplement them?

**Sub-Questions.**

1. What types of professional-development activities have teachers engaged in to support their implementation of the NGSS and the Common Core State Standards for English Language Arts/Literacy that supplement them?

2. What knowledge and skills do teachers perceive they gained from participation in NGSS professional-development activities that supported their implementation of these content standards in their classrooms?

3. What are the features of professional-development activities that teachers perceive as most helpful for gaining new knowledge and skills to support their implementation of these content standards?

4. What areas for improvement in NGSS professional-development activities do teachers identify to better support their implementation of these content standards?
Follow-Up Email Introduction:

The purpose of this follow-up email is to learn more about some of the things you shared during your participation in our focus group. There are no right or wrong answers.

I would like to remind you that this follow-up email is confidential. This means that I will not use your name in my dissertation. Finally, I will not use information revealed by your participation in this study in any way that impacts your employment or evaluation of your work.

Follow-Up Interview Questions and Probes:

1. During our focus group, you indicated that [restate portion of focus group response shared by interviewee]. To help me further clarify and better understand what you said, can you please tell me more about shared?
   a. Can you please say what you meant by [repeat the response they shared during the focus group]?
   b. During the focus group, it sounds like you were saying [paraphrase what I think they said]. Is that an accurate summary?
   c. Tell me more about that…
   d. Can you please give me an example?
   e. What did that look like?
   f. How did you feel about that?
   g. Why did that stand out to you?
   h. How did that help you?