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Exploration of Lived Experiences of Science Teachers of English Language Learners: A Transcendental Phenomenological Study

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Abstract

English language learners (ELLs) are a talented pool of culturally and linguistically diverse students who are persistently increasing both in absolute size and percentage in the U.S. school population; however, they are underrepresented in science, technology, engineering, and mathematics (STEM) fields in college as well as in the workforce (National Academies of Sciences, Engineering, and Medicine, 2018). Although educational leaders, policy makers, and researchers have emphasized the importance of STEM for the country's continued prosperity, both education and scientific communities have found it challenging to improve students' participation in STEM fields (Martinez et al., 2011). Exploring science teachers' experiences could aid in improving academic achievement of ELLs and promoting educational equity. The purpose of this transcendental phenomenological study is to explore and describe the lived experiences of science teachers of ELLs at a public high school in a large Midwestern city in the USA. Data will be collected from 5-10 science teachers of ELLs (or until data saturation is reached) using individual in-depth, semi-structured and focus group interviews. Data will be analyzed using MAXQDA to search for dominant themes. The findings and discussion will describe these themes, i.e., the overall essence of the phenomenon of teaching science to ELLs. Insights into teachers' experiences will help educators, educational leaders, policy makers, and researchers to better understand methods to improve ELLs' science outcomes. I will include potential limitations, implications, and possible areas for future research that could pave ways for increasing participation of ELLs in STEM fields and related careers.

Keywords: English language learners, STEM education, 5E inquiry-based instructional model, NCLB, NGSS, NCCRS-S

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Introduction and Statement of the Problem

Context of the Problem

Science educators and educational institutions have long been concerned about the status of science content being taught in K-12 schools and the delivery of the content. Educational reformers in the United States continue to strive to solve the problem on how to best teach science for optimal success in learning for all students. With mandatory testing nationwide, along with an increase in science, technology, engineering, and mathematics (STEM) jobs and little workforce to fulfill these needs, the question of what to teach and how to teach science remains a concern among educators and all stakeholders (McWright, 2017).

In the educational context of the USA, there have been sweeping educational reforms that focus on “high academic standards and achievement for all students” (Buxton & Lee, 2014, p. 204). There has been an increased urgency to raise the standards of science education due to four primary factors: (a) the growing linguistic and cultural diversity of the U.S. student population, (b) persisting gaps in standardized and high-stakes testing across the demographic subgroups that is intensified by No Child Left Behind Act (NCLB) and Race To The Top (RT^3) initiatives by the government, (c) evolving social and personal motives for learning advanced science for making informed decisions and for career and college readiness, and (d) the increase in linguistic and cognitive demands which are present in Next Generation Science Standards (NGSS) and NRC’s (2012) *Framework for K-12 Science Education* (Buxton & Lee, 2014). As the site of my research will be a public high school in a large Midwestern city in the state of Nebraska, I would like to add that the State of Nebraska also has its own science standards called Nebraska’s College and Career Ready Standards for Science (NCCRS-S) mirroring the three dimensions of NGSS of disciplinary core ideas, cross-cutting concepts, and science and engineering practices (see Appendix G).

The creation of NGSS and implementation of Common Core education have been in the spotlight as ways to improve K-12 education. The purpose of NGSS is to better prepare students for the workforce and college by developing critical-thinking skills and scientific literacy and building interest in science, technology, engineering, and mathematics (McWright, 2017).

The USA ranks 20th among all nations in the proportion of 24-year-olds who earn degrees in natural science or engineering (Cadle, 2020). According to the projections for 2012-2022 of the United States Department of Education and the United States Department of Labor, STEM jobs are likely to grow by 13%, with mathematical and scientific fields projected to have the highest growth at 26%, followed by computer and mathematical sciences at 18%, life sciences and social sciences at 10%, and architectural and engineering fields at 7.3%. STEM-related jobs grew at three times the rate of non-STEM jobs between 2000 and 2010 (“The STEM Imperative,” 2016). As the demand for STEM jobs is increasing, the number of students entering STEM fields, especially people of color and minority students, is not increasing. The number of students entering STEM fields majoring in STEM fields in college is low, and the number of students taking science classes, such as physics and chemistry, is extremely low for many states (McWright, 2017). In the U.S. job market, nearly 2.4 million STEM jobs went unfilled in 2018 (Moseley, 2019). At the same time, minorities are very much underrepresented in STEM fields—just 2.2% of Latinos, 2.7% of African Americans, and 3.3% of Native Americans and Alaska Natives have managed to earn a university degree in STEM fields. This underrepresentation means that minorities lack qualifications to access STEM-related jobs, which are also better paid than many other jobs (“The STEM Imperative,” 2016). Moreover, there could be more job opportunities for the minorities who can potentially take up unfilled STEM jobs, upward economic mobility as the average salaries of STEM jobs is 70% more than the national average, and development of skills for the minorities as the U.S. Bureau of Statistics says that in the next 20 years 80% of jobs will require technical skills (U.S. Department of Education, n.d.). Bybee (2010) emphasizes that by enrolling in STEM disciplines, students can develop 21st Century skills such as adaptability, complex communication, social skills, nonroutine problem solving, self-management/self-development, and systems thinking (NRC, 2010). He adds that in STEM programs, student investigations and projects present the time and opportunity for teachers to help students develop 21st Century skills (Bybee, 2010).

The reason to select emergent bilinguals as this paper's target student population is because they mostly belong to the minority population of the USA, and because science teachers experience many problems teaching science to ELL students. The Hispanic or Latinx students are the majority among the ELL student population, and Spanish is the most commonly spoken language in the USA ("Our Nation's English Learners," n.d.). The percentage of ELL students studying in public schools in the United States has increased from 8.1% in Fall 2000 to 9.6% in Fall 2016 ("English Language Learners in Public Schools" [NCES, 2019]). Many skills required for STEM jobs and other jobs can be developed in inquiry science classrooms (Bybee, 2013). Based on the conception of equity and social justice from a cultural anthropology or cross-cultural perspective, I want to address issues of equity in science learning and teaching for students from diverse languages and cultures.

Significance of the Study

The ELLs embark on a personal journey when they learn science, which becomes their lived experiences that shape what they become and how they interact with others (Torres-Ovrick, 2014). Bandura (1993) posited that "the task of creating environments conducive to learning rests heavily on the talents and self-efficacy of teachers" (p. 140). With my research, I hope to add to the body of literature concerned with the need to provide opportunities to engage science teachers in the process of self-reflection, deconstruction, and reconstruction of their held beliefs regarding teaching the culturally and linguistically diverse students. I believe that the need for science teachers to engage in critical reflections about their beliefs is imperative. Thus, by researching on the lived experiences of science teachers, I hope to gain insights that could pave new ways for increasing participation of ELLs in STEM fields and related careers.

Definitions of Key Terms

English Language Learners

Emergent bilinguals, English language learners (ELLs), or English learners (ELs) are a diverse group representing different cultures, languages, ethnicities, and nationalities ("Our Nation's English Learners," n.d.). They are learners who are in the developing stages of acquiring their native language (L1) and/or a second language (L2), and who have the ability to tap into both languages as resources. The term "emergent bilingual" signifies a positive description of these students as it indicates that the student is learning in two languages, and that both languages are of value ("What is Emergent Bilingual," 2020).

STEM Education

According to Hom (2014), STEM is a curriculum based on the idea of educating students in four specific disciplines—science, technology, engineering, and mathematics—in an interdisciplinary and applied approach. The U.S. Department of Education emphasizes that in an ever-changing, increasingly complex world, it is more important than ever that the nation's youth are prepared to bring knowledge and skills to solve problems, make sense of information, and know how to gather and evaluate evidence to make decisions. These are the kinds of skills that students develop in STEM.

5E Inquiry-Based Instructional Model

Since the late 1980s, Biological Sciences Curriculum Study (BSCS) has used one instructional model extensively in the development of new curriculum materials and professional development experiences. That model is commonly referred to as the BSCS 5E Instructional Model, or the 5E Inquiry-Based Model. It consists of the following phases: engagement, exploration, explanation, elaboration, and evaluation. Each phase has a specific function and contributes to the teacher's coherent instruction and to the learners' formulation of a better understanding of scientific and technological knowledge, attitudes, and skills. This model helps science teachers to improve their instructional practices to enhance student learning (Bybee et al., 2006).

No Child Left Behind Act (NCLB)

No Child Left Behind (NCLB) Act was the main law for K–12 general education in the United States from 2002–2015. NCLB Act of 2001 was a version of the Elementary and Secondary Education Act (ESEA). NCLB was replaced by Every Student Succeeds Act (ESSA) in 2015. When NCLB was the law, it affected every public school in the United States. Its goal was to level the playing field for students who are disadvantaged, including students in poverty, minorities, students receiving services, and those who speak and understand limited or no English. The law held schools accountable for how kids learned and achieved. The law was controversial partly because it penalized schools that did not show improvement (Lee, 2020).

Next Generation Science Standards (NGSS)

The Next Generation Science Standards (NGSS) are K–12 science content standards. Standards set the expectations for what students should know and be able to do. The NGSS were developed by the states to improve science education for all students. A goal for developing the NGSS was to create a set of research-based, up-to-date K–12 science standards (“Next Generation Science Standards,” 2020).

Nebraska’s College and Career Ready Standards for Science (NCCRS-S)

Nebraska’s College and Career Ready Standards for Science (NCCRS-S) were adopted by the Nebraska State Board of Education on September 8, 2017. The development of Nebraska’s College and Career Ready Standards for Science were guided by The National Research Council’s *A Framework for K-12 Science Education*. Nebraska’s vision for science education is aimed at all students having meaningful access to the educational resources they need at the right moment, at the right level, and with the right intensity supported by high quality instructional materials (“Science Education [NCCRS-S],” 2017).

Philosophical Assumptions and Theoretical Framework

Before elaborating on the theoretical framework for this study, it is important to address my philosophical assumptions regarding qualitative research. Babchuk and Badiee (2011) stated that considering the philosophical and epistemological perspectives and paradigms is “critical both for evaluating others’ research as well as the ability to conceptualize and operationalize one’s own research designs” (Babchuk & Badiee, 2011, p. 27). My study will use social constructivism or interpretivism as the framework (Creswell & Poth, 2018) because as a researcher, my goal is to interpret the participants’ (science teachers’) constructions of meaning of teaching science to ELLs. Denzin and Lincoln (2011) stated, “the constructivist paradigm assumes a relativist ontology (there are multiple realities), a subjectivist epistemology (knower and respondent co-create understanding), and a naturalistic (in the natural world) set of methodological procedures” (p. 13). Creswell & Poth (2018) also stated that social constructivism is an interpretivist framework which relate to the ontological, epistemological, axiological, and methodological philosophical beliefs. Neuman

(2011) stated regarding epistemology, “the best knowledge about the world that we can produce is to offer carefully considered interpretations of specific people in specific settings” (p. 93). I will use these philosophical assumptions to guide my study.

To understand the underpinnings of science teachers’ beliefs, a socio-constructivists’ framework is assumed in which knowledge is constructed and mediated within sociocultural contexts. Gonzalez (1997) assumed a socio-constructivist stance when analyzing teachers’ beliefs. From this ideology, I recognize that knowledge is constructed on two mental planes, i.e., interpsychological and intrapsychological (Vygotsky, 1978). People’s conventional ideas, beliefs, and conceptualizations are formulated from experiences they have within a sociocultural context, such as familial and educational experiences. In essence, the social structure becomes the mechanism for modeling expectations and standards of the norms of a given community or society (Flores, 2001).

The framework for this paper is based on the social constructivist learning theory of Vygotsky using the 5E Inquiry-based Instructional Model for scaffolding instruction and Krashen’s theories of second language acquisition. Sociocultural theory (SCT) has its origins in the writings of the Russian psychologist L. S. Vygotsky and his colleagues (Lantolf, Thorne, & Poehner, 2015). Vygotsky’s (1978, 1986) sociocultural theory of cognitive development and human learning describes learning as a social process and the origination of human intelligence in society or culture (Lantolf, Thorne, & Poehner, 2015). “Science educators have used social constructivism as a theoretical framework for research and practice for several decades. Constructivist learning theory suggests new knowledge is built by learners by integrating new ideas into what they had previously learned” (Weinburgh, Silva, Smith, Groulx, & Nettles, 2014, p. 521). The major theme of Vygotsky’s theoretical framework is that social interaction plays a fundamental role in the development of cognition. This theory stresses the interaction between developing people and the culture in which they live. SCT argues that human mental functioning is fundamentally a mediated process that is organized by cultural artifacts, activities, and concepts. For example, a child cannot learn many things (like language skills) without society. They need to be with people to learn how to use language. Practically speaking, developmental processes take place through participation in cultural, linguistic, and historically formed settings such as family life, peer group interaction, and institutional contexts like schooling, organized social activities, and workplaces (Lantolf, Thorne, & Poehner, 2015). SCT argues that the most important forms of human cognitive activity develop through interactions and conditions found in instructional settings (Engeström, 2019). I believe this is quite relevant for ELL students to learn science in a school/classroom setting.

Vygotsky focused on social interactions and language as tools to scaffold instruction for the students to promote their understanding. There are useful models that can be used to teach science for ELLs based on Vygotsky's theory. In the era of NGSS, Rodger W. Bybee and a team of his colleagues proposed the BSCS 5E Instructional Model. The 5E Instructional model (see Appendix H) is based on the psychology of learning (NRC, 1999) and the observation that students need time and opportunities to formulate or reconstruct concepts and abilities. These two factors justify the perspective for each phase and the sequence of 5E. Using the 5E model, science teachers of emergent bilinguals can effectively engage the students, explore phenomena, explain phenomena, elaborate scientific concepts and abilities, and evaluate ELLs (Bybee, 2014). The 5E Inquiry-Based Instructional Model on Scaffolding Instruction is based upon cognitive psychology, constructivist theory to learning (Vygotsky's ZPD principle), and best practices in STEM instruction. The conceptual framework of Vygotsky can be found in Appendix I. Vygotsky proposed that children and adults are both active agents in the process of the child's learning and development, and it is the quality of teacher-learner interaction that is most crucial in the child's learning (Vygotsky, 1978). The two principles of Vygotsky's work are: (a) "More Knowledgeable Others" (MKO) and (b) "Zone of Proximal or Potential Development" (ZPD). The teachers or more skilled peers are the MKO, and they are integrally linked to the second principle of ZPD. ZPD is defined by Vygotsky as "the difference between actual level of development as determined by independent problem solving and the higher level of potential development as determined through problem solving under guidance or in collaboration with more capable peers" (Verenikina, 2010, p. 3). According to Vygotsky, the key processes in development and learning of children are zone of proximal development, scaffolding, language/dialogue, and tools of culture (McLeod, 2018). The teaching implications for Vygotsky's theory are that it establishes opportunities for children to learn with the teacher and more skilled peers. To put it simply, ZPD relates to the difference between what a child can achieve independently and what a child can achieve with guidance and encouragement from a skilled teacher or partner (McLeod, 2018). According to Vygotsky, "good learning" occurs in the Zone of Proximal Development (Verenikina, 2010).

Furthermore, in his Acquisition-Learning Hypothesis, Krashen (1981, 1982) proposes that language acquisition is a natural and subconscious process similar to first language acquisition through explicit instruction and casual interactions with the language. Second language learners acquire language from their social environment through meaningful interactions (Torres-Ovrick, 2014). Krashen (1982) asserts that we acquire language when we receive messages that we can comprehend. This is known as the Comprehensible Input Hypothesis. Students need to understand what they hear or read in order to learn. Therefore, it is quite possible that an ELL might not have enough English knowledge to learn English or to learn subject matter (science) taught in the second language. Krashen (1996) found that it is easier for children to learn to read in a language they understand and then transfer that knowledge to English, and he stresses the importance of acquiring content knowledge, which

I believe, is especially important for learning science that has many challenging scientific terminologies, equations, and concepts. To understand the science meaning-making process of emergent bilinguals, Aikenhead (2001) also explains that science is easily understood by students if there is similarity between their own culture and experiences and culture of modern school science, which he terms as “cultural border crossings of students into school science” (Aikenhead, 2001, p. 1).

Literature Review

In the extant literature relevant to this study, there were some references to benefits of teaching science/STEM to ELLs. In the following paragraph, I have synthesized salient points of the literature related to the urgent need to improve science literacy for ELL students, the “achievement gap” between the white race and other minorities in STEM education, science teachers’ beliefs and perceptions of teaching ELL students, need for family/community engagement models for ELLs, and the need for professional development for science teachers who teach ELLs.

As the school student population in the USA is becoming more linguistically and culturally diverse, it is essential to set up a knowledge base that enhances academic achievement and equity for all students (Lee, 2003). With increasing demand and need for students to enroll and succeed in STEM subjects, it is imperative that science education research focuses on the strategies to improve the scientific literacy of ELL students who are the fastest growing K-12 student population (Turkan & Liu, 2012). There is an urgent need for effective family and community engagement models for ELLs in STEM to recognize and make connections to families’ and communities’ cultural and linguistic practices and study their relationship to STEM topics (Francis & Stephens, 2018). Santau et al. (2010) identified that there is an urgent need in the USA and other countries of the world for science education reforms due to the rapidly changing technological and economic demands of the modern era. Caucasian and Asian-American students outperformed African American and Latino/Hispanic-American students in science achievement tests (Lawrenz et al., 2001). Hart and Lee (2010) indicate that teachers will need more professional development programs to be able to implement and maintain reform-oriented practices that will enhance science achievement of linguistically and culturally diverse students. Kirmaci, Allexsaht-Snider, and Buxton (2018) state that teacher-parent collaboration can play a critical role in promoting diverse students' post-secondary education attendance and academic success. Their findings highlight the potential for designing new professional development opportunities to support secondary teachers in collaborating with parents who bring a wide range of cultural, ethnic, socioeconomic, and linguistic resources in supporting their children's learning and schooling. Another study by Tandon, Viesca, Hueston, and Milbourn (2017) examined data from 36 teacher candidates and novice teachers of multilanguage learners (MLLs) to explore their perceptions and understandings of linguistic responsiveness. The findings illustrate that there are challenges faced by teachers in demonstrating linguistically responsive teaching practices in the early and initial stages of entering the teaching profession, and that more research is necessary to understand how to support teachers in this complex mission.

Thus, the overall findings of the literature reveal that the capability of ELL students to demonstrate high levels of scientific achievement and possible careers in scientific fields is enhanced when the teachers demonstrate self-efficacy and possess unique qualities that help ELLs; use culturally and linguistically responsive teaching methods; have good support systems from the school administration, parents, and educational policies; have professional development opportunities; and provide the students with equitable and favorable learning and assessment opportunities by using scaffolding and inquiry method in their instruction. The four overarching benefits of teaching STEM for ELL students were also identified: a) improving the academic outcomes of ELLs, b) meeting the requirements of NGSS, NCLB, and other state and national science standards, c) improving college readiness among the ELL population, and d) creating competent scientific workforce (Turkan & Liu, 2012; Francis & Stephens, 2018; Lawrenz et al., 2001; Hart & Lee, 2010; Lee, 2003, Santau et al., 2010).

The Present Study

Researcher Positioning and Reflexivity

According to Creswell and Poth (2018), it is important for all qualitative researchers to position themselves in their study and writing. Being reflexive means that "a writer engages in self-understanding about the biases, values, and experiences that he or she brings to a qualitative research study" (p. 229). As my study is a phenomenological study, I am going to use epoché or bracketing (Moustakas, 1994) to set aside my own personal experiences regarding teaching science to ELL students while collecting and analyzing data to be able to view the data without any personal bias or preconceived notions. As Lichtman (2013) also emphasizes about epoché that "bracketing involves placing one's own thoughts about the topic in suspense or out of question. Epoché involves the deliberate suspension of judgment" (p. 88). Merriam and Tisdell (2016) and Creswell and Poth (2018) have also stated that the researchers must suspend their personal experiences, biases, and assumptions with or towards the phenomenon, and they must approach the phenomenon from a new perspective to understand the meaning the participants have created and to discover elements that have been "taken for granted" as being true (Bogdan & Biklen, 2007, p. 25).

Taking all the views of these scholars into consideration, I would like to position myself in this study as an Asian woman of color, a Ph. D. student aspiring to become a university professor, who has lived in India, D. R. Congo, and the USA. I am also a mother of a 19-year-old boy, an undergrad at UNL, who lives with me. I have traveled widely to different parts of the world, such as Dubai, Singapore, Thailand, and Zambia, in effect I have encountered and interacted with people of diverse races, ethnicities, socioeconomic classes, religions, cultures, and nationalities. I have two master's degrees, one in environmental toxicology and another in business administration. I have been in the teaching profession for a major part of my career, having taught in high schools in D. R. Congo, pharmacy colleges in India, and is presently teaching “Multicultural Education” and “Teaching Science in the Elementary School” at our university. Due to my overall work and teaching experience of 26 years, I have had the opportunity to teach diverse international students. For almost 6 years, I have taught Biology and Chemistry to English language learners in an American International high school in Lubumbashi, D. R. Congo. I would say that teaching scientific vocabulary-rich subjects has not been easy to these students who were either culturally or linguistically diverse (many of them were Swahili or French speakers). As I am from a science background, I used to have a postpositivist mindset, but now I am increasingly getting attracted to the constructivist worldview because of my continuing education. Hence, because there is a possibility of my perceptions affecting the study (because of the probability of shared experiences with the participating teachers), I would like to take necessary steps and precautions to suspend my judgments during the data collection and analysis stages. I understand that my perceptions and assumptions could be biased and maybe incorrect, so I will work to bracket my ideas and thoughts in order to understand the participants' point of view. I believe my own lived experiences and understandings as a science teacher will aid my hearing and understanding the perceptions of the participants. One way that I could bracket myself is by journaling my own feelings, thoughts, biases, assumptions, and experiences while I am in the process of interviewing and analyzing the data so that I can reflect on some elements that may interfere with unbiased interpretation of participants' views and subsequent findings of the study. I will also ensure to follow up with validation strategies to support my data and to make my study trustworthy.

Purpose Statement

The purpose of this transcendental phenomenological study is to describe the lived experiences of science teachers of ELLs at a public high school in a large Midwestern city in the USA.

Research Questions

Central Question

What are the common experiences of science teachers teaching English language learners?

Sub-Questions (SQ)

SQ1: What supports are available to the teachers for teaching science to ELLs?

SQ2: What are the challenges experienced by the teachers in teaching science to ELLs?

SQ3: In what ways do extrinsic factors (e.g., parents, school administration, and educational policies) and intrinsic factors (e.g., motivation and self-efficacy) influence the teacher's ability to teach science to ELLs?

Methodology

Conceptual Framework

Science teachers aid in the construction of knowledge of emergent bilinguals by various social interactions and their own beliefs and perceptions. I hypothesize that teachers' knowledge, perceptions, and scaffolding of instruction could increase the ELLs' understanding of science. Based on the conceptual framework of Vygotsky's classical social constructivist theory, 5E Inquiry-Based Instructional Model, and Krashen's theories of second-language acquisition that I have already described in the theoretical framework section, I have proposed the conceptual framework for my study (see Appendix J). While researching about the perceptions of science teachers in the extant literature, I identified six major stakeholders, and the interconnections between them highlights the importance of using the inquiry method and other theories for teaching science for ELLs, as is illustrated in the overlapping Venn diagram. All the stakeholders are linked to each other by arrows that outlines the purpose of their interaction, further emphasizing the need for scaffolding instruction for ELLs to improve their academic outcomes and their interest in pursuing STEM careers, as I have mentioned in my abstract. "Each "E" helps in building the scaffolding necessary for students to construct their own knowledge" (Shelton, 2014). Science teachers need to be explicit and intentional in planning the scaffolding and should layer it appropriately, so that scaffolding addresses the students' misconceptions and aids in closing the gaps in students' learning. During a 5E's sequence, students begin by connecting to their own experiences or by tapping into their own curiosity and continually build on and revise their understanding. Furthermore, the framework is also supported by two hypotheses of Krashen (1981, 1982, 1996).

Rationale for a Qualitative Research Design

Merriam and Tisdell (2016) state that qualitative research is implemented when *researchers are particularly interested in exploring how people interpret their experiences*, how they construct their worlds, and what meaning they attribute to their experiences. According to Creswell and Poth (2018), qualitative research begins with assumptions and the use of interpretive/theoretical frameworks that inform the *study of research problems addressing meaning individuals or groups ascribe to a social or human problem*. Bogdan and Biklen (2007) define qualitative research as an approach to social science research that emphasizes *collecting descriptive data in natural settings, uses inductive thinking, and* *emphasizes understanding the subjects' point of view*. Denzin and Lincoln (2011) illustrate that the role of qualitative researchers is to "study things in their natural settings, attempting to make sense of or interpret phenomena in terms of the meanings people bring to them" (p. 3). These guidelines compliment my goals in this study for me to understand how science teachers ascribe meanings to their unique experiences working with ELL students. Using a qualitative design will help me collect rich information on the science teachers' interpretations of their lived experiences, how they perceive their challenges and support systems, and how their ability to teach ELL students is affected by extrinsic and intrinsic factors. I also hope to describe the essence of the lived experiences in a literary form of writing that allows the reader to explore the complexities of the topic (Creswell & Poth, 2018). So, I believe that a qualitative design fits my study and its requirements.

Rationale for a Transcendental Phenomenological Approach

Although there are many choices of approaches of qualitative research, I specifically chose phenomenological approach because of the following reasons: a) phenomenology emphasizes the participant's experience and their interpretation of that experience (Merriam & Tisdell, 2016), b) it describes a common meaning for the individuals who have lived experiences of the same phenomenon (Lichtman, 2013; Creswell & Poth, 2018), and c) the practice of phenomenology is rooted in the idea that all of us construct our own reality (Bogdan & Biklen, 2007). Among the sub-approaches of phenomenology, my research study is well suited for a transcendental approach since it satisfies most requirements of this sub-approach. To elaborate further, my research focus is to understand the essence of the experience of teaching science to ELLs, and my research problem is to describe the essence of a lived phenomenon, i.e., teaching science to ELLs. Moustakas' (1994) transcendental approach focuses less on the researchers' interpretations and more on the description of participants' (science teachers') experiences (emic perspective). "Transcendental" means "in which everything is perceived freshly, as if for the first time" (Moustakas, 1994, p. 34). It also involves setting aside (bracketing) one's own judgments or bias and focusing on the way the participants understand and experience a particular phenomenon (Creswell & Poth, 2018). I would also analyze the data and reduce it to significant statements and quotes and combine them into themes. Then I will develop textural description of experiences of the science teachers (what they experienced) and structural description (how they experienced it in terms of conditions, situations, or contexts), and the overall essence will be conveyed by combining both the textural and structural descriptions (Creswell & Poth, 2018).

IRB and Ethical Considerations

To ensure that I am conducting an ethical study, I will seek approval from the Institutional Review Board (IRB) of University of Nebraska-Lincoln before commencing my data collection procedures. I will first submit a proposal detailing my research procedures to the IRB. All personnel, including myself, working on this project will complete all of the required CITI course training for the University of Nebraska-Lincoln IRB committee. As the participants will be chosen purposefully using a criterion sampling, I will ensure that all participants are adult teachers (above 19 years of age) who will be interviewed individually and as a focus group. It will be emphasized that there will be no identified risks to the participants, and the study does not pose any harm/discomfort to the participants. However, as Neuman (2011) has pointed out, I will follow several procedures to ensure privacy, anonymity, and confidentiality during and after the study is completed. All the participants will be sent a recruitment email (see Appendix A), requested to sign an informed consent form (see Appendix B), and will be given opportunities to ask any questions related to the project (Creswell & Poth, 2018). It will be stressed that participation is completely voluntary. The informed consent form, as per IRB guidelines, will detail the purpose and procedures of the research and provide statements on the risk, confidentiality, compensation, and their freedom to withdraw from the study at any time. I am planning to incorporate a “reciprocity” component to the participants (for graciously agreeing to participate in my study) of compensating each participant with a $15 gift card from Barnes & Noble for each participant. Because all participants are science teachers, I anticipate that they would appreciate this gesture. All participants will be assigned a pseudonym in the study to protect their identities and locations, and any information that is collected that could potentially identify the participants will be left out of the final research report. A sheet containing real names and the related pseudonyms, signed informed consent forms, collected data (audio files and the transcripts), data analysis records, and personal information such as names and email addresses will be stored in a locked drawer in my office where only my advisor and myself will have access to, and they will be deleted and destroyed after three years of completion of the study. All paper copies of research and disclosure forms signed when receiving compensation will be kept in a locked cabinet in the voice lab for seven years, per UNL Accounting and Bursars Office requirements. The information obtained in this study may be published in journals or presented at conferences; however, the data will be reported as aggregated data, and only pseudonyms will be used. Additionally, Box.com folders will be used for storing data because UNL has a contract with this website, and it is more secure than any other online ways of storing information, such as Google Drive or Dropbox.

Sample Selection and Details of Participants

Creswell and Poth (2018) have stated that the number of participants in a phenomenological study can range between 1 and 325. However, “Dukes (1984) recommends studying 3-10 participants” (Creswell & Poth, 2018, p. 159). Based on this guideline, I will choose 5-10 science teachers (or until data saturation is reached) who will be chosen purposefully from a high school in a large Midwestern city. More people will be recruited if the data has not reached saturation after that point. As I need to find teachers, who have all taught science to ELL students (same criterion), I will use "criterion sampling" as this will be useful for quality assurance (Creswell & Poth, 2018, p. 159). I will use "maximum variation" sampling as it will allow diverse variations of individuals or sites based on specific characteristics (Creswell & Poth, 2018, p. 159). Hence, I will select a mix of novice and experienced teachers belonging to diverse ethnic/cultural groups and genders, and I will verify whether they are ELL certified. I will ensure that all the teachers recruited to participate in this study are adults (above 19 years of age) and will have the experience of teaching science to ELL students. The participants will be invited to participate in the study using a recruitment e-mail (see Appendix A). IRB-approved procedures will be followed to obtain permission from the participants. They will sign the informed consent forms if they agree to participate in the study. They will also receive a follow-up thank you email (see Appendix E) once the data collection procedure is completed, and they will be notified that they will be contacted for member-checking via an email (see Appendix F), before reporting the findings of the study.

Data Collection Methods and Instruments

For my study, I will employ primary and secondary data collection procedures.

Primary data collection. The primary data collection instrument will involve individual in-depth and semi-structured interviews of 30-45 minutes' duration with high school science teachers conducted by myself and another researcher from my team (to offer a different viewpoint and to improve the study's internal validity and credibility). This structure allows the interviewer to have a guide, but it also allows the interviewer to be flexible in the use and order of questions (Merriam & Tisdell, 2016). Creswell & Guetterman (2019) state that data recording protocols are forms designed and used by qualitative researchers to record information during observations and interviews. During interviewing, it is important to have some means for structuring the interview and taking careful notes. Creswell (2016) states that an interview protocol is a form designed by the researcher that contains instructions for the process of the interview, the questions to be asked, and space to take notes of responses of the interviewee. Hence, a peer-reviewed semi-structured interview protocol (see Appendix C) will be used, and all the interviews will be audio-recorded and transcribed. The sites of interviews will be calm and quiet places, as determined by the participants. During the interviews, the interviewer will also be taking notes of thoughts, ideas, and observations of the interviewee. All the participants will be given opportunities to ask questions and engage in another follow-up interview when they will be given the $15 bookstore gift card, thanked for their cooperation and participation in the study, and shown the preliminary findings to member-check with them.

Secondary data collection. Secondary data collection tool will involve focus group interviews at the end of the academic year. According to Creswell and Guetterman (2019), a focus group interview is the process of collecting data through interviews with a group of people, typically four to six. The researcher asks a small number of general questions and elicits responses from all individuals in the group. Thus, a focus group interview protocol will guide my interview process (see Appendix D). The focus group interviews will be conducted in a mutually agreed-upon place (between the participants and the interviewer/s) for a duration of approximately one hour; this will also be audio-recorded and transcribed for data analysis. Since the goal of my study is to determine the essence of the shared experience of teaching science to ELLs, I believe focus group interviews would offer a rich description of the shared lived experience. This could generate some new themes that do not come up in individual interviews. Hence, I believe that focus group interviews are appropriate for this study. Since both individual and focus group interviews are conducted by at least two researchers, it will add multiple perspectives and also help in triangulating the data.

Data Analysis Methods

The data analysis in Moustakas' (1994) transcendental phenomenology complements the search for understanding (Moerer-Urdahl & Creswell, 2004) and will fit my exploration to understand the phenomenon of teaching science to ELLs. After the data collection stage, I will commence the data analysis by first assigning pseudonyms for the participants and then transcribe all the recorded individual and focus group interviews. I will put aside (epoché or bracketing) all my own experiences and preconceived notions about teaching science to ELLs to better examine this phenomenon (Moustakas, 1994). I will then focus on identifying descriptions of the phenomenon of teaching science to ELLs (Starks & Trinidad, 2007). I will then cluster these descriptions into categories and will then describe the "essence" or core commonality that participants experienced of the phenomenon (Starks & Trinidad, 2007). I will analyze the transcribed data by uploading the transcripts into the computer program called MAXQDA and reduce the information to significant statements. Significant statements/quotations that the teachers make will be pulled out and interpreted later. This process is called the "horizonalization" of the data (Creswell & Poth, 2018). I will then categorize this information into meaning units and ultimately create dominant themes. I will also use Microsoft Word and Microsoft Excel for analyzing the data. Since I am following Moustakas' (1994) transcendental phenomenological approach, I will create a textural description of "what" participants experienced as well as a structural description of "how" participants experienced the phenomenon (Creswell & Poth, 2018, p. 77). Both structural and textural descriptions will help me to arrive at the essence of the phenomenon.

Standards of Validation

After data analysis, every qualitative researcher should ensure that the study is rigorous, trustworthy, reliable, and credible. Creswell and Poth (2018) have tabulated eleven different validation perspectives and corresponding terms used in qualitative research. They also present nine generally accepted validation strategies through the lenses of the participant, researcher, and the reader (Creswell & Poth, 2018), and I will use some of them and the others proposed by other scholars in my study as given below:

a) Multiple interviews (two individual and one focus group with diverse participants in my study) with the same participant (i.e., triangulation of data sources in my study), with "repeated listenings to taped interviews and readings of transcripts," and focused analysis of the critical "episodes" will be used. This is to verify "internal consistency" (Loh, 2013, p. 9). Hence, *triangulation* of data will be done in my study by including multiple sources and adding multiple perspectives (team of two researchers to collect data). This could improve the study's *internal validity and credibility*. Peer validation will also be done by requesting peers (who share the common field of research with me) to review my writing and research.
b) *Reliability* will be checked by verifying whether the findings are consistent with the data collected.
c) *Dependability* will be established by an outside researcher conducting an inquiry audit, called as *external audit*, on my research study.
d) I will generate *rich, thick descriptions* of the participants and the setting (*maximum variation sampling*) to allow the reader to make decisions about *transferability and external validity.*
e) I will be disclosing my own biases, values, and prior experience of teaching science to ELLs (*reflexivity*) so that the reader can understand the assumptions that may impact my inquiry.
f) After arriving at the essence or findings, *member checking* or seeking the participants' feedback will be done.

Discussion

Potential Research Findings

After completing the data analysis, I will prepare a detailed report of the findings of my research project. I plan to use teachers' quotes extensively and present an organized description of identified themes and their relation to my research questions. I will also include how my findings evolved during the course of the data collection and analysis and incorporate my role as the researcher in the findings. I will create tables and figures to enhance the presentation of my findings. Some of the themes that could emerge are science teachers' self-efficacy and unique qualities, teachers' cultural responsiveness and linguistic competence, teachers' support systems and professional development programs, and teachers' pedagogical practices and use of scaffolding for ELLs (Kirmaci et al., 2018; Tandon et al., 2017). A sample table for presenting my themes, codes, and quotations in the qualitative findings section is provided in Appendix K.

Possible Strengths and Limitations

I believe that there would always be strengths and limitations to any research study. I envision some strengths in my study such as gaining insights into science teachers' perceptions of teaching ELLs by understanding their lived experiences, which is an underrepresented topic in the extant literature. As majority of the ELL student population have been historically the oppressed class, belong to the low socioeconomic class, and do not have many opportunities to excel in STEM careers, this study could inform the academia and policy makers about the ways to improve the academic outcomes of ELL students and their interest in pursuing STEM careers. Interview data itself is a great strength for this study as it upholds the voice of the participants. There are also some limitations to this study; the first one being the sample size, which is 5-10 (or until data saturation is reached). Only individual interviews and focus groups are used as data collection methods in my study, so maybe triangulating with more data collection procedures, such as site observations, teacher reflections, and their journals could be used in future studies. Another limitation is that epoché is difficult to achieve, and participant biases could also arise from individual interviews and focus group interviews. I also foresee that some participants may not share personal experiences for which I need to be prepared with alternate questions to collect as much rich data as possible. Another limitation could be that all teachers will be recruited from the same city in the Midwest, and they could share similar school/community variables and resources. So, some findings might not be generalizable to the entire teaching community around the world.

Suggestions for Future Research

As I have already stated, this topic is underrepresented in the literature, and this study will hopefully open the doors for more research in this area. Some researchers have examined how students' perception of teachers' support may influence student engagement, motivation, and achievement (Kelly & Zhang, 2016). Future studies in this area could consider the interactions between science teachers and their ELL students through researcher observations. Classroom observations could add another dimension to the data and serve to provide a more comprehensive view of the way science teachers operate within their classrooms. Studies could be conducted about ELL students' perceptions too. This could also pave new ways to look into the benefits of scaffolding, use of inquiry methods, and use of culturally and linguistically responsive teaching methods to teach science for ELL students. This research could also look into interactions between the teachers and their co-workers, parents, school administration, educational policy makers, and the wider community. This could lead to better support systems for science teachers in the way of science-content-based professional development programs to prevent "teacher burnout," in the present-day, highpressure "standardized-testing-based" educational scenario. This could lead to better teacher retention in critical school environments, such as the rural and urban settings. In light of the rapidly-changing demographics of the US student population, urgent need for improving the science achievement of all students, high-stakes assessment and accountability policies, and the underrepresentation of this topic in the research literature, more research on science teachers' perceptions on teaching emergent bilinguals is definitely warranted, and that this topic is a fertile area for future research.

Implications of the Study and Conclusion

As the demographics of United States continues to shift towards people who are culturally and linguistically diverse and growing need for scientifically trained workforce in the future, there is a pressing need for educating English language learners in STEM-related fields. STEM education can provide a significant pathway toward economic advancement and social contribution for youth of historically marginalized communities. As the number of emergent bilingual students continues to increase in U.S. public schools (UN DESA, 2015), it becomes important for researchers to gain insights into science teachers' experiences, which could aid in improving academic achievement of ELLs and promoting educational equity. This might help educators, educational leaders, policy makers, and researchers to better understand methods to improve ELLs' science outcomes (Calabrese Barton et al., 2017; Kirmaci et al., 2018; Tandon et al., 2017; UN DESA, 2015). I strongly believe that *all* students in the United States can realize their "American Dream" if educators create ways and means for them to succeed. Hence, I would like to conclude that equity and social justice for ELLs or emergent bilinguals can be enacted when educators support, nurture, and guide them in knowledge construction, particularly in teaching science. Overall, ELL students face unique challenges but also represent a tremendous asset for the USA if their full potential can be unlocked and harnessed.

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Appendices

Appendix A: Participant Recruitment Email

Dear [Name]:

Warm greetings to you! I am conducting a research study on the lived experiences of science teachers of ELL students. After my preliminary research into the perceptions of science teachers, I have found that teacher beliefs and perceptions could affect ELL student outcomes and their interest in pursuing with STEM careers. As the primary investigator for this study, I am writing this email to request your participation in this study of science teachers' beliefs and perceptions of teaching ELL students. The initial interview and focus group interviews will take 2-3 hours of time, with no more than one hour in one sitting. This includes an initial 30-45 minutes' in-person interview at a mutual location agreed upon by both of us, followed by a review of my findings for participant feedback and verification. The second portion of the process will be conducted as a focus group interview with the other participants at the end of this academic year for a maximum duration of one hour. If you are interested, further details regarding the study and a request for informed consent will be e-mailed to you so that you can sign it and send it back to me. In appreciation of your participation in this study, you will receive a $15 worth gift card from a famous bookstore in our city during our individual follow-up meeting after the interviews. There are no known risks involved in this research. If you have any questions, please do not hesitate to contact me. Thank you.

Uma Ganesan
Ph. D. Student
University of Nebraska – Lincoln
uganesan2@huskers.unl.edu

Mobile: 402-405-2652

Appendix B: Informed Consent Document

Title of Research:

Exploration of Lived Experiences of Science Teachers of English Language Learners.

Purpose of Research:

This study will investigate lived experiences of science teachers, including teachers' beliefs and perceptions while teaching science to English language learners. You must be 19 years of age or older and should have taught science to ELL students in order to participate.

Procedures:

Participation in this study will require approximately 2-3 hours of time. You will be asked to sign this consent form that gives permission for the investigator to use your interview answers and focus group answers that you will provide the researchers for the purpose of this study. The study will use direct quotations from the transcripts of your interview answers and focus group discussions. You will be either interviewed by the principal investigator or her associate and will be again approached for verification and your approval about your statements, after the primary investigator has arrived at the findings of the study.

Risks and/or Discomforts:

There are no known risks or discomforts associated with this research.

Benefits:

The results of this study will be used to increase understanding about science teachers' beliefs and perceptions of teaching ELL students of diverse backgrounds and the impacts these beliefs will have on ELL students' academic outcomes and their interest in pursuing STEM-related careers. Your personal benefit will be a $15 gift card from a famous bookstore in the city if you complete all processes of the interviews.

Confidentiality:

Only your name will be taken, but it will be kept confidential. Your words will be reported anonymously in the research paper. Records and data will be kept until the project is completed, but no longer than three years. Records will be stored securely via a cloud service to which only the primary investigator and another associate will have access.

Opportunity to Ask Questions:

If you have any questions about your rights as a research participant or to report any concerns about the study, please contact the Research Compliance Services Office at 402-472-6965 or irb@unl.edu. You may ask any questions concerning this research at any time by contacting the primary investigator, Uma Ganesan (402-405-2652), email: uganesan2@huskers.unl.edu.

Freedom to Withdraw:

Participation in this study is voluntary. You can refuse to participate or withdraw at any time without harming your relationship with the researchers or the University of Nebraska-Lincoln, or in any other way receive a penalty or loss of benefits to which you are otherwise entitled.

Consent, Right to Receive a Copy:

You are voluntarily making a decision whether or not to participate in this research study. Your signature certifies that you have decided to participate having read and understood the information presented. You will be given a copy of this consent form to keep.

______________________________________ __________________

Signature of Research Participant *Date*

Name and Phone number of Principal Investigator:

Uma Ganesan, 402-405-2652

Appendix C: Semi-Structured Interview Protocol

Participant's Name: ___________________________________

Location: ____

Time/length of interview: _____________________________

Central Research Question: What are the common experiences of science teachers teaching English language learners?

Sub-Questions

SQ1: What supports are available to the teachers for teaching science to ELLs?

SQ2: What are the challenges experienced by the teachers in teaching science to ELLs?

SQ3: In what ways do extrinsic factors (e.g., parents, school administration, and educational policies) and intrinsic factors (e.g., motivation and self-efficacy) influence the teacher's ability to teach science to ELLs?

Introduction during the interview:

Warm greetings to you! Thank you for consenting to participate in my research study. In this study, I am going to explore the lived experiences of science teachers, including teachers' beliefs and perceptions while teaching science to English language learners. I hope that the results of this study will be used to increase understanding about science teachers' beliefs and perceptions of teaching ELL students of diverse backgrounds and the impacts these beliefs will have on ELL students' academic outcomes and their interest in pursuing STEM-related careers. Your participation is voluntary, and I will honor your confidentiality and privacy. You can withdraw from the study at any time, and all the information you provided will be deleted. I will provide you with an opportunity to verify my findings once I complete data analysis. To aid my data analysis process, I would like to record our conversation today.

Individual Semi-Structured Interview Questions:

1) What does "teaching science to ELLs" mean to you?
2) What events or factors have led you to pursue teaching science as a career?
3) How does demographics of your classroom affect your beliefs of teaching?
4) What are some of the ways that your unique abilities help you while you teach?
5) Describe the nature of your interactions with your non-ELL students?
6) Describe the nature of your interactions with your ELL students?
7) What words come to your mind when you think of STEM and ELL student achievement?
8) If we asked your students, what do you think they would describe as your greatest strengths?
9) Are there things about your teaching experience that you wish were different or you would like to see changed?
10) What further resources and supports from school administration for teaching ELL would help you better succeed as a teacher? If so, what are they?
11) What are some challenges that you have experienced while teaching science to ELLs?
12) Please tell me how knowing the language and culture of your ELL students might benefit you?
13) What do you feel about the inquiry methods and importance of scaffolding for your ELL students?
14) What kinds of professional development opportunities are available to you in your school/school district? Do you feel they are adequate for teaching science to ELLs?
15) How often and in what ways do you interact with the parents of your ELL students? How do you feel this interaction has helped you in teaching your students?

Appendix D: Focus Group Interview Protocol

Participants' Names: ____

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____

____

Location: ____

Time/length of interview: ________________________________

Focus Group Interview Questions:

1) Is language important when teaching science? How do you feel about integrating science content and language instruction?
2) In what ways do cultural and linguistic responsiveness aid in teaching science to your students?
3) What are your greatest accomplishments in your own classrooms? Please provide examples.
4) What are your greatest struggles while teaching ELLs?
5) Do you identify yourself more with ELL students or non-ELL students?
6) How have your interactions with your more experienced colleagues influenced your teaching of ELL students?
7) Do you use inquiry and 5E instructional model in your teaching? If so, how has it helped or not helped?
8) What are the usual emotions you feel while teaching science?
9) What do you do to increase your own motivation to teach science for ELLs in your classrooms?

Appendix E: Follow-up and Thank you Email to Participants

Dear [Name]:

Thank you so much for sharing your experiences today. During the course of the next few weeks, I will analyze your description of your experiences and perceptions of teaching science to ELL students. May I follow up with you at a later date for your feedback on any conclusions or findings that will emerge from your descriptions? This is to ensure that I am grasping the essence of your experiences accurately. Thank you.

Uma Ganesan
Ph. D. Student
University of Nebraska – Lincoln
uganesan2@huskers.unl.edu

Mobile: 402-405-2652

Appendix F: Member-Checking Request E-mail

Dear [Name]:

Hope you are doing well! Your kind cooperation in the interviews and focus groups has helped me complete the initial analysis of your interview. There are some conclusions and findings that I have drawn regarding your experiences, and I would love to have your feedback. May I come and meet with you on [Date of follow-up] at [Time] for a maximum of 30 minutes to request you to review and verify my findings? Please feel free to contact me if you have any questions. Thank you.

Uma Ganesan
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University of Nebraska – Lincoln
uganesan2@huskers.unl.edu

Mobile: 402-405-2652

Appendix G: Nebraska's College and Career Ready Standards for Science, 2017

The following table lists the disciplinary core ideas, crosscutting concepts, and science and engineering practices:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
• Asking Questions and Defining Problems • Developing and Using Models • Planning and Carrying Out Investigations • Analyzing and Interpreting Data • Using Mathematics and Computational Thinking • Constructing Explanations and Designing Solutions • Engaging in Argument from Evidence • Obtaining, Evaluating, and Communicating Information	LS1: From Molecules to Organisms: Structures and Processes LS2: Ecosystems: Interactions, Energy, and Dynamics LS3: Heredity: Inheritance and Variation of Traits LS4: Biological Evolution: Unity & Diversity PS1: Matter and Its Interactions PS2: Motion and Stability: Forces and Interactions PS3: Energy PS4: Waves and Their Applications in Technologies for Information Transfer ESS1: Earth's Place in the Universe ESS2: Earth's Systems ESS3: Earth and Human Activity ETS1: Engineering Design	Patterns Cause and Effect Scale, Proportion, and Quantity Systems and System Models Energy and Matter Structure and Function Stability and Change

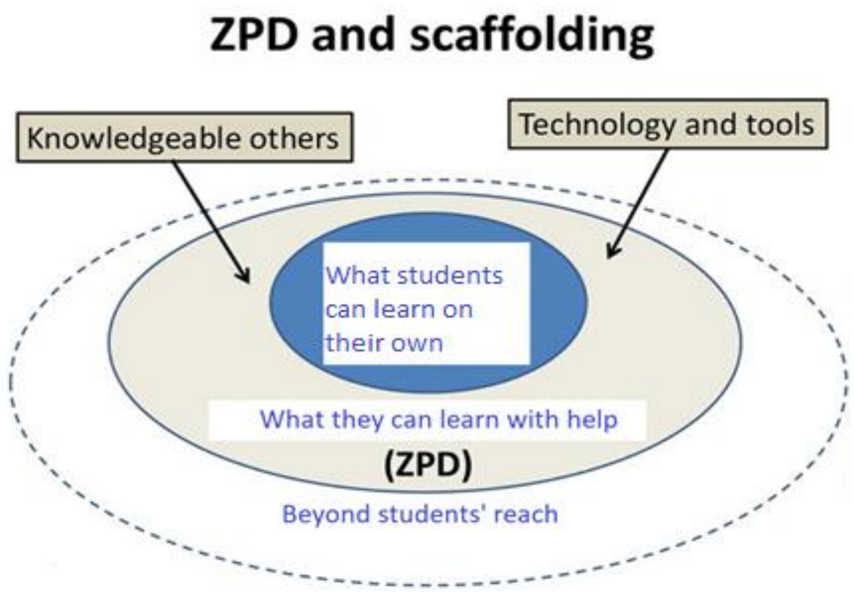
(NCCRS-S, 2017)

Appendix H: Summary of 5E Inquiry-Based Instructional Model

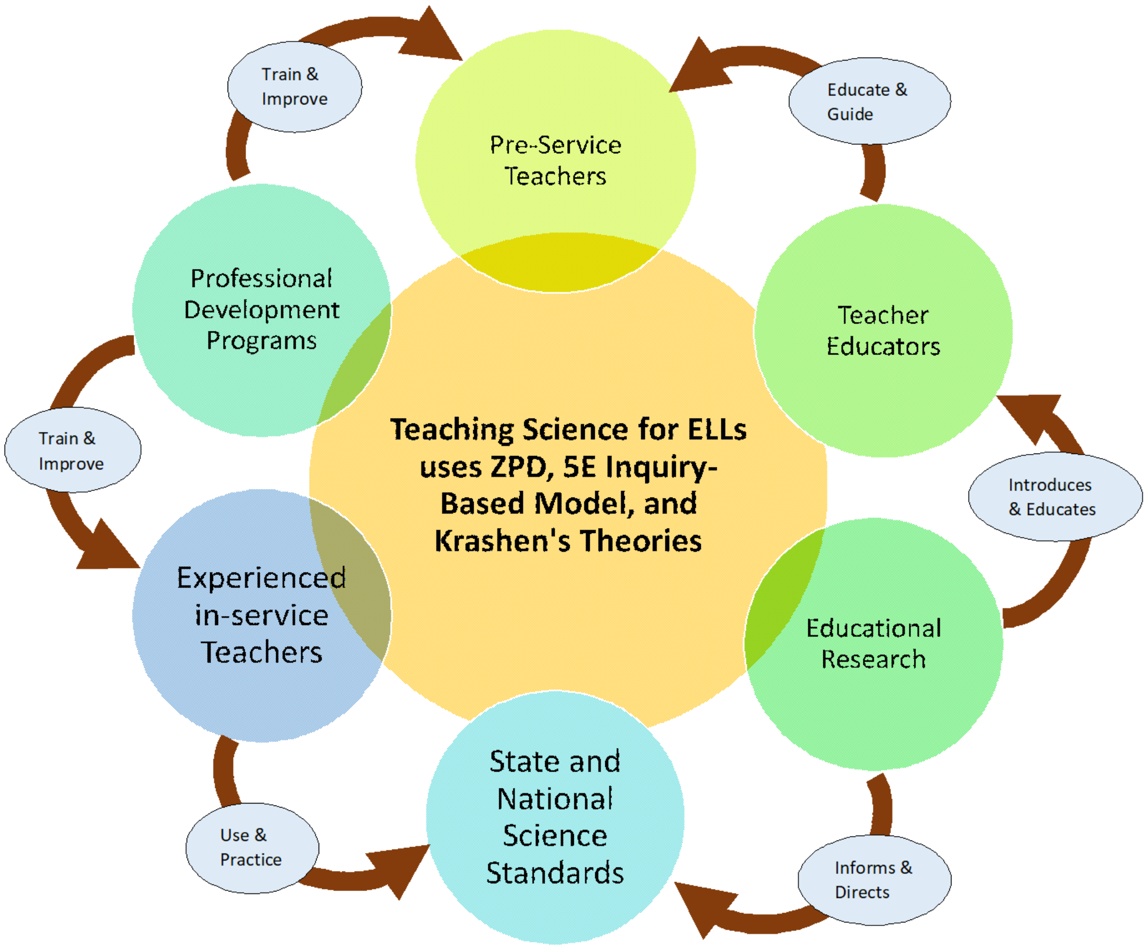
Phase	Summary
Engagement	The teacher or a curriculum task assesses the learners' prior knowledge and helps them become engaged in a new concept through the use of short activities that promote curiosity and elicit prior knowledge. The activity should make connections between past and present learning experiences, expose prior conceptions, and organize students' thinking toward the learning outcomes of current activities.
Exploration	Exploration experiences provide students with a common base of activities within which current concepts (i.e., misconceptions), processes, and skills are identified and conceptual change is facilitated. Learners may complete lab activities that help them use prior knowledge to generate new ideas, explore questions and possibilities, and design and conduct a preliminary investigation.
Explanation	The explanation phase focuses students' attention on a particular aspect of their engagement and exploration experiences and provides opportunities to demonstrate their conceptual understanding, process skills, or behaviors. This phase also provides opportunities for teachers to directly introduce a concept, process, or skill. Learners explain their understanding of the concept. An explanation from the teacher or the curriculum may guide them toward a deeper understanding, which is a critical part of this phase.
Elaboration	Teachers challenge and extend students' conceptual understanding and skills. Through new experiences, the students develop deeper and broader understanding, more information, and adequate skills. Students apply their understanding of the concept by conducting additional activities.
Evaluation	The evaluation phase encourages students to assess their understanding and abilities and provides opportunities for teachers to evaluate student progress toward achieving the educational objectives.

(Bybee et al., 2006)

Appendix I: ZPD and its Relationship to Scaffolding



Appendix J: Conceptual Framework for Teaching Science for ELLs based on Vygotsky's ZPD using the 5E Inquiry-based model and Krashen's theories



Appendix K: Sample Table for my Themes, Codes, and Quotations

Themes	**Codes**	**Possible Examples of Quotations**
Use of scaffolding for ELLs	Science Teachers' pedagogical practices	"I use 5E Inquiry-based model for teaching science to help ELLs."
Science teachers' content knowledge, confidence, and experience	Science Teachers' self-efficacy	"I believe that I can effectively teach inorganic chemistry to ELLs because I have majored in chemistry in my undergraduate studies and have taught this subject for 4 years."

(table adapted from Creswell, 2016, p. 180)