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FROM A DISTANCE: AN INTERPRETIVE PHENOMENOLOGICAL ANALYSIS OF SIXTH TO TWELFTH GRADE STEM TEACHERS' PERCEPTIONS TOWARD TEACHING ENGLISH LEARNERS REMOTELY DURING THE COVID-19 PANDEMIC

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ABSTRACT

FROM A DISTANCE: AN INTERPRETIVE PHENOMENOLOGICAL ANALYSIS OF SIXTH TO TWELFTH GRADE STEM TEACHERS' PERCEPTIONS TOWARD TEACHING ENGLISH LEARNERS REMOTELY DURING THE COVID-19 PANDEMIC

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The COVID-19 pandemic that emerged in China and spread globally in early 2020 caused schools to shut down and forced educators to adapt their curricula to an online format. For many students, especially English learners (ELs), this disruption exposed vast disparities in terms of access and equitable instruction. For science, technology, engineering, and math (STEM) educators, the changes presented several challenges and barriers to adapting science content that required hands-on experiential learning to a virtual, two-dimensional format. For ELs in STEM classes, it has been particularly challenging learning in this new remote modality. This study involved using interpretive phenomenological analysis (IPA) to explore a cohort of STEM teachers' perceptions on the impact of teaching ELs remotely during the COVID-19 pandemic. Using IPA enabled the researcher to gather contextualized accounts of this unprecedented event to add to the limited extant literature in the field. Results provide unique insights stakeholders can use to develop future comprehensive professional development for STEM teachers to better support them in teaching STEM to ELs, whether in person or online.

DEDICATION

This dissertation would not have been possible without the generosity of time, energy, and passion of the teachers who participated in this study. For this, I dedicate my work to teachers. With the upheaval and stress caused by the COVID-19 pandemic, I have learned that teachers were the constant in the chaos. They rose to the challenge and maintained steadfast dedication to their students and their profession. I am deeply humbled by their commitment to educating children while at the same time personally enduring the travails of a global pandemic. The pandemic forced them to open their homes and family lives to teach remotely, largely without training or guidance, to keep our children occupied, engaged, and learning.

ACKNOWLEDGMENTS

The pandemic was an unprecedented event in modern history that was experienced by different people in different ways. We will be looking into and dissecting our collective experiences for many years to come. For my acknowledgments, I would like to express my gratitude to the many people who contributed to my work or facilitated my ability to do the work. I would also like to acknowledge their sacrifices and their own hardships as they too navigated this pandemic.

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CHAPTER 1: INTRODUCTION

Background

English learners (ELs) have consistently been left behind their native English-speaking counterparts in all areas of education since the National Assessment of Educational Progress (NAEP) began using performance metrics to plot the academic achievement of students in Grades 4, 8, and 12. The NAEP, also known as *The Nation's Report Card*, published scores from the 2015 assessment that evidenced a larger inequity between ELs and native English speakers in the science, technology, engineering, and math (STEM) content areas with math scores (Grades 8 and 12) in particular ranging between 28 and 41 points below those of non-EL students (McFarland et al., 2017). The important takeaway is that between the NAEP assessments administered in 2013 and 2015, the percentage of ELs scoring "below basic" in both science and math increased (McFarland et al., 2017).

The NAEP national assessments taken in 2015 revealed the so-called "achievement gap" between ELs and non-ELs increased. Educators, scholars, and policymakers have made STEM education a priority and closing the disparity of achievement for ELs is one of the driving forces behind educational research. Schools in the State of California, in particular, follow the Next Generation Science Standards (National Research Council, 2013), which are a rigorous curriculum of benchmarked science standards designed to improve K-12 science education. One of the ideals of NGSS is to provide *all* students access to equitable, high-quality, research-based STEM education.

A 2018 consensus report published by the National Academies of Sciences, Engineering, and Medicine (NASEM) showed "the majority of current testing practices with ELs are ineffective in eliminating language proficiency in the language of testing as a factor that negatively affects performance of these students on tests" (p. 207). The NASEM report also showed ELs are perceived through a deficit lens based on their linguistic challenges as opposed to an asset lens based on their actual mathematical skills. Where do these perceptions come from? How do STEM teachers view their EL students? These questions were at the heart of the current study as it was designed to build upon the extant literature on understanding STEM teachers' perceptions toward teaching ELs. The results of this study were intended to increase the understanding of how to better support and teach ELs in the STEM subjects.

The persistence of using a deficit-oriented lens to view ELs has thus far been explained in the current literature and the evidence points to a lack of EL-specific preparation and professional development (PD) for STEM teachers (Cochran-Smith et al., 2016). STEM teachers in particular receive limited preparation for teaching ELs, especially in response to changing science and math standards, with requirements left up to school district leaders or state education regulators (NASEM, 2018).

Inequity between ELs and their non-EL counterparts has now been compounded by the COVID-19 pandemic. Research on finding better ways to support ELs in achieving academic success will now include inquiry into the inequities of access and the availability of specialized and adapted instruction as a result of the mandated shutdowns of in-person learning. State and federal governments followed quarantine and social distancing guidelines based on advice from the Centers for Disease Control and

Prevention (CDC). These guidelines forced schools to abruptly move all in-person learning to remote online formats.

Statement of the Problem

It has been predicted that by the year 2030, ELs will make up 40% of K-12 students in U.S. public schools (National Center for Education Statistics [NCES], 2021). Yet, even with this projected growth, ELs are severely underrepresented in higher education as a result of their national high school dropout rate of 40% (NCES, 2021). Among those who do graduate, only 18% go on to a 4-year college, and among this group, only 25% graduate.

For the purposes of this study, it is important to understand the demographics of students who made up the population taught by the participating STEM teachers. The study included STEM teachers in Grades 6–12 from three separate school districts in Southern California. This region is located near the southern border of the state. As such, most of the EL students served were from Mexico or other Central American countries. In fact, Spanish-speaking ELs make up 85% of the total number of ELs in California (Hill, 2012). The majority of the students referenced in the current study were ELs who emigrated from countries just beyond the southern border of the United States and were largely Spanish speakers.

However, one of the school districts represented in the study was situated in an area with many tech and biotech companies that employed families whose children attended local public schools. Many of these students were from Asian and South Asian countries such as China, Japan, Korea, and India. There have been very different outcomes in STEM learning achievement during the COVID-19 pandemic among these

groups of non-native English speakers. STEM subjects are very important to families within this demographic. In addition, families play an instrumental role in the successful outcomes of these students. The differences between EL groups are discussed in greater detail in the findings section of Chapter 4.

A Global Pandemic

In December of 2019, a new and highly contagious virus emerged from the city of Wuhan in the Hubei Province of China. In February of 2020, the World Health Organization (WHO) named the virus officially as the "coronavirus disease 2019," which became known by the acronym "COVID-19." Because of the novel nature of the virus, little was known about how it was transmitted and what effects it would have on infected people. The exact source of the virus, according to the CDC, is still under study. An international coalition of scientific investigators will publish the results at the conclusion of the investigation. The hypothesis on the origins and source of the virus, as initial reports indicate, is that it originated from animals and, most likely, bats (CDC, 2021).

What was known, however, was that this novel virus spread quickly and jumped from China to the United States and other countries at alarming rates and levels of severity of infection. In March of 2020, the WHO declared COVID-19 a global pandemic. What ensued was a shutdown of businesses, social gatherings, and schools. Many state governments ordered residents to remain at home to isolate themselves. Deaths from this devastating disease climbed to the hundreds of thousands in the United States alone (CDC, 2021).

For most students in the United States, March 13, 2020, marked the end of in-person learning. Learning would become remote, online, and mostly from home (Harold,

2020). The scramble to pivot instruction to an online format was fraught with difficulties. This sudden transition to a new learning format exposed great disparities in equity (Harold, 2020). In particular, the students who struggled the most were those without the necessary accoutrements to succeed in this new learning modality. The most vulnerable students were low socioeconomic status (SES) students, students living in locations without internet connectivity, special education students, and ELs (Harold, 2020).

A Divided Nation

To better contextualize how the COVID-19 pandemic affected schools across the nation, it is important to look at the political climate and governmental response that figured prominently in the spread, containment, and eradication of this devastating disease. In 2019, President Donald Trump presided over the nation and his leadership style as a provocateur created a deeply divided nation with factions of Trump loyalists of the far-right movement clashing with the so-called "radical left" (Applebaum, 2020). When COVID-19 was declared a global pandemic in early 2020, the disease itself became politicized with ideological battles mounting between the Trump Administration and the CDC and other agencies with most of the furor targeting Dr. Anthony Fauci, medical advisor to the president.

Rejecting or following CDC prescribed guidelines became emblematic of the side of the political spectrum to which people belonged. Trump loyalists in Republican states often rejected CDC guidelines and instead echoed the rhetoric of the Trump White House. This resulted in a splintered national effort to curtail the spread of the disease and instead caused increased rates of infection, transmission, and loss of life in communities that were often poor, rural, and predominantly minority and immigrant (Kamarack,

2021). The following timeline (see Table 1) illustrates the trajectory of the COVID-19 pandemic, including political tensions that permeated school districts with stakeholders having to navigate the divisions and anger over shutdowns, masking, testing, and mandatory vaccinations.

Table 1

Timeline of COVID-19 Pandemic

Month	Events
March 2020	President Trump declared COVID-19 a national emergency, which gave the federal government power to enact various emergency orders like the Defense Production Act to manufacture masks and ventilators.
	Commercial COVID-19 diagnostic tests were approved.
	Travel ban for non-U.S. citizens traveling from Europe went into effect.
	California issued statewide stay-at-home order.
July 2020	WHO announces COVID-19 can be airborne.
	U.S. government partners with pharmaceutical companies Pfizer and BioNTech to produce 100 million vaccine doses.
August 2020	Presidential candidate Joe Biden calls on governors to mandate masks for citizens.
	COVID-19 becomes the third leading cause of death in the United States.
November 2020	Joe Biden elected 46th President of the United States.
January 2021	Supporters of President Trump storm the U.S. Capitol.
	Vaccine and mask mandates are criticized by Republicans, causing deeper divides.
September 2021	U.S. schools returned to in-person learning.
	Masking and testing required for students.
October 2021	California becomes the first state to begin requiring student vaccinations.

Theoretical and Conceptual Frameworks

I employed a combination of theoretical and conceptual frameworks to help understand teachers' perceptions of teaching remotely during a pandemic. What follows

is a discussion of these theories in addition to the scholars and philosophers whose research provided the groundwork for future scholars to build upon their seminal work.

Critical Theory

The primary theoretical framework that grounded the study was critical theory. Critical theory contains a focus on power structures in society and how social problems exist as a result of these structures. The goal of critical theorists is to question power, domination, and the status quo (Morrow & Brown, 1994). The conceptual framework of critical pedagogy developed out of critical theory and applied concepts within the field of education of social justice and democracy.

Critical Pedagogy. As imagined by Paulo Freire (1968) in his seminal tome *Pedagogy of the Oppressed*, critical pedagogy exposes the notion of implicit cognition [bias] and criticizes teachers for controlling knowledge and believing students to be empty vessels for the knowledge to be deposited. Freire equated education with freedom. He lamented, however, that freedom was elusive for the oppressed, the marginalized, and the outsiders. This elusiveness of freedom has only been exacerbated during the COVID-19 pandemic. Linguistic minority students have been historically marginalized in this country and the achievement gap supports this notion. The pandemic will likely widen this gap, which has already exposed barriers to equitable learning (Clark et al., 2020).

The principles of critical pedagogy hold that social justice, democracy, and education are not discrete and one cannot stand alone without the support of the others (Freire, 1968). Teachers' attitudes and beliefs about their own abilities, their students, their institutions, and even their politics and ideas of the relationship between government and social justice can reveal a power structure and patterns of inequity for

ELs. Practical structural changes, Freire (1968) argued, can have immediate effects on the oppressed.

Positioning Theory. Positioning theory (Harré et al., 2009) holds that teachers' perceptions are related to how they position students within their classrooms. I employed a positioning lens in the current study to view how STEM teachers perceived themselves in relation to their EL students, to their native English-speaking students, and within the (virtual) STEM classroom as a whole. These nuanced, practical, and structural positions provided the means to gain a deeper understanding of STEM teachers' perceptions of teaching ELs even when positioning occurred within this new virtual learning environment.

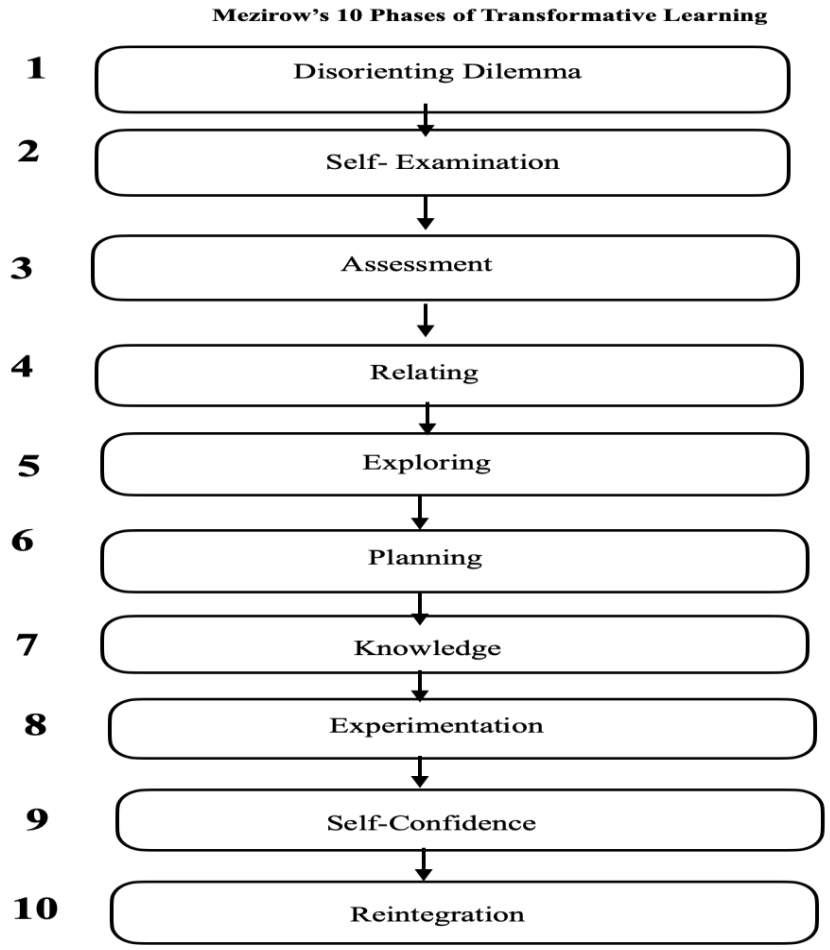
Teachers' perceptions of EL positioning that uncovered implicit bias within the STEM virtual classroom were important to the inquiry. Freire (1968) noted implicit bias causes educators to behave without being aware of their own biases. In investigating teacher perceptions, it was informative to discover both implicit and explicit biases as to how they perceived ELs in their classes as well as how administrations mandated teachers' behavior with regard to the EL population.

Transformative Learning Theory

In addition to critical pedagogy, another conceptual framework grounded in critical theory that I deemed appropriate for this study is the transformative learning theory. Theorist Jack Mezirow developed this theory after researching factors related to the success of women's reentry to community college programs in the 1970s. He developed 10 phases of transformation, beginning with the first phase of what he referred to as a "disorienting dilemma" (see Figure 1; King, 2002).

Figure 1

The Ten Phases of Transformative Learning



A disorienting dilemma is usually triggered by a life crisis (Mezirow, 1994). The COVID-19 pandemic is one such crisis. According to Mezirow, this is the impetus for profound, transformative, and systemic change (King, 2002). An example of transformative and systemic change after a phenomenon like the COVID-19 pandemic would call for stakeholders in education to radically change their approach to using technology to effectively teach EL students both in person and, if called upon, remotely.

Transformative learning theory supports the argument that adult practitioners must continue to learn and adapt to changing technology and skills to become life-long

learners (King, 2002). Understanding teachers' attitudes toward teaching using technology in a distance learning platform was intended to inform future professional development protocols as well as to help teachers believe in themselves and their abilities to overcome challenges.

As mentioned, the COVID-19 pandemic, in keeping with Mezirow's phase 1, was the disorienting dilemma, a phenomenon that caused upheaval in all sectors of society. It necessitated careful and deliberate investigation as to its impact on teachers and how they moved beyond disorientation and pivoted to a new teaching reality.

Chapter 4 demonstrates how the participants progressed through Mezirow's phases with varying degrees of success. These revelations gave rise to the super-ordinate theme of *resilience* and how the subordinate themes that emerged from the data served to inform how being resilient was instrumental in overcoming and adapting and reaching Mezirow's phase 10 of *reintegration*.

Phenomenology

The focus in this study was to explore the conscious experiences of participants, in this case teachers who lived and worked through the pandemic. These lived experiences were unique and my role as the researcher was to describe not only *what* was experienced but *how* it was experienced. To achieve this, I used a hermeneutic phenomenological approach, also known as interpretive phenomenological analysis (IPA; Creswell & Creswell, 2018), to interpret those lived experiences. These subjective experiences were all interconnected between social, cultural, and political ideologies. Therefore, the conceptual frameworks of critical theory and transformative learning theory grounded the IPA approach.

Purpose of the Study

The purpose of this qualitative study was to investigate STEM teachers' perceptions of teaching ELs online during the COVID-19 pandemic. I designed the study to gain insight into STEM teachers' lived experiences to understand the challenges and barriers they faced in their attempt to teach science and math in a remote format. The goal was to fill the literature gap on pandemic-related education as it was without modern precedent.

Rationale

With the evolution of mainstreaming ELs from bilingual-taught classes to traditional sheltered ESL classes into English only general education or content area classes, STEM teachers have been tasked with teaching both content along with necessary English language arts (ELA; Hoffman & Zollman, 2016). In 1998, California led the charge with the passage of Proposition 227, known as the "English Language in Public Schools Initiative Statute." Though proponents of the statute promised that children would not be enrolled in English only classrooms without school supports (Nibert, 2019), it did set in motion a system that mandated ELs to be taught in English only without necessarily preparing content area teachers to differentiate instruction for students with limited English proficiency (Nibert, 2019).

Recent studies have shown there is a correlation between EL student achievement and EL-specific PD for STEM teachers (NASEM, 2018). There is evidence to show that if STEM teachers receive instructional support in the form of EL-specific training, ELs can succeed in STEM subjects (Cook, 2003). However, comprehensive PD for STEM teachers is not widely administered or required and the number of STEM teachers who

receive training differs from district to district. In addition, the COVID-19 pandemic prompted an abrupt transition from in-person to remote learning with STEM teachers having to adapt to their new circumstances largely without training.

The rationale for new research in the area of STEM education for ELs through PD for STEM teachers is clear. The predicted learning loss as a result of the COVID-19 pandemic could have lasting implications for ELs as a result of an ever-widening disparity in equitable achievement between them and their peers. The literature (discussed in Chapter 2) indicates PD empowers teachers with instructional strategies to adapt, modify, and differentiate instruction to engage EL students. In addition, PD provides much needed cultural and linguistic backgrounding to equip teachers with context and a deeper understanding of ELs (NASEM, 2018).

However, teaching STEM to ELs online in a distance learning platform has, thus far, not been meaningfully explored. There are studies in the extant literature, discussed at length in Chapter 2, on teaching English to speakers of other languages (ESOL) online, but there is a gap in the research on teaching academic content and specifically STEM subjects to ELs via an online format.

Significance of the Study

The significance of this study was to learn from the challenges and barriers that STEM teachers faced related to teaching STEM subjects remotely and to contribute to the body of knowledge that can be used to design future PD for teachers. Results illuminated how these teachers adapted, improvised, and were supported by school administrations. In addition, participants described the technological challenges they had to overcome and reflected on what worked and what did not. Ultimately, the study provided context

through in-depth interviews that documented experiences to contribute to the growing body of research on pandemic teaching and learning for the development of future comprehensive EL-specific PD for STEM educators.

My goal in exploring STEM teachers' attitudes toward ELs was to reveal how either deficit or asset beliefs influenced their teaching. Previous research on teacher attitudes revealed an approach to teaching ELs from a deficit perspective (NASEM, 2018). Studies showed STEM teachers perceived ELs as deficient and behind their peers and needing to catch up. However, seeing ELs through an asset-oriented lens depends on the amount of outside support students receive (asset) as compared to students who have none (deficit).

In 2016, California repealed the English only statute Proposition 227 by passing Proposition 58, or "The California Multilingual Education Act" (Nibert, 2019). This law signaled a substantial change in attitudes toward multilingualism and dual language programs. It also gave district leaders more autonomy in implementing customized instruction to fit their EL student populations. Proposition 58, which became effective in 2017, ushered in a new era of looking at bilingual or emergent bilinguals through an asset- versus deficit-oriented lens (Nibert, 2019).

Scientists have predicted that the COVID-19 pandemic will not be a one-off virus (Sargent, 2020). Experts expect more outbreaks and pandemics to occur in the future (Sargent, 2020). At present, new strains of the virus have emerged that could threaten in-person learning in the near future. Educators should prepare to adjust their teaching modalities in the event of future shutdowns.

Positionality

Before introducing the research questions for this study, I note the underlying values of the research and articulate the direction in which I took the inquiry. The nature of the inquiry was to understand and interpret teachers' perceptions of their lived experiences teaching during the pandemic. More than that, I hoped to learn from these perceptions and experiences and take away ideas of how to better prepare STEM teachers to support ELs.

I have spent years teaching ELs as a practitioner and now have devoted several years as a scholar and advocate in the pursuit of empowering ELs to be on equal footing with their peers. This work served to shed light on the challenges and barriers of teaching during COVID-19, and though changing the status quo as a result of this study will not be immediate, results will serve to move the research forward.

Research Questions

The research questions that guided the study were:

RQ1: How did STEM teachers experience the COVID-19 shutdown and pivot to online learning?

RQ2: How did STEM teachers perceive equity and access for EL students in the distance learning format?

RQ3: How did STEM teachers view their ability to adapt, innovate, and differentiate their instructional practices to teach both native and non-native speakers remotely?

Definition of Terms

Content area: Academic subjects such as math, science, English/language arts, reading, and social sciences. Language proficiency may affect these areas but is not included as a content area.

Differentiated instruction: An approach to teaching that includes planning out and executing various approaches to content, process, and product. Differentiated instruction is used to meet the different needs of students in terms of readiness, interests, and learning needs.

Digital literacy: The ability to effectively navigate, evaluate, and generate information using digital technology (e.g., computers, software, digital devices, and the internet; Loewus, 2016).

English learners (ELs): Formerly known as limited-English-proficient (LEP), ELs are those students for whom there is a report of a primary language other than English.

Mainstream: A term that refers to the general education classroom that almost all children attend.

STEM: An acronym for classes in the areas of science, technology, engineering, and math.

Limitations

At the time of this study, COVID-19 remained an active and ongoing issue. As such, the ability to conduct educational research was restricted by the St. John's University Institutional Review Board (IRB) to prevent the transmission of the virus. This meant all research had to be conducted remotely. Therefore, I conducted all interviews, surveys, and other data collection online or by telephone.

The COVID restrictions made it difficult to conduct data collection and limited the sample size as a result. There existed a so-called "Zoom fatigue" as potential participants expressed reluctance to spend more hours on a Zoom call during their summer vacations. One participant admitted they had never sat so much in their life when they went from live in-person teaching to sitting in front of a computer at a desk for 6–8 hours per day. With these limitations, a smaller sample size was used.

Delimitations

Delimitations included setting boundaries of the inquiry to hone in on STEM teachers who were teaching ELs remotely during the pandemic. By limiting the scope of the inquiry, I was able to contextualize and situate teaching STEM to ELs during the COVID-19 pandemic within the broader fields of research and discussion such as STEM learning and PD (Butin, 2010).

STEM teachers provided perspectives and attitudes about teaching ELs during the COVID-19 pandemic and reflected on teaching in a new online modality. During the study, teachers returned to the classroom for the new school year as vaccinations proliferated and most teachers were offered the opportunity to get vaccinated. Therefore, I also documented participants' reflections on returning to in-person teaching.

Assumptions

It was assumed the teachers reported attitudes and perceptions that were candid and truthful. Another assumption was that the chosen privacy considerations allowed teachers to speak freely and openly without fear of retribution from superiors. All efforts were made to collect qualitative data that provided a fair and balanced account of teaching ELs during the time of COVID-19.

Researcher bias was a concern as the nature of interpretation involves values and opinions that are not easily bracketed or set aside. As such, I acknowledge this bias and discuss the significance in Chapter 5.

Summary

As the COVID-19 pandemic enters its second year, effective vaccines have begun to be administered to Americans starting with the most vulnerable and the elderly. As more teachers and students in California receive vaccines, schools have reopened for in-person learning in addition to hybrid (online, synchronous, remote) and asynchronous online formats. Families have been given the option of either in-person or remote as many adults may still be vulnerable to virus exposure. Instructional, institutional, and technological support for teachers, especially content area teachers (i.e., STEM) who teach ELs, will be paramount to academic success.

CHAPTER 2: LITERATURE REVIEW

Critical pedagogy is an important lens through which to view the importance of STEM learning for ELs. Paulo Freire and Donaldo Macedo, in their book *Literacy: Reading the Word and the World* (Freire & Macedo, 1987), argued that there must be radical change in literacy education to empower the marginalized. Current trends in literacy education have expanded the definition of literacy to now include multiple literacies such as financial literacy, digital literacy, media literacy, and so on (Soules et al., 2014). Multiple literacies are dynamic and fluid as technology evolves, requiring learners to possess a holistic skill set to be literate (Stewart, 2017). As such, it can be argued that STEM education encompasses multiple literacies, and chief among them is strong linguistic competence (Soules et al., 2014).

The STEM fields have historically been populated by graduates from elite educational institutions, which are competitive universities that accept students who can do well at the foundational levels of these disciplines and progress toward expertise to gain entry into professional fields (Nietzel, 2021). ELs have been left out of this group and the data reflect that ELs underperform in STEM subjects as compared to their native English-speaking classmates (NASEM, 2018).

ELs (as a group) are underrepresented in the STEM workforce even when, according to the Pew Research Center (2018), jobs and job vacancies in STEM fields have surpassed job openings in other sectors for decades. In fact, Hispanics represent 16% of the U.S. workforce but only 7% of the STEM workforce (Pew Research Center, 2018).

The population of ELs in the current study comprised mostly Hispanic students from Mexico or other Central American countries, as Spanish-speaking ELs make up 70% of the K-12 EL student population in the United States (NASEM, 2018). Though it can be argued that ELs from Asian countries make up a large majority of STEM students filling STEM jobs, there are differences and explanations for this that are presented in the findings section in Chapter 4 and further discussed in Chapter 5.

Broadly speaking, EL students' underperformance in STEM subjects happens when the demands of content language requirements for understanding STEM subjects exceed the ability of EL students' linguistic competence (NASEM, 2018). Freire and Macedo (1987), in arguing for the importance of language competence within the dominant society, drew a comparison to the role of the Portuguese language in the former Portuguese-African colonies. They argued that the dominant society and its *official* language control the power, meaning those without command of the dominant language are without power. The disparity of representation by linguistic minorities in the STEM fields occurs as linguistic *incompetence* "screens out the majority of the masses" (Freire & Macedo, 1987, p. 104). Though the authors based their assumptions on former Portuguese colonies in Africa, they asserted that the role of language could be generalized to any contexts with "asymmetrical power relations" (Freire & Macedo, 1987, Preface section, para. 2). To better understand the role of language and English language development in the United States, it is helpful to look at the history of EL education to illuminate the current challenges.

Organization of the Literature

This chapter will guide the reader through the historical beginnings of EL education and follow a trajectory of research designed to find ways to provide equitable STEM education for EL students to be on par with their classmates. The chapter presents a review of the extant research on teacher perceptions that will show the many gaps in the literature. Most importantly, the chapter is used to frame teaching STEM content to ELs in the context of remote instruction during the COVID-19 pandemic. It will become evident that this area of inquiry is only beginning to be investigated.

ELs were once referred to as limited English proficient (LEP) students and the negative connotation of that moniker is a good example of how ELs were perceived as deficient (NASEM, 2018). However, recent researchers have striven to re-cast this population through multicultural and linguistic understanding to present a more asset-oriented lens through which to view EL education. In addition, the push to increase and improve STEM education has challenged educators to find innovative ways to reach ELs as they are far behind their counterparts in these content areas.

EL Education: A Look Back

Since the enactment of the 1965 Elementary and Secondary Education Act, the federal government has passed legislation to provide funding to ensure quality education to all students without regard to race, religion, SES, or language background. U.S. Congress is responsible for making changes to federal laws to accommodate the changing needs and demographics of federally-funded public schools. Congress enacted the No Child Left Behind Act (NCLB) of 2002 to support the quality education initiatives.

NCLB was reauthorized in 2015 and renamed the Every Student Succeeds Act (ESSA) but retained many of the same provisions of quality education for all.

However, two of the components of NCLB eliminated in ESSA were the "highly qualified" teacher provision and teacher evaluation requirements (Leachman et al., 2016). NCLB also shifted the governing powers from the federal government to the states, providing more state and local control over their schools. Though the promise of educational equity was mandated, it was up to the states to determine accountability. This was a new frontier for educators. Expectations were high for students but unchecked and unsupported for teachers (Leachman et al., 2016).

Funding for sheltered ESL classes was drastically cut during the Great Recession in 2008 (Leachman et al., 2016). Sheltered ESL classes provided content area instruction to ELs with inclusion of English language development to promote language proficiency. In addition, the migration of ELs to historically monolingual regions has forced general education teachers to bear the responsibility of including ELs into mainstream classes, which then requires them to teach both English language and content area knowledge simultaneously (Leachman et al., 2016). This was an additional burden placed on already overburdened and unprepared teachers. It also infringed on EL students' civil rights that were established to guarantee equitable education for all.

The ruling in the pivotal 1974 Supreme Court case *Lau v. Nichols* was that students with language deficiencies should not be denied the same opportunities to a quality education as other students in the same school system. However, putting ELs into a classroom of native English speakers with a teacher who lacks proper certification or

specialized training for ELs is, in fact, denying them the same opportunity to a quality education.

Teaching ELs and STEM

A recent consensus report published in 2018 by the NASEM shed light on the current best practices as evidenced in the literature for teaching STEM to ELs. Several effective strategies were identified in the report to promote STEM learning for ELs:

- Provide explicit instruction in literacy components
- Develop academic language during content area instruction
- Provide visual supports to make core content comprehensive
- Encourage peer-assisted learning opportunities
- Capitalize on students' home language, knowledge, and cultural assets
- Screen for language and literacy challenges and monitor progress
- Provide small-group support in literacy and English language development for ELs who need additional support

Other studies have emerged in response to the need to identify effective interventions for promoting EL STEM education. Hart and Lee (2003) investigated the effects of PD during a 3-year longitudinal study. In addition to a PD intervention, the study included attitude and belief surveys. Participants consisted of 53 elementary school teachers from six schools in a large, diverse district in the southeast United States.

The PD intervention involved specially designed science texts that incorporated EL linguistic and cultural experience strategies. In addition, the science texts included instructional strategies specific for ELs to develop literacy skills while building on prior knowledge. The results demonstrated teachers' improved use of linguistic scaffolds

enhanced EL student understanding of science concepts (Hart & Lee, 2003). Hart and Lee (2003) argued that the results warranted continued PD to support and maintain what teachers had learned during the study.

In a follow-up critique on recent federal legislation for English language proficiency (ELP) standards, Lee (2018) addressed concerns surrounding the challenge of aligning ELP standards with content standards. This puts further emphasis on the need for evidence-based PD and teaching practices that call for closer collaboration between language and content educators (Lee, 2018). A 2018 exploratory study by Besterman et al. (2018) echoed the Lee (2018) critique after conducting a school and staffing survey (SASS) and teacher survey that revealed the number of STEM teachers across the United States who had participated in any EL-specific PD had risen only slightly over the past 4 years. On the contrary, the number of ELs in STEM classes with untrained teachers had risen dramatically and swiftly (Besterman et al., 2018).

To find a solution to the issue of unprepared STEM teachers who work with ELs, a preservice training study of novice STEM teachers tested an intervention designed to promote EL literacy development through modified elementary science methodology (Shaw et al., 2014). The treatment participants were first-year elementary science teachers who, after the training intervention, taught the same science unit. The results showed EL student learning improved in not only the science concepts but also in the areas of writing and vocabulary.

In addition, Shaw et al. (2014) concluded that with the exception of vocabulary measures, the EL students' learning gains were on par with those of native English speakers. Though the researchers conceded that the results warranted further analyses,

they indicated the possibility of a link between preservice teacher preparation and EL student learning outcomes. In addition, the study confirmed that integrating science learning with literacy practices can have measurable effects in the area of EL science achievement (Shaw et al., 2014).

STEM Teacher Perceptions Toward ELs

In addition to research on using practice interventions to improve STEM teaching and learning for ELs, studies on teacher perceptions toward ELs shed light on attitudinal stances that can inform future PD. Research on STEM teacher perceptions toward ELs is scant though studies on teachers as a whole have shown how perceptions influence teaching practices and as a result affect student performance (Desimone, 2013; Nieto, 2010). Huerta et al. (2019) reported findings of a study of STEM teachers' attitudes toward ELs and how they were influenced by demographic variables. Results showed female teachers had more positive attitudes toward ELs than did male teachers. However, the most notable outcome of the research was that most STEM teachers in the study emphasized the importance for teachers to receive specialized training on diversity and second language teaching to foster positive attitudes toward ELs.

Teacher Attitudes Toward ELs and the Rigor Gap

Recent studies on general education teacher attitudes toward ELs have shown teacher beliefs of *rigor* in curriculum requiring critical thinking differ for EL students and non-EL or general education students (Figueroa-Murphy & Torff, 2019). Teacher belief surveys demonstrated a belief that ELs were not ready for rigorous critical thinking activities, which resulted in "watered down" activities that demanded less rigor (Figueroa-Murphy & Torff, 2019).

Professional Development

To combat the problem of untrained STEM teachers, C. C. Johnson and Fargo (2014) looked at the impact of the transformative professional development (TPD) model on EL student achievement on state-mandated science assessments. The TPD model is characterized by intense, continuous, and sustained teacher training. The C. C. Johnson and Fargo study was based on a 2-year TPD intervention involving two elementary schools, one intervention and one control. The teachers in the intervention group received TPD and the teachers in the other school received no training. The TPD model emphasized culturally relevant pedagogy (CRP) in addition to strategies for science instruction. CRP uses students' cultural background knowledge as a reference in order for students to relate to the course content (C. C. Johnson & Fargo, 2014).

The results of the study demonstrated an improvement in EL student achievement of 25%–67% in science after the 2-year period (C. C. Johnson & Fargo, 2014). Conversely, the control school reported lower gains. The results, according to the authors, illustrated the need for future research on PD in the area of CRP combined with science instructional strategies. Indeed, CRP, though not a new construct, has garnered renewed attention with an added sense of urgency in recent years (C. C. Johnson & Fargo, 2014). This urgency should expedite future evidence-based inquiry into the potential effects on EL literacy achievement.

The Role of Academic Language

Much has been written about the need for ELs to possess a strong competency of English academic language in order to succeed in content area subjects (Rolstad, 2005). Cummins's (2017) groundbreaking theories in second language acquisition have received

renewed interest as educators explore effective ways to improve EL academic language acquisition. Cummins distinguished second language acquisition into two skill sets: Basic Interpersonal Skills (BICS) and Cognitive Academic Language (CALP).

BICS represents the rapidly acquired conversational skills sometimes referred to as "playground language," whereas CALP requires a longer and more structured acquisition period. Cummins (2017) clarified the distinction to help explain the academic difficulties of bilingual students and argued that the premature mainstreaming of EL students before CALP readiness sets them up for failure. Cummins claimed mainstream teachers do not provide EL students with the adequate language support to ensure mastery of CALP so they can succeed in content area subjects. However, with the implementation of the Common Core State Standards (CCSS), the focus on the development of academic English (i.e., CALP) for ELs has become more important than ever (Rolstad, 2005).

Tong et al. (2017) looked at PD surrounding CALP as an instructional intervention. The researchers examined EL student learning outcomes after a comprehensive and intensive teacher training program on the use of academic language for ELs (Tong et al., 2017). The results of the study showed the treatment teachers spent more time in CALP during instruction than did the control teachers. This use of academic language by the treatment group teachers had measurable effects on student outcomes. The results demonstrated an increase in EL students' expressive vocabulary, oral reading fluency, and retell fluency (Tong et al., 2017). Additional studies to understand more completely the key tenets of academic language PD are required to make a case for generalizability for future application.

Another study of PD and academic language involved the use of previously established scaffolding methodology for content area teachers (CATs; Pawan, 2008). The study measured the use of academic and content area language in conjunction with cultural scaffolding. The effects were measured in a study of CATs participating in a PD program at an American university (Pawan, 2008). The researcher coded scaffolding statements by participating CATs that represented conceptual, social, and cultural scaffolding (Pawan, 2008). The results indicated the CATs' existing knowledge of cultural scaffolding was limited compared to other scaffolding strategies. Pawan (2008) stated future PD involving cultural scaffolding warranted further inquiry and application. However, Pawan provided the groundwork for future investigations of PD on cultural scaffolding with academic content and language and the potential for EL student success.

Academic language is recognized as a critical factor in EL student achievement (Wilson et al., 2016). Academic language is fostered effectively through oral engagement based on theorist Lev Vygotsky's theory that dialog improves student thinking (Wilson et al., 2016). Wilson et al. (2016) studied the disparity between how often ELs and native English speakers engaged in academic discourse in classrooms and reported that ELs spoke approximately 27% to native English speakers' 73%. As a result, Wilson et al. recommended the following best practices for teachers to engage EL students' oral academic language:

- hold high expectations,
- emphasize and teach content vocabulary,
- provide structures/routines to scaffold conversations, and
- increase opportunities to talk while lowering anxiety.

Further PD research that tested the efficacy and implementation of best practices should be conducted to measure the extent of improved EL oral academic engagement. However, as with scaffolding, this gap in the research presents opportunities for future investigations to validate the kinds of conclusions that can be drawn and to move the research forward.

Academic language serves the function of promoting academic engagement within content area classes. Previous studies have demonstrated the disparity between EL students and native speakers in oral participation, which can be further complicated by teachers' positioning practices that create disadvantageous "interactional architecture" (Pinnow & Chval, 2015).

Positioning Theory and the Role of Positioning and ELs

Positioning theory emerged in the 1980s out of social psychology and grew to include disciplines such as gender studies with the seminal work of Bronwyn Davies and others. In recent years, research on positioning has permeated the educational domain as Davies and Harré (1990) argued that social interactions can limit access for individuals when these limits are imposed by others.

Within positioning theory there are two modes: self-positioning and interactive positioning (Davies & Harré, 1990). Self-positioning is how individuals see their own position within the world and place themselves in accordance with this stance. Interactive positioning occurs when what is said or done by one individual can, in effect, position another (Davies & Harré, 1990). Both self-positioning and interactive positioning can influence and restrict discourse and actions. These social restrictions serve to maintain a

hierarchy of positions that reinforces importance and power structures within an existing social order.

Pinnow and Chval, in a 2015 longitudinal study that looked at EL interactional competence through a positioning theory lens, found that positioning greatly influenced ELs' access to classroom interactions. Pinnow and Chval (2015) purported that positioning is a symbolic act and language plays an important role in students' ability to achieve agentive positions.

Language is only one component of agency through interactions, however. Others are physical control of space, time, gesture, and gaze that create the multimodal "fluencies" necessary for agentive positions (Pinnow & Chval, 2015). The authors contended that these fluencies showcase capabilities and promote an asset view or attitude of ELs rather than a deficit view.

Teaching ELs Online

There is a growing body of research on distance or online learning (Castro & Tumibay, 2021). Many institutions offer online classes, especially in the higher education realm. Secondary education has also seen an increase in online courses that provide students with alternatives to traditional high school settings. Teaching English to speakers of other languages (TESOL) in an online environment is a growing area and studies are beginning to emerge that show the efficaciousness of the model (Easton, 2003).

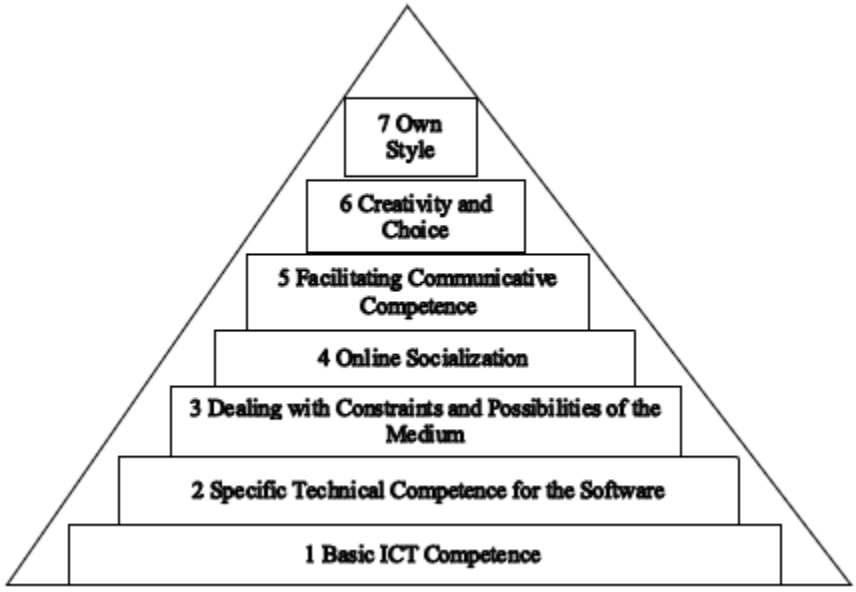
The research in the area of online teaching has debunked the notion that if teachers are good at teaching in a face-to-face format, they can easily "jump in" and teach in the online medium (Easton, 2003). Easton (2003) argued that there are required skills for online teaching and instructors must change their thinking and shift their instructional

strategies to engage students in a digital online format. Computer assisted language learning (CALL), as the discipline was historically referred, was in its infancy in the early 2000s and grew along with the trajectory of technological advances. However, the research demonstrated that though the technology may have developed, pedagogy in the area of instructional strategies was slow to develop (Hubbard, 2008).

In 2005, after years of training online language teachers, Hampel and Sickler (Torsani, 2016) develped a "pyramid of skills" encompassing seven competencies necessary for successful CALL (see Figure 2).

Figure 2

Skills Pyramid



The skills pyramid shows how foundational basic information and communication technology (ICT) skills must be strong enough to scaffold the subsequent skills to achieve competence, creativity, and style (Torsani, 2016).

Teaching ELs STEM Online

Studies investigating teaching STEM to ELs in an online format are beginning to emerge, though there is little in the extant literature. One study relevant to the current inquiry looked at the effectiveness of using interactive online units to enhance science learning (Terrazas-Arellanes et al., 2018). Terrazas-Arellanes et al. (2018) conducted a 3-year study of over 2,000 middle school students enlisted to measure the effectiveness of an interactive online science learning intervention. The results of the randomized controlled trial demonstrated a pretest to posttest improvement on standards-based content specific assessments. The results showed ELs did as well as their peers and came away with deeper knowledge. A gap in this area of research exists as it is unknown whether this intervention can be adapted and successful in an online, distance learning format.

Teaching ELs Online During the Pandemic

There is research emerging in the existing literature designed to understand how teachers taught ELs online during the pandemic. One such study looked at teachers' perceptions of the shift from the classroom to online teaching (Todd, 2020). The shift, according to the author, was perceived by teachers as something that was forced upon them and initially was fraught with problems (Todd, 2020). However, after some weeks, the problems were largely corrected. Todd (2020) reported three factors that assisted teachers in adapting to online teaching:

- Teachers' willingness to experiment, seek advice, and adjust their approach
- Teachers received help from fellow teachers, IT departments, and students
- The school administration provided non-judgmental support

From the perspective of ELs learning online, one recent study explored the role of student engagement (Sari, 2020). Though the participants in the study were college-aged ELs, the findings are relevant to the current inquiry relating to distance learning during the pandemic. The findings showed student engagement was affected by compulsory task submissions, content courses, unstable internet connections, and limited internet data (Sari, 2020). The students reported these factors were "demotivating" and a possible cause for not completing online activities or finishing a course. Though research into student motivation was beyond the scope of this particular study, understanding some of the factors of disengagement and technological difficulties will help to contextualize teachers' perceptions in similar areas.

Learning Loss

Multifaceted areas of research are beginning to emerge in response to the pandemic. However, because the COVID-19 pandemic is an unprecedented event in modern U.S. history, there is virtually no frame of reference. Scholars have predicted learning loss based on the extant research on what is known as "the summer slide" (L. Smith, 2012). Researchers are extrapolating the degree of loss from the traditional 2-month summer vacation to the year and a half of distance learning during the pandemic (Clark et al., 2020). However, it would be irresponsible to make accurate and meaningful comparisons of learning loss based on loss from summer vacations. Learning loss from the COVID-19 pandemic will be without any comparable precedents. However, if the predictions are true, the level of learning loss could be devastating with the repercussions lasting for years (Soland et al., 2020).

Spring benchmark testing in 2020 in California has been controversial (Stavely, 2021). In fact, parents were given the choice to opt out of testing altogether. Many have argued that the results would not be valid and testing would put undue stress on students during an already stressful time. For this reason, measuring learning loss will be difficult and it will take one or more testing cycles to fully document (Stavely, 2021).

For ELs, testing was canceled in 2020 due to the pandemic. However, the federal government requires testing for ELs every year to measure progress in English proficiency (Stavely, 2021). The shutdown in March of 2020 interrupted or did away with testing altogether. Testing is important for ELs not only as learning measurements but to determine what supports are needed. Critics argue that even if EL families opted to get testing, the online versus in-person testing formats pose additional challenges, including civil rights issues of equity and access (Stavely, 2021).

Teacher Self-Perceptions of Teaching STEM to ELs

The current study was designed to document and interpret teachers' perceptions of their experiences teaching STEM to ELs in a remote format. The relationship between teacher perceptions of their own abilities and their instructional behaviors and practices has been evidenced in the literature. A brief look at the extant literature that supports this relationship is important to interpreting perceptions and how they relate to teacher practice.

A study that encapsulated this notion demonstrated English teachers who perceived themselves as possessing a high level of English proficiency positively correlated with greater perceived self-efficacy in their instructional strategies (Yilmaz,

2011). Yilmaz's (2011) teacher-reported surveys confirmed that teachers who believed they spoke better English also believed they taught better.

Summary

This review was by no means meant to be an exhaustive examination of literature heretofore that explained the EL achievement gap and how to fix it. Instead, it was meant as a survey of what has come before and what gaps exist that call for more robust and current inquiry. I designed the current study to contribute to the body of knowledge regarding how STEM teachers experienced the COVID-19 shutdown and pivoted to online learning; how STEM teachers perceived equity and access for EL students in the distance learning format; and how STEM teachers viewed their ability to adapt, innovate, and differentiate their instructional practices to teach both native and non-native speakers remotely.

The review of the literature has shown that there remains much work ahead. The COVID-19 pandemic has, if anything, ripped the proverbial bandage off and exposed great disparities in all segments of society, and none more than the marginalized EL. Current and forthcoming research will help to find meaning and context for what effect the pandemic has had not only on STEM educators and ELs, but on all segments within the educational domain.

CHAPTER 3: METHODS

In Chapter 3, I present the research design and rationale and my role as the researcher. I discuss the selection of participants and the instrumentation along with the research procedures.

It is important to situate the research within the context of the COVID-19 pandemic. Conducting research during the pandemic presented unique challenges that limited the scope of the study. All data collection was done remotely and approved by the St. John's University IRB. This meant recruitment and participant interviews were all conducted online. Because the goal of the study was to understand how teachers taught remotely during the pandemic, interviewing participants through a remote modality provided a close approximation to the experience.

Research Approach

I designed this qualitative study to delve deeply into the lived experiences of STEM teachers who taught ELs in addition to their native English-speaking classmates remotely during the pandemic. As the United States emerges collectively from the constraints of the pandemic to return to a semblance of normalcy, there is a need to digest, reflect on, and learn from what has transpired as a result of the drastic upheaval teachers and students endured. To achieve this goal, I employed the IPA approach, a qualitative research method that was primarily used in psychology and healthcare but has expanded to the social sciences and, in particular, education (J. A. Smith et al., 2009).

The research questions that guided the study were as follows:

RQ1: How did STEM teachers experience the COVID-19 shutdown and pivot to online learning?

RQ2: How did STEM teachers perceive equity and access for EL students in the distance learning format?

RQ3: How did STEM teachers view their ability to adapt, innovate, and differentiate their instructional practices to teach both native and non-native speakers remotely?

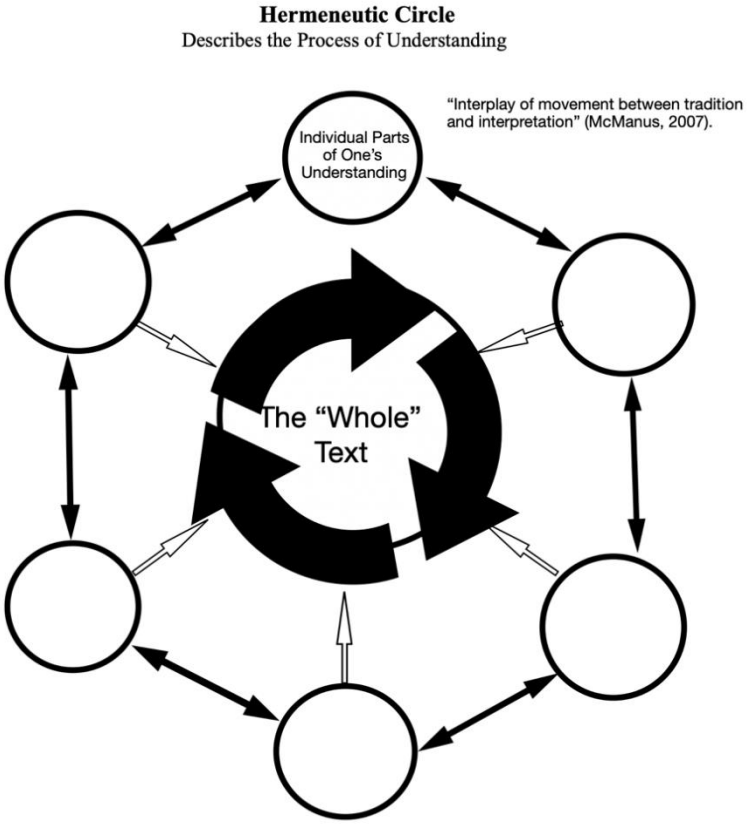
Phenomenology and Interpretive Phenomenological Analysis (IPA)

Jonathan Smith, Michael Larkin, and Paul Flowers are three of the most prolific researchers and practitioners in the field of IPA (J. A. Smith et al., 2009). The IPA approach was influenced by the philosophy of phenomenology, which is focused on the study of experiences and consciousness. One of the prominent theorists in the field of phenomenology, Max van Manen, produced extensive research on the topic of hermeneutical phenomenology (J. A. Smith et al., 2009).

The term "hermeneutical" is derived from hermeneutics, which is the theory and methodology of interpretation. Indeed, the pandemic was such an unprecedented life-altering event it demanded thoughtful, meaningful, and reflective interpretation of the lived experiences of those who experienced it. Figure 3 is my visual interpretation of the hermeneutic circle that depicts the sense making process.

Figure 3

Hermeneutic Circle Depicting the Process of Understanding



The concept of the hermeneutic circle is that it is a process of referencing one's own *parts* of understanding of an event that encircles *the whole* of the event that then triggers reflection and interpretation. Though hermeneutics is rooted in philosophy and historically used for the interpretation of biblical texts, it has entered the domain of research with an emphasis on the "art" of understanding and communication (Van Manen, 1990).

IPA Criticism

In recent years there has been an ongoing philosophical debate between IPA's Jonathon Smith, phenomenology's Max van Manen, and Danish philosopher and Husserl scholar Dan Zahavi on the nature of phenomenology and its use in scholarly research

(Halling, 2021). What follows is a discussion of the positions and arguments by Smith, van Manen, and Zahavi followed by a reflection on using IPA for a study on COVID-19 as the phenomenon and the lived experiences of the participants who lived and worked through it.

Psychologist and professor emeritus Steen Halling (2021) provided an overview of the Smith, van Manen, and Zahavi debate that began with van Manen's critique of IPA and its lack of adherence to scholarly phenomenological research traditions. The crux of the argument, as surmised by Halling, centered around the notions of interpretations of experiences (IPA/Smith) as distinguished from adherence to a framework to explain phenomena (phenomenology/van Manen). Halling chided Smith, van Manen, and Zahavi on the trivialities of their published arguments on staking claims of authority on whose theory is more scholarly and rigorous and reminded us of the gravity of phenomenological research and its attempt to understand human experience.

Halling (2021) further asserted that phenomenological research requires innovation in both theory and method rather than strict adherence to earlier foundational works by the likes of Husserl et al. Halling suggested that researchers use an evaluative lens when reading established "thinkers" while at the same time developing their own authority based on experience and practice.

Role of the Researcher

The role of the researcher in IPA involves a "double hermeneutic" circle (J. A. Smith et al., 2009). J. A. Smith et al. (2009) contended that the researcher's role is an attempt to make sense of the participants' experiences as the participants themselves are trying to make sense of their own lived experiences (in this case, living and working

through a global pandemic). J. A. Smith et al. saw the researcher as having a dual role: both researcher and participant. What they meant is that the researcher as participant must draw upon their own lived experiences and resources to make sense of the world. As such, the researcher must try to make sense of what the participant reports and use their own experiential lens to do so (J. A. Smith et al., 2009).

Research Site

The research sites were three public school districts in Southern California. The school districts shared California STEM education standards but varied in size, student populations, socioeconomic status, and student ethnicities. Conducting interviews off campus rather than on the school campuses seemed to allow the teachers to be more relaxed and able to speak more freely.

Participant Selection

I used purposive sampling to enlist representative STEM teachers whose classes had both native English speakers and EL students. Purposive selection was advantageous for this IPA study as it allowed for deeper and more descriptive data (J. A. Smith et al., 2009). I drew the participants from a pool of teachers of STEM classes in Grades 6–12. I used purposive sampling to target specific characteristics that were shared by the teachers (see Appendix A). However, spreading the word through "snowballing," where teachers recommended potential participants who fit the participant profile, ultimately provided the participants for the study.

I initiated participant recruitment to ascertain feasibility and interest by posting flyers on social media and professional websites. Facebook produced the most responses as known "friends" were able to "tag" prospective participants directly. I was then able to

follow up with the tagged “friends” and message them directly through Facebook’s private messaging system.

I conducted all contact with participants via email or Zoom. I interviewed the teachers individually in live sessions via Zoom software and recorded the sessions. Simultaneous transcriptions were provided by Zoom. I then uploaded the transcriptions of sessions to Zoom’s cloud service for storage. I pilot tested this software before starting the interviews and was able to attest to the accuracy of transcriptions that could be downloaded and codified during the analysis phase.

Sample Size and Rationale

An optimal number of participants for IPA, according to the literature, is between two and 25 (Saldaña, 2016). The goal of IPA is quality, rather than quantity (J. A. Smith et al., 2009). A smaller sample allows the researcher to spend more time with each participant, which promotes richer interpretation of the data. IRB protocols for data collection during the ongoing COVID-19 pandemic limited in-person contact due to health safety concerns. For this study, I selected four participants ($N = 4$) as optimal as this number allowed for time to have multiple meetings.

The smaller sample size allowed for deeper involvement in the participants’ lived experiences. Because I began the initial interviews during the summer hiatus, I conducted follow-up interviews after the new school year began, which allowed teachers to further reflect and compare their teaching experiences of teaching remotely to teaching in person.

This so-called “multi-perspectival” approach (J. A. Smith et al., 2009, p. 52) enabled me to look at the phenomenon from three specific perspectives: (a) when the

pandemic first hit that prompted an abrupt shutdown, (b) when schools re-opened via a hybrid teaching approach, and (c) when schools fully opened with the availability of vaccines for both teachers and students. This approach provided deeper insight into the participants' experiences teaching in different modalities while at the same time constrained the data to the central phenomenon of teaching during a pandemic.

I conducted a total of eight interviews with four participants who represented a purposive homogeneous sample. The homogeneity reflected teachers who taught STEM subjects in Grades 6–12 in public schools. Creswell and Creswell (2018) stated that when using IPA, it is important that all participants have experienced the same phenomenon. To meet the requirement, in addition to sharing the phenomenon of teaching through a pandemic, chosen participants shared these characteristics: (a) taught remotely, (b) had EL students, and (c) were not bilingual certified teachers.

J. A. Smith et al. (2009) warned researchers of being overwhelmed by the amount of data generated, which further supported having a smaller sample size. Indeed, even with the relatively small sample of four participants, the raw data generated 200 pages of transcriptions and notations and 8 hours of recorded interviews.

Procedures

I sent prospective research participants the informed consent form (see Appendix B) and, after those were completed and returned, scheduled the interviews. Time was an important consideration as it was beneficial to conduct interviews while the teachers were on summer hiatus. Their memories were still fresh with any pertinent documentation or artifacts readily available. Time was also a factor in order to plan for any follow-up

interviews. I conducted secondary written interviews after the new school year began so participants could reflect on their experiences returning to the classroom.

One of the most important factors that is supported in the literature is to establish rapport with the participants (Creswell & Creswell, 2018). It is important to establish this rapport and build trust to ensure a relaxed and candid interview (Creswell & Creswell, 2018). Snowball sampling helped with rapport building as a known person initiated the referrals and made introductions. This provided me the ability to have multiple conversations to explain the study and opportunities to get acquainted with the prospective participants.

Data Collection

I conducted the study by following the IPA guidelines as prescribed by J. A. Smith et al. (2009):

- I conducted semi-structured and unstructured interviews with each of the four participants. The cohort was established by those who responded to invitations to participate in addition to those who were referred through snowball sampling.
- The duration of each interview session was between 60–90 minutes.
- I conducted one initial interview per participant with follow-up interviews after the new school year began.
- The time and location were decided by the participant. J. A. Smith et al. (2009) suggested it should be a place of comfort. All interviews were conducted via Zoom from the participants' homes.

In accordance with Creswell and Creswell's (2018) data recording procedures, I followed an interview protocol tool. The protocol tool helped keep the interviews consistent and uniform. The following is the step-by-step protocol I used for conducting the interviews:

1. Contacted participants to schedule an introductory meeting (see Appendix A).
2. At the introductory meeting, explained further the context of the study, asked about specific background and demographic information, and asked general questions to establish rapport (see Appendix C for introductory protocol questions). This meeting lasted 60–90 minutes and was recorded on a secured Zoom account. Videos were stored on a password-protected hard drive.
3. Contacted participants for a follow-up meeting.
4. At the follow-up interview, asked the questions in Appendix C. The follow-up questions required the participants to reflect on returning to in-person teaching after the start of the new school year. The participants shared personal experiences and perceptions related to ELs in an attempt to elicit concrete examples and narratives.
5. Sent a thank-you note to participants along with a gift card at the completion of each interview session.

In addition to the protocol tool, Appendix C contains the interview script I used to promote uniformity in the procedures. It helped at the onset of each interview to introduce the study and explain the requirements and follow an established set of interview questions. Introducing the study and explaining the interview guidelines also

helped to break the ice and build rapport. It gave the participants an understanding of expectations regarding what would be asked and how long their participation would take.

To strengthen validity, the interview questions were carefully designed to get to the participants' lived experiences while at the same time addressing the research questions that guided the study (J. A. Smith et al., 2009). The following is a list of the interview questions included in the protocol script along with the underlying theoretical domains and research questions that each question was designed to answer:

RQ1: How did STEM teachers experience the COVID-19 shutdown and pivot to online learning? Theoretical framework: Transformative learning theory

1. How did you experience the school shutdown after COVID-19 became a pandemic?
2. What has been the biggest challenge and why?
3. What kind of support or guidance did you receive from your administration?
4. What did you miss about teaching in person?
5. What were your biggest concerns about online teaching?

RQ2: How did STEM teachers perceive equity and access for EL students in the distance learning format? Theoretical framework: Critical theory

6. How equitable do you feel the technology and access to learning was for your students?
7. How do you think your students have adapted?
8. How did you promote student engagement?

RQ3: How did STEM teachers view their ability to adapt, innovate, and differentiate their instructional practices to teach both native and non-native speakers remotely? Theoretical framework: Critical theory

9. How have English learners (ELs) adapted to online learning?
10. What are the challenges in teaching ELs online?

Data Analysis

After completing the interviews and downloading the transcripts from Zoom, I began the analysis and coding of the transcripts. The first step in the coding process was to read through the transcripts to identify common themes and often repeated words and phrases. J. A. Smith et al. (2009) recommended reading the transcripts several times to not only identify common themes, but to get to the underlying "state of mind" of the participants.

Saldaña (2016) provided a pragmatic approach for conducting and writing about field work and recommended leaving oneself "open" to choosing the right coding method for the right job. What he meant, presumably, is that there is no best way to code and write IPA. Saldaña stated some instructors and institutions have allegiances and preferences for certain models, but noted there is a certain art to interpreting transcripts.

This open mindedness facilitated the coding process. Once the transcriptions were divided into themes, the next task was to look at the different cases (participants) and try to connect these themes to look for commonality. Next, I created tables to "cluster" themes and listed them for a visual representation to support the narrative (Saldaña, 2016). However, Saldaña (2016) cautioned that not all meaningful data are connected by common patterns. As my goal was to understand teachers' individual and unique

perceptions, the idiosyncrasies therein were just as important and meaningful (Saldaña, 2016). Table 2 illustrates the steps I followed for data analysis.

Table 2

IPA Data Analysis Steps

Step	Description
Step 1	Read interview transcripts to get a sense of participants' complete story. Delete any information irrelevant or repetitive such as filler words (e.g., um, you know, etc.). Listen and watch the recordings while reading the transcript. This helps to put the focus on the participant and to have a voice in the narrative (J. A. Smith et al., 2009).
Step 2	Develop preliminary meaning units. These units reveal a feature or trait that could develop into emergent themes (J. A. Smith et al., 2009). Themes emerge that speak to the essence of meaning that should be both grounded and conceptual (J. A. Smith et al., 2009).
Step 3	Search for connections across emergent themes. J. A. Smith et al. (2009) encouraged analysts to be innovative in organizing the analysis. Some emergent themes may be discarded to make way for more dominant common themes that connect cases.
Step 4	Look for patterns across cases that reveal super-ordinate themes. These represent higher order concepts shared among cases (J. A. Smith et al., 2009). This may necessitate relabeling themes.
Step 5	Highlight situated narratives. Organize experiences and direct quotes (narratives) for each case thematically.
Step 6	Create general narratives from the situated narratives. This unites participants' accounts into a general description.

Presentation of Findings

The final stage in the IPA process is to write up the interpretation from the gathered findings. In Chapter 4, I present a narrative to synthesize and find meaning in the participants' lived experiences. This is where the themes are fully explained and

connections are made to the extant literature and theories to ground the findings for deeper understanding and reflections all the while supporting the narrative with verbatim excerpts from the case transcripts.

Validity and Reliability

To promote validity and reliability for this study, it was of the utmost importance to adhere to the research design with fidelity. Though the interviews were semi-structured in nature, there was still a structural format of questions that was replicated for each participant to encourage consistency, continuity, and organization.

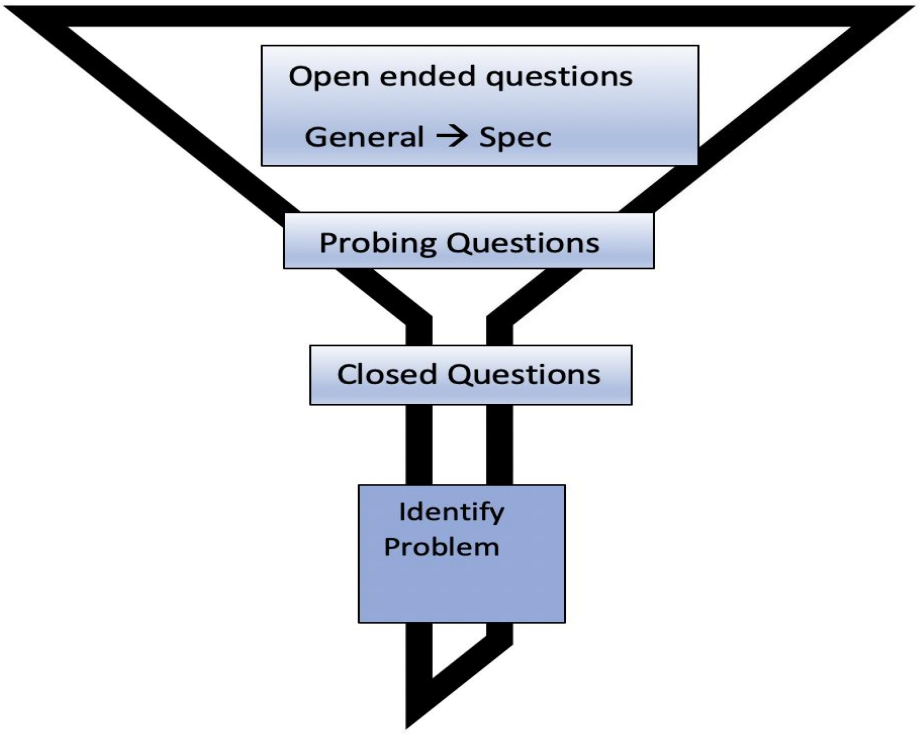
One of the most important skills I gained while conducting interviews was being as neutral as possible and refraining from leading the participant to an answer. J. A. Smith et al. (2009) warned novice IPA researchers that achieving this is not easy. It was necessary to ask good, open-ended questions that began broadly and were followed up with probing questions to solicit deeper insight and detail. Funneling was a questioning strategy that supported this. Figure 4 depicts my interpretation of the funneling approach.

One of the threats to internal validity was what is known as "response effect bias" (Butin, 2010). Response effect bias occurs when interviewees adapt their answers to come across as more agreeable and more socially acceptable. Butin (2010) argued this often happens with more "complex" and controversial subject matters. Because the topic of the study was inherently controversial and involved issues of culture, race, policy, sickness, and others, there was a greater risk for response effect bias. To mitigate this risk, it was important to pose short, "non-directive," open-ended questions that were broad and general (J. A. Smith et al., 2009). This enabled the respondents to speak candidly without any leading so they could use their own words to tell their own stories.

As illustrated in Figure 4, the funneling approach narrows the scope from general to specific using probing questions. The purpose of probing was to encourage the participants to elaborate and to elicit more detailed and insightful responses (J. A. Smith et al., 2009).

Figure 4

Illustration of the Funnel Approach to Questioning



Ethics

The major ethical considerations in conducting the current study were anonymity, confidentiality, and informed consent. Each participant was duly informed as to the procedures and the protection of their privacy. Each participant was provided with an informed consent that they signed and emailed back before interviews commenced. To

promote anonymity, each participant was given a pseudonym and any identifiable markers were redacted.

Privacy and anonymity were especially important to the inquiry. The COVID-19 pandemic has been a tumultuous time for learning institutions and educators. A deeply divided nation was reflected in vociferous criticism from parents and communities toward school districts for shutting down school sites so abruptly. A lack of consensus and a general sense of distrust put school district leaders on the defensive when justifying any actions taken (Sawchuk, 2020).

This made conducting research within school districts fraught due to a lack of transparency about COVID-19 remote teaching practices. Fellow scholars had reported that district IRBs were denying researchers access due to the pandemic. It was insinuated that some district leaders were not ready to expose the chaos and inequities of remote teaching and learning. Below is an excerpt from the Los Angeles Unified School District (LAUSD) website that illustrates this point:

> Due to the difficulties experienced by our school and District communities during 2020, we will be approving only a select few proposals from every submission. Only those research projects found by program decision-makers to be of concrete and timely benefit to the District will be considered. CERR, in concert with program staff, will determine the benefit to the District proposed by the researcher(s). (Los Angeles Unified School District, n.d., para. 4)

This obfuscation by "decision makers" exemplified a protective and defensive stance that was echoed by the teachers in the current study. Therefore, confidentiality and anonymity were very important to ensure protection of the participants' privacy and jobs. These

protections allowed the participants to speak freely without judgment or professional repercussions.

Trustworthiness

J. A. Smith et al. (2009) advised that when interpretation of the data begins, it is important to focus on the individual instead of one's own preconceptions. I ensured trustworthiness by separating my preconceived notions from the reported experiences of the participants and preventing these parti-pris to color the interpretation.

It was important to put aside or "bracket" my own fore-structure, but I also found that trustworthiness involves admitting whether one's preconceptions were wrong or confirmed. Because the COVID-19 pandemic was without any modern precedent, it has not thus formed any deeply held "fore-projections"—there simply were not any to compare. I was not a STEM teacher who taught math or science remotely to children, so I approached this aspect of the research as a tabula rasa.

However, I did live and work through the pandemic and had my own experiences of which I was trying to make sense. For me, trustworthiness was demonstrated in the interpretation of the participants' testimonials and was supported by careful listening to the interviews and re-reading of the transcripts.

I used member checking so the participants could verify intended implications and statements in the transcripts, which served to bolster trustworthiness. This fidelity also confirmed and refuted any preconceptions I had brought to the interviews. It turned out that each participant had uniquely different experiences living through the same phenomenon. Further evidence of trustworthiness is discussed in Chapter 4.

Summary

IPA was a timely and appropriate research design for this study. The COVID-19 pandemic was a phenomenon of unequaled scope and impact within our society's modern memory. The need to document every nuanced experience will be valuable. It is important to remember and learn from individual as well as collective memories. It deserved a faithful commitment to listen, document, and analyze the lived experiences of the participants involved in this study.

It was my hope that the IPA approach would produce new insights that would be conducive to elevating and engaging dialogue on the "meaning" of these lived experiences. J. A. Smith et al. (2009) recognized that researchers are not value free. Indeed, it was a guiding principle during the study for me to foster the dialogue for the purpose of bringing to words participants' experiences. In acknowledging any predisposed bias, I endeavored to address the issue with transparency and candor.

CHAPTER 4: RESULTS

The purpose of this IPA study was to explore the lived experiences of STEM teachers who taught both ELs and native English speakers remotely during the COVID-19 pandemic. In Chapter 4, I present the research findings and connect the findings of the study with phenomenological philosophy in addition to the theoretical and conceptual frameworks of critical theory and transformative learning. I discuss the processes of data collection and analysis and reflect on employing the IPA approach.

Phenomenological Philosophy

Phenomenological research is focused on the commonality of lived experiences within a particular group (Creswell & Creswell, 2018). The philosophical underpinnings that guided the study are credited to Husserl and Heidegger who originated the following two strands of phenomenological research: transcendental, meaning descriptive, and hermeneutic, meaning interpretive (Neubauer et al., 2019). The results of this study reflect both phenomenological approaches to fully encapsulate both living and working through the pandemic.

One of the goals of the research was to explore the lived experiences of STEM teachers and how they taught and lived through the COVID-19 pandemic. Coincidentally, Husserl's initial work in phenomenology focused on mathematics as the phenomena under study (Neubauer et al., 2019). For this study, the phenomenon of math and science educators teaching a prescribed curriculum through a remote modality necessitated a more descriptive and epistemological lens with greater objectivity from me as the researcher.

However, Husserl contended that there is an overlapping of subjective and objective knowledge (Neubauer et al., 2019). Husserl held, and the results of the study confirmed, the existence of common or "universal essences" that were perceived by the participants. These essences, according to Husserl, represent the "true nature" of the phenomenon, which can then be developed into a generalizable description (Neubauer et al., 2019).

Distilling the universal essences of the participants required measured subjectivity on my part. Indeed, Husserl referred to this reflective process as *transcendental subjectivity* whereby I needed to assess and "neutralize" any biases I brought to the study (Neubauer et al., 2019). In retrospect, maintaining neutrality was a challenge at the onset of data collection, which prompted greater mindfulness to re-center my thinking to simply listen and understand.

Even so, the transcribed interviews revealed several instances throughout the dialogues where my biases were explicitly stated. Conversely, there are also examples of restraint on my part, with the use of probing techniques that allowed the interviewees to express themselves more honestly and openly without judgment.

Reading the transcripts and listening to the recorded interviews yielded rich data that would have been missed in an unrecorded casual encounter. The results of the study, in its *Husserlian* incarnation, synthesized the participants' descriptions of conscious experiences into essences of the phenomenon that were "epoché" or "bracketed" from my own biases.

The overarching objective of the study was to understand STEM teachers' perceptions toward teaching ELs in a remote format. These perceptions were viewed

through an ontological lens to understand the nature of the relationship of participants' perceptions or "life worlds" as Heidegger referred. Heidegger and hermeneutic phenomenology guided the study to understand how the phenomenon influenced participants' experiences. Hermeneutics, at its core, relies on interpretation, which goes beyond mere description of the phenomenon. Instead of bracketing, hermeneutic phenomenology embraces and draws from the life world of the researcher (Neubauer et al., 2019). A Heideggerian lens permitted my "life world" as an educator and advocate of ELs to illuminate participants' perceptions through interpretation.

IPA provided a practical framework for documenting and interpreting participants' experiences. IPA is aligned with Heidegger in terms of interpretations that include researcher biases but is also in accordance with Husserl's reflective practice of bracketing to keep preconceived notions in the forefront of the interpretation.

The "life worlds" of the study participants in some ways aligned with my own experience of living and working through the pandemic. We all experienced the same phenomenon, which provided a foundation of mutual understanding and a shared language affixed to emotions that have become emblematic of living through this unprecedented time. This common experience made the interviews richer and deeper and served to strengthen a rapport that, according to J. A. Smith et al. (2009), is fundamental in getting to the essence of the lived experience of participants.

Setting

The setting of the study deserves closer scrutiny considering the context of the topic. I designed the study to understand how teachers taught remotely during the COVID-19 shutdown and conducted the study itself remotely during the same ongoing

pandemic. Indeed, the setting was at the forefront of the study and it would be remiss to not delve further into a modality that became ubiquitous for both educators and remote workers—Zoom.

Zoom Video Conferencing Software–The New Classroom

When the COVID-19 pandemic broke out in March of 2020 and schools were shut down, many educators were unfamiliar with remote synchronous online instruction. However, in short order, Zoom Cloud Meetings, or more commonly Zoom, became the go-to video conferencing software platform used within school districts (S. Perez, 2020). In addition to the education sector, Zoom video conferencing gained popularity in the jobs sector during the pandemic as more and more businesses moved their operations online with employees working from home. This was evidenced between March 14–21 when there were more than 62 million downloads of the Zoom software (S. Perez, 2020).

The use of Zoom conferencing allowed for an approximation of face-to-face encounters. It enabled participants to see each other and speak in real time with a capacity of hundreds of participants live at the same time. For schools, Zoom offered teachers the opportunity to conduct classes synchronously while providing accountability and engagement. What started as a promising substitution for in-person learning proved riddled with myriad issues that exposed great disparities in equitable access (Smolens, 2021).

Digital Divide. Zoom video conferencing provided a lens through which vast inequities in student access to technology and support could be seen. The gulf between students with technology hardware, software, and internet connectivity with the digital literacy skills to use them and those without was divided along socioeconomic lines

(Smolens, 2021). In Southern San Diego, California, for example, it was reported that only one in five households had any internet connection at all (Smolens, 2021). Even when students had an internet connection, it was often too slow to properly engage and participate in synchronous Zoom class sessions.

Policymakers were made acutely aware of the fundamental importance of broadband highspeed internet for all students during the nearly 2 years of remote learning. A recent bipartisan infrastructure bill introduced in Congress proposed $65 billion in spending on broadband internet access to help close the digital divide (Smolens, 2021).

Privacy. Another concern manifested by Zoom video classes related to privacy. In California, leaders of individual school districts were left to mandate their own camera policies (S. Johnson, 2020). One Southern California school district, for example, mandated that all students keep their cameras on in an effort to promote student engagement (S. Johnson, 2020). Critics of this policy argued that forcing students to keep cameras on may be an infringement on their privacy rights. Finders and Muñoz (2021). The federal Family Educational Rights and Privacy Act (FERPA) gives parents legal rights over their children's education records and control over the disclosure of any personal and identifiable information.

Three of the four participants in the current study reported that initially they had required their students to keep their cameras on but were later told by their administrations to not force their students to appear on camera because of the potential for privacy infringement. One participant reported that her district had explicitly mandated a "cameras on" policy. The participants provided narratives with unique

insights and perspectives on teaching to students with cameras on and off and how they adapted and fostered engagement via creative methods that did not infringe on privacy.

Positioning of ELs Within the Digital Classroom

Virtual classrooms were designed to visually appear like a "brick and mortar" classroom with students' and teachers' faces on screen to approximate a live, in-person experience. Within the virtual "classroom," as with in-person classrooms, participants described a dynamic interplay of social interactions that established "positions," thereby reinforcing the dichotomy between the *powerful* and the *powerless* (Harré, 2012).

Studies on positioning theory have evidenced negative repercussions for ELs as teacher–student positioning affects learning processes (Rumenapp, 2013). This supports the notion that teachers' attitudes and beliefs about perceived EL disengagement, as reported by the participants in reference to ELs not appearing on camera or participating in class discussions, positioned ELs at a lower level of importance. This perceived lack of engagement in the digital Zoom classroom revealed varying degrees of positioning biases. Classes with cameras on or off optional policies had the unintentional effects of negative positioning, especially for EL students. Participant narratives that illustrate the point are presented in the findings section of this chapter.

However well-intentioned the policy of allowing students to keep their cameras off during Zoom classes, participants admitted it caused many ELs to be "in the shadows," which resulted in an "out of sight, out of mind" scenario. The Zoom classroom, with a lens directed into the lived worlds of students, was a missed opportunity to explore and understand EL students in what researcher Kris Gutiérrez referred to as a "third space" (Rumenapp, 2013).

Gutiérrez et al. (1999) defined the third space as the blending of experiences and interactions from a student's home, community, and social network. In remote learning, the third space can be viewed as the intersections created by online and offline experiences. Gutiérrez et al. considered the third space to be a zone of transformation that is generated when teachers and students interact socially, placing value on home, community, and school identities within a learning environment.

The fear of privacy infringement became the catchall response for the hands-off policies of teachers and administrations toward not forcing students to have their cameras on. However, it also hinted at an underlying fear of *seeing* the inequities that existed among the most vulnerable students.

Participants

Four STEM teachers participated in the study. Three of the teachers identified as female using "she/her" pronouns and one teacher identified as non-binary with the pronouns "they/them." Each teacher had between 10 and 20 years' experience teaching STEM to students in Grades 6–12 in the State of California. All teachers had master's degrees in their fields. Table 3 is a presentation of the participants and their teaching and school demographics.

Table 3

Participant Demographics

Participant name*	Gender	Age range	Subject taught	Grades taught	Years taught	Formal EL training	Taught: remote, hybrid, both
Colleen	Female	30s	Math	6	17	Part of credential	Online only

Jennifer	Female	60s	Science	6	26	Part of credential	Both
Teresa	Female	50s	Science	7	20	Part of credential	Both
Jan	Non-binary	40s	AP Bio	9-12	20	Part of credential	Both

* Pseudonym

"Community" of STEM Teachers

The acronym STEM represents the collective disciplines of science, technology, engineering, and math. Though distinct in terms of the competencies required to teach and learn within each discipline, they share and overlap important multi-literacy skills (Stewart, 2017). Indeed, the interdisciplinary nature of the STEM subjects dictates that each would not be able to stand on its own merits without the influence of the others.

The current study was situated in Southern California and all participants received their credentialing through programs accredited with the State of California Commission on Teacher Credentialing. Each participant in the study possessed a single subject credential for secondary educators either in math or science. In addition, each participant received the required certificate known as Cross-cultural, Language, and Academic Development (CLAD), which authorizes teachers to instruct English language development (ELD) in listening, speaking, reading, and writing skills for ELs. California state law stipulates the following requirement:

> For these pupils to have access to quality education, their special needs be met by teachers who have essential skills and knowledge related to English language development, specially designed content instruction delivered in English, and

content instruction delivered in the pupil's primary languages. (Commission on Teacher Credentialing, 2021, para. 6)

This educational code (EC) requires all public schools in California to deliver services to accommodate both the academic and linguistic needs of ELs (Commission on Teacher Credentialing, 2021). Understanding the homogeneity of the participants served to provide a shared culture that linked the participants professionally.

Shared Curricula

All three school districts shared the following federal or California state standards:

- Common Core State Standards (CCSS): Standards adopted by 41 states that include the knowledge and skills gained through reading, writing, speaking, and listening that students require to be successful in college. Mathematics standards are included in the NGSS with emphasis on the skills of problem solving, reasoning and proof, communication, representation, and connections (Common Core States Standards Initiative, n.d.).
- California Next Generation Science Standards (CA-NGSS): In 2013, the State of California Department of Education (CDE) adopted the CA-NGSS to promote STEM learning. The goal was to give students opportunities to experience STEM learning from kindergarten to Grade 12. The CA-NGSS teach students the skills to practice science like scientists (experimental) while at the same time developing science content knowledge. Topics are scaffolded from the macroscopic in the lower grades to the microscopic and submicroscopic and abstract science in the upper grades (cde.ca.gov).

It is important to point out that the standards were implemented to promote "hands-on" experiential science *in* the classroom. Teaching the CA-NGSS in a remote modality proved to be challenging and was achieved with varying degrees of success as reported by the study participants.

School District Demographics

The three school districts represented in the study were all located in Southern California. Each district had distinct characteristics and demographics that represented the location, socioeconomic status, employment sectors, and linguistic and cultural backgrounds. Table 4 lists the demographics of the representative school districts and is followed by an overview of the characteristics of each district.

Table 4

District Demographics

School District	Enrollment* (*2019-2020)	ELs	Predominant language of ELs	Economically disadvantaged	Study participants
District 1	122,916	24,028	Spanish	70,779	Jennifer
District 2	36,586	3,387	Spanish	7,382	Jan, Teresa
District 3	3,063	93	Spanish	337	Colleen

District 1 is the largest school district represented in the study with an annual operating budget of $1 billion. It is considered one of the top large urban school districts in the United States. District 1 serves approximately 122,000 students with more than 200 facilities and 13,000 employees. Among the student population, 26% are ELs and more than half are eligible for free or reduced-priced meals. The language predominantly spoken by ELs is Spanish with over 23,000 native speakers.

District 2 is the second largest district represented in the study. It serves over 36,000 students among 38 K-12 schools with 4,400 employees. Its operating budget is $405 million. Among the students served in District 2, 10% are ELs and 16% qualify for free and reduced-price meals. Multiple languages make up the largest percentage spoken by ELs with Spanish representing the second largest percentage of speakers. District 2 is located in a geographic location with a concentrated hub of tech companies that employ scientists, many of whom come from China, Korea, Vietnam, and India. As such, a large percentage of ELs in the district speak several different languages, including Mandarin, Korean, Vietnamese and Hindi.

District 3 is the smallest of the three representative districts in the study. There are five schools in the district, including two high schools, one middle school, and two elementary schools. The district serves approximately 3,000 students with ELs making up 3% of the population. Ironically, this district is situated the closest geographically to the southern border with Mexico. The district is in an affluent location with some of the most expensive real estate in the region. The percentage of students qualifying for free or reduced-price meals is approximately 10% with a trajectory showing an increase in 1 year.

Data Collection

Data collection consisted of conducting semi-structured interviews over a period of several days in the summer of 2021. Teachers were on their summer hiatus, and it was not clear whether they would be going back to fully in-person teaching or continuing in a hybrid format for the coming school year. The initial interviews took place in the summer and subsequent follow-up interviews took place after the teachers went back to school in the fall to gather their impressions of the transition from online to back to in-person learning. Conducting follow-up interviews with participants provided a broadened sense of their lived experiences during school shutdowns and the subsequent reopening of schools. However, COVID-19, at the time of this writing, is an ongoing and persistent issue as evidenced by a new variant known as the "Delta Variant" (CDC, 2021).

Data Analysis

Data analysis involved taking the interviews from the Zoom recordings and uploading them to a transcription service and then downloading the transcriptions to a Word document and stripping out any unnecessary filler words and misinterpreted words.

After that, I uploaded the transcriptions to the NVivo software where they were further cleaned and organized. From that point, the coding began by looking through the transcriptions to find emergent themes and coding them with appropriate names and flagged with a color. When the coding was completed, I was able to create mind maps and explore the data to find patterns and interesting outliers.

Transcriptions and Qualitative Data Software Analyses

Once the interviews were transcribed, I used a qualitative analysis software to explore the data and create codes and concept maps and compare participants. The data analysis software provided a lens to view language use and word frequencies. Further in this chapter, I discuss the findings on language use and meaning drawn from qualitative data analysis software.

Looking at the Language

One of the criticisms of IPA is that it does not look closely at language per se with meaning making drawn from contexts and narratives (Tuffour, 2017). J. A. Smith et al. (2009) argued that experience is already intermingled with language and culture. In addition, Heidegger believed interpretations of experiences are informed by language (J. A. Smith et al., 2009). Interview transcriptions revealed interesting distinctions between participants in the study and their use of language. The participants' word choices were revealing in and of themselves. Data analysis of the language informed attitudinal stances comparing each participant and their choice of words and frequency of their use (Alderson & Hamp-Lyons, 1996).

In addition to word choice and frequency, I analyzed nonverbal communication such as tone, pauses, gestures, posture, and body language to further understand and

interpret participants' meanings. The results of the linguistic analyses are presented in the findings section.

Findings

This section summarizes the findings and contributions made by the study participants by providing insights into their life worlds. In addition, I provide narrative reflections as well as discussions through the theoretical lenses that guided the inquiry. Finally, though the findings cast new light on teaching and learning remotely during the COVID-19 pandemic, there were several limitations that are acknowledged and discussed later in this chapter.

Emergent Sub-Themes

Participant interviews produced raw data transcribed from audio recordings. I then read the transcripts for clarity and edited them accordingly. I engaged in initial noting using pen and paper to illuminate how the participants felt and responded to interview questions. Notations also helped me remember subtexts and attitudes throughout the transcripts.

After making the initial notations, I uploaded the transcripts to the NVivo data analysis software for coding. Coding is the analytical process of organizing data, in this case interview transcripts, into predetermined (deductive) or emergent (inductive) categories. I analyzed the transcripts inductively and assigned emergent themes a code that represented an attitude or characteristic or theme. Each set of transcripts received the same coding markers and I then compared and cross-referenced them to look for cross-case themes. The sub-themes emerged from the data and were coded after each representative utterance.

The emergent themes included a spectrum of sentiment within the codes ranging from positive to negative. This meant the data represented a degree of polarity within the themes (J. A. Smith et al., 2009). I present the findings of the sub-themes, including the oppositional relationships in Table 5, followed by contextual narratives introducing the participants.

Table 5

Sub-Themes With Explanation of Spectrum of Polarity of Sentiment

Theme	Definition	Polarity within context of study
Self-efficacy	Belief in one's own capabilities	Efficacious ------>Incompetent
Autonomy	Self-directing freedom	Autonomous------>Dependent
Attitude	The way one thinks or feels about something	Positive---------->Negative
Partnership	Working jointly with another person	Attachment------->Disassociation
Family	Group of people who are related	Supportive------->Unsupportive
Engagement	Motivating students to be involved and interested	Engagement----->Disaffection
Humor	The ability to be funny or amused by situations	Humorous-------->Severe
Health	State of being or fitness	Healthy---------->Frail

Participant Introductions—Contextualizing Emergent Sub-Themes

The following narratives represent a researcher perspective through observational accounts. However, Larkin et al. (2019) cautioned of the limitations as it only reports the view from within a particular "cultural frame" without making claim on commenting on all cultures.

However, Larkin et al. (2019) argued that subsequent studies could extend the research, and this could eventually lead to more generalizability. Thus, in addition to the

individual participant perspectives, I contextualized the community of STEM teachers that reflected a localized culture or group with shared, implicit, and underlying features including the sub-themes along with examples of polarity (Larkin et al., 2019).

Colleen. I first met Colleen after being introduced via social media by a mutual friend. Colleen fit the bill because she was a sixth-grade math teacher and taught in one of the local school districts in Southern California. At our first meeting, Colleen appeared enthusiastic and supportive in joining the study and supporting me as the researcher. Colleen had recently gone through her own doctoral dissertation research and realized and appreciated how difficult it was to find participants.

After sending Colleen the informed consent and discussing the parameters of this study and what was expected, we set up a time for a video interview via Zoom. At the Zoom meeting, I finally got to meet Colleen face-to-face, albeit in a virtual environment. I was able to observe her surroundings, what was on her walls, and the ambient sounds around her house. It was interesting to let my eyes wander to the background of her home and the portraits of her children. Colleen came across as very organized, serious, and compassionate. Below are the narratives of the themes that Colleen demonstrated.

***Self-Efficacy*.** One aspect of Colleen's personality that emerged promptly was adaptability and self-efficacy. This was evidenced when she told me how the first thing she did with her family knowing they would be in quarantine for the unforeseeable future back in March of 2020 was to get a brand-new puppy. She told me how excited her children were and how because having a puppy required a lot of home time and nurturing, she saw being at home as an opportunity.

Autonomy. One of the characteristics of the school district where Colleen taught was that the administration afforded a lot of autonomy to teachers, especially for Colleen and her teaching partner. This is probably due to the fact that it is a small district with only about 3,000 students. This autonomy made the transition when the pandemic hit easier to manage because the speed at which she and her partner had to pivot in order to prepare for online teaching was so fast. Colleen expressed that she was given a lot of leeway from her administration. I believe this autonomy provided by the administration contributed to a better outcome for online learning for her students as opposed to the top-down bureaucracy reported by other participants.

Attitude. From an interpretive standpoint, one of the first things I interpreted from Colleen and her personality was her sense of empathy. Though I did not ask her explicitly, I imagined she may have been a person of faith as she mentioned the word "grace" a few times. I think what she meant by grace was providing understanding and space during this difficult time of COVID-19.

Colleen explained how she had come to the realization that every family was experiencing the pandemic in different ways and that she needed to be sensitive to the plight of some of the families who may or may not have been handling the transition to online learning as easily as other families.

Partnership. Colleen was enthusiastic about speaking of the strong partnership she had with her fellow math teacher. She expressed how having this partnership helped save time and energy in preparing the curriculum as well as provided a sounding board for general teaching concerns or concerns about students. Colleen and her partner would get together frequently during the summer hiatus to prepare for the upcoming fall

semester every year. Colleen admitted this strong partnership also played a significant role in helping her home life run smoothly.

Family. During our Zoom interview, I noticed on the walls right behind Colleen were portraits of her children and husband. It became evident throughout our interview how important family was to her. She is a mother of two young children, both in elementary school. She was able to speak not only about the district in which she taught, but about the neighboring school district where her children attended school. When we began our interview, I asked her to think back to March 13, 2020, and the first time that she became aware of the COVID-19 pandemic and the subsequent shutdown at her school. I asked her to go back to that place in her mind and reconstruct the day. I was not sure how this was going to go, but I found she was able to harken right back to that moment when she first learned that the school was shutting down and her classes would be moved to a remote modality.

She also recalled how not only her own classes that she taught would be virtual but suddenly her entire family would also be at home together for the first time. She recalled how her priorities were first to set up her own children and made sure they were comfortable with appropriate laptops and connections to their own school classes, as because her children were quite young, they were unable to do this themselves. Her other priorities were to make sure she had her own students connected in the same way. This proved to be a lot more difficult because she did not have the same access to her students as she did to her own children.

One of the challenges Colleen faced was that of teaching from home. She expressed that her husband, who was a university professor, was also at home teaching

along with their two young children, one of whom was on the autism spectrum. It became clear from our interview that Colleen was responsible for not only the childcare at home in addition to setting them up for homeschooling, she was also the technological wizard for the family.

Colleen spent a lot of time setting up her children's technology for home learning as well as her husband's university teaching system. It seemed as though Colleen carried a lot of weight and family responsibilities on her shoulders. For this reason, I can understand why Colleen spoke about the importance of having a strong teaching partnership.

Engagement. This was one of the weak points in the testimony given by Colleen with regard to student engagement during the online teaching time. One of the mandates handed down from her district administration was that of a laissez-faire attitude toward attendance or those who did not have their cameras on or indeed did not complete or turn in work. She was told to give a lot of space to these students in order to reduce the stress and not cause any undue stress for families who may have been suffering strain or ill health as a result of the pandemic. Though this seemed to be a good idea at the time, upon reflection, it resulted in a level of student engagement to the point where it did not exist. Consequently, it almost appeared Colleen was teaching a college type course and lecturing to her students without attempting to engage or interact. This may be an overstatement, but what was made clear was that the students who did not engage were ultimately the most vulnerable of the students and especially the ELs.

Humor. For many, humor is a coping skill and a way of deflecting pain or stress. Many people use self-deprecating humor as a way to deflect attention away from

themselves. This was not the case for Colleen. Instead, she was earnest and kind and displayed a calm and sober demeanor. She was professional and serious and did not display a humorous side, so I do not know if one existed.

Health. Colleen suffers from a compromised immune system and therefore when it was time for the students to go back to school after the initial year of distance learning, Colleen had the option of remaining at home, which she chose in order to protect her health. She did not go into details about her condition, though it appeared she was sufficiently worried to choose to stay home.

The school accommodated for her teaching from home and hired a substitute who was in the classroom while at the same time Colleen taught live synchronous from her home via Zoom. The substitute would hold up an iPad showing Colleen's face so she could speak to the students directly and the substitute could maintain class behavior management. Colleen admitted it was an awkward situation, but it was the best way to ensure she remained healthy.

Jennifer. Jennifer is a sixth-grade science teacher at a middle school in a large public school district in Southern California. She has taught for more than 20 years and has a master's degree in education. She appeared to be in her late 50s to early 60s and shared that she was married and had grown children, so therefore it was just her and her husband at home. Jennifer had an abundance of energy and of things to say about teaching remotely.

Self-Efficacy. Jennifer seemed very efficacious as well as tenacious. She had an abundance of energy and curiosity and a drive to succeed in the face of adversity.

Jennifer loved her job and expressed her passion for her work and determination to put out an "excellent product," not a mediocre "product" as she called it.

Even with this abundance of energy, Jennifer admitted she had limitations when it came to technology. Though she was not a digital immigrant, she did have her challenges in setting up online teaching platforms and classroom management software. Jennifer exhibited a can-do persistence and the wherewithal to find out how to get things done.

Autonomy. Unlike Colleen's school district, which was very small and provided a degree of independence and autonomy, Jennifer taught in the largest school district in the study that had a strong centralized top-down administration. In addition, the school site had strong leadership that dictated how she was to run her classes and teach her curriculum. For this reason, she did not have a lot of autonomy to innovate and try new things.

Jennifer did express, however, that during the chaos of the shutdown, she was left to her own resources. Jennifer's school administration was slow to determine how to proceed and make sure every student was included and accounted for to provide equitable learning for all.

Attitude. Jennifer had a positive attitude and displayed an appreciation for her students. Jennifer spoke with great fondness toward her students and lamented that she could not be in the classroom with them. She spoke with an unwavering can-do idealism describing how the students would ultimately overcome their pandemic learning obstacles.

Partnership. As with Colleen, partnership for Jennifer was very important. Jennifer's partner was a fellow science teacher and together they planned curriculum and

lessons throughout the year. Jennifer also expressed how she worked throughout the summer in order to prepare for the upcoming school year.

What was different in the circumstance of teaching during the pandemic was that Jennifer's partner had young twin daughters who were also at home learning remotely. This presented a difficult situation for Jennifer as she was not able to rely on her partner as much as she wanted. She also admitted that she felt a little bit guilty in that her children had already grown so it was just her and her husband at home and she had the luxury of having a quiet house and an undisturbed space in which to work.

Family. Jennifer expressed feeling a sense of isolation at being at home. She felt restricted and limited in the ability to teach online versus her live in-person teaching practices. She said she really missed the kids and being in the classroom and was looking forward to getting back as soon as she could. From an interpretive standpoint, even though she displayed exuberance and enthusiasm, she also mentioned almost offhandedly how she had to be hooked up to a heart monitor during part of the year when she had heart palpitations due to anxiety. So, on one hand she was discussing how much she loved teaching and how great everything was, and on the other hand she confessed to how she became physically ill due to anxiety.

Engagement. Engagement was the most challenging aspect for Jennifer. She admitted that she was a very hands-on teacher who liked to interact with her students and spend one-on-one time with them face-to-face to check in on them and see how they were doing, and teaching online really took that away from her. She expressed how challenging it was to try to re-create this engagement in an online format. She found teaching online and sitting very limiting and she really missed the experience of being

physically in her classroom and moving about her room. As such, she worked extremely hard to try to re-create in-person engagement by reaching out to her students to get them to turn on their cameras to play games, answer questions, and generally just stay focused in the class.

Humor. Humor was one of the distinctive traits Jennifer possessed. She was very self-deprecating and jovial and liked to make jokes. She had a general humorous side to her that appeared to be a coping mechanism to get through the tough times.

Health. Even with Jennifer's high level of efficaciousness and positive attitude and humor, her life was not without stress entirely. She admitted to me that she did suffer from some kind of anxiety as a result of teaching during the pandemic or just the stress of the pandemic itself. Jennifer revealed she had heart palpitations and was not sure what caused them. She went to the doctor and was referred to a cardiologist and was instructed to wear a heart monitor to monitor her stress levels to make sure her heart and blood pressure were in good condition. She laughed about it with her self-deprecating humor but she seemed genuinely concerned about her health.

Teresa. Teresa and I met one morning after she had come back from a kickboxing class. She appeared on camera with wet hair slicked back in a ponytail and no makeup, and with a very relaxed no-nonsense attitude. She was very funny and self-deprecating. She seemed to be very self-possessed and comfortable in her own skin. She had been teaching for more than 20 years and was in her 50s, and she had one child and a husband who was also a teacher.

Self-Efficacy. Teresa was an interesting interviewee because she also had background experience teaching online at the community college level. She had been

teaching online classes for several years, so she brought an interesting perspective to the online teaching experience. When she had to pivot her seventh- and eighth-grade science classes to an online format, she relished the experience. She said she loved being at home and looked forward to teaching more online in the coming school year because her district was going to offer both in-person learning and an independent online academy.

It was striking how Teresa's self-efficacy was so prominent in her experience with teaching online during the pandemic. Her extensive experience teaching online college courses really made a difference in how she experienced the pivot to remote teaching. It showed that there is no substitute for experience and training. She even stated many teachers came to her for guidance and assistance in setting up their own online teaching platforms.

Autonomy. Because of Teresa's high level of experience and training in teaching through a remote modality, she was afforded a great deal of autonomy by her school district. Teresa's school district is the second largest in a study and though it is still a large district, it seems to provide a degree of independence to the teachers as I surmised from my interview with Teresa.

Teresa's desire for autonomy was also evidenced in the fact that she loved teaching from home as she liked the freedom and independence it gave her. This is why Teresa volunteered to teach in the online academy that her district is offering for those students who wish to remain strictly online. This was in striking contrast to Jennifer, for example, who deplored having to teach from home and could not wait to get back into the classroom.

Attitude. Teresa had an excellent and positive attitude toward her circumstances. Maybe it was because she had just come from a workout, but she seemed to be light and positive and forward thinking. She delighted in teaching from home and was happy to be at home with her family. She also expressed excitement at the challenge of setting up an online academy for her district.

Partnership. In keeping with Teresa's self-efficacy and autonomy, she did not rely on a teaching partner or engage in a partnership. Instead, it appeared she was more of a leader in that regard and other teachers looked to her for guidance and leadership. I think it also may have had something to do with the fact that her husband was a fellow science educator so I think the partnership others experienced with fellow teachers Teresa had with her own life partner.

Family. As mentioned previously, Teresa had a strong support system at home with her husband who was a fellow science teacher. In fact, her husband was the teacher on special assignment (TOSA) for science in the district. This meant he was not in the classroom but moved around from school to school supervising instruction and coordinating the science curriculum and assessment. It also meant he was home during the pandemic and conducted his supervisory duties online. Teresa and her husband had one daughter and Teresa expressed that she was old enough to be fairly independent with her online learning, so it seemed her household was quite peaceful.

Engagement. Teresa expressed that she had a high level of engagement that was evidenced in the way in which she described her use of recommended digital software programs that promoted engagement. Her experience teaching online really came through when it came to finding innovative ways to engage her students through technology. She

seemed to have a digital literacy that was well above that of her fellow teachers. For this reason, she had a wealth of information that she used to engage not only her native English speakers but her ELs as well.

Humor and Health. I am combining humor and health for Theresa because it seems her humor is what makes her healthy. She displayed an excellent sense of humor and ability to laugh and find humor in situations that keeps her spirits up and her attitude positive. She also appeared to be very healthy as she participated in exercise classes such as kickboxing.

Jan. Interviewing Jan was my first experience interacting with a non-binary person. I was already familiar with the use of non-gendered pronouns (e.g., they, them, and their), but I had never encountered a non-binary person socially. It was a unique opportunity to try to understand their life world. Jan was very open and considerate and enthusiastic in supporting the study.

Self-Efficacy. Jan seemed to be highly efficacious especially with knowledge about their Advanced Placement Biology subject matter. They had a master's degree in biology and the location where Jan teaches requires a high level of knowledge and skill. The students at this school have historically received high test scores in the STEM subjects. This school district is very popular among families who want to have an excellent science oriented public-school experience.

Autonomy. As with Teresa, Jan had been afforded a high degree of autonomy as they both teach in the same district. Therefore, when it was time to pivot to an online format, Jan had the ability to innovate and find interesting teaching software that the students would appreciate and that, more importantly, would challenge the students.

Again, the student body is very advanced and so it is always a challenge for Jan to find interesting ways to challenge students.

Attitude. Jan had a very positive and inclusive attitude. They were very concerned with equitable access for all students and very much concerned with gender, gender identity, and gender fluidity as they expressed concern and opinions on various LGBTQ issues.

Partnership. As with Colleen, Jan had relied on a strong partnership with a fellow science teacher over the years. However, they expressed that unfortunately the pandemic had taken its toll on their partner who had decided to leave the profession. They felt the stress of the pandemic probably was the catalyst for this decision. Their partner had initially decided to take a year off prior to the pandemic in order to spend more time with family or travel. Jan thought the onset of the pandemic was the reason their partner made this final decision on their career.

Family. Jan is married to a woman who is in the nursing profession. Jan expressed that they were happy that their wife did not have to work shift hours like many nurses and that she had normal 9-to-5 hours as she worked in administration. Jan and their wife had 8-year-old twins, one boy and one girl, though Jan expressed that the boy recently had come out as a trans person. My interview with Jan did not go deeper into this subject but they did express that this revelation was quite stressful in their household in addition to the stress related to assisting their twins with remote learning, which made teaching from home difficult.

Engagement. Jan has been teaching AP Biology for several years and loves it. They are very social and missed the interaction and connection they had with students in

the classroom. However, Jan was very excited to share how they were able to recreate the social connections and engagement in an online format even with the relative isolation of digital modality.

Humor. Jan had an excellent sense of humor and expressed that this humor came in handy with students. AP Biology students are very intense, according to Jan, and I think humor was a way for them to interact and break the ice with the students and get them to feel more comfortable in the class and with each other.

Health. Although we did not discuss health in particular, it appeared Jan was very healthy physically though I do not know to what extent the stress that existed in their home life affected their physical health, if at all. Jan mentioned that one of their coping mechanisms was that they enjoyed more "adult beverages" than before.

Themes Across Cases

After the emergent sub-themes were organized and parsed from the narratives, the data revealed overlapping themes that I then organized into cross-case themes and grouped accordingly. Table 6 illustrates how these cross-case themes incorporated multiple emergent themes and were distilled to be representative of the group. This level of analysis was descriptive and gave me a measure of freedom with which to organize themes (J. A. Smith et al., 2009).

Table 6

Emergent Themes Presented With Themes Across Cases

Emergent sub-themes	Themes across cases
Self-efficacy Autonomy	Adaptability
Attitude Partnership Engagement	Connection
Family Humor Health	Social-emotional well-being

Instructional Resources Used by Participants

The cross-case themes of adaptability, connection, and social-emotional/well-being were shared by participants and were developed and supported by instructional resources that promoted engagement and online learning. Table 7 lists several instructional resources extracted from the interviews used by participants in the study.

Table 7

Participants' Recommended Online Instructional Resources

Participant	Grade & subject taught	Recommended instructional resource	Description	Supports ELs
Colleen	6th grade math	Desmos	Animated, interactive	Yes
		Ed Puzzle	Online video tool to embed content	Yes
		Kahoot	Game based learning platform	Yes
		Blooket	Game based learning platform	Yes
Jan	9th–12th grade AP bio	HHMI	Audio add on for online reading	Yes
		Pear Deck	Interactive online science learning	Yes
		Canvas	Audio add on for online reading	Yes
Jennifer	7th grade science	Amplify	Science curriculum Hands-on literacy rich	Yes
Teresa	7th–8th grade science	Google Translate	Talk/text language translation software	Yes
		Tik Tok	Short form video application	Yes
		Gizmos Explore	Online math and science simulations	Yes
		Brain Bop	Animated learning videos with quizzes	Yes

Answering RQs Thematically

In this section, I address each research question thematically along with representative data extracts from each participant. The data showed numerous examples of how the participants responded to the abrupt transition to remote learning, how they adapted their curriculum to digital platforms, and how they viewed their students' equity and access to learning. Tables 8–10 provide data extracts to address the research questions.

Table 8

RQ1: How Did STEM Teachers Experience the COVID-19 Shutdown and Pivot to Online Learning?

Theme	Participant	Reference	In-vivo code
Adaptability	Colleen	Assessment	We knew that testing wasn't going to happen, so that kind of took a bit of pressure off, and we also knew that there was not this expectation that I needed to see every kid.
	Jan	Changing existing lessons	So, we scrapped a bunch of things that my teaching partner and I [had] always used [and] we had set up a collaborative inquiry learning.
	Jennifer	Benefit of prior student relationship	Because I had a relationship with those kids already from the school year it was no problem. As a matter of fact, some of my EL kids did almost better and so did my kids with IEPs and 504s almost did better when I had a relationship with them.
	Teresa	On teaching online	I was so excited about it. I love it. I've been teaching online [college classes] for 20 years.
Connection	Colleen	Partnership	At my school, we have teaching partners. [Name] and I worked really hard to figure out how we were going to get through the rest of the school year.
	Jan	Creating online groups	With our kids we set up the year where we have them do Myers-Briggs personality tests and then we would set up their teams based on their results and try to mix introverts with extroverts.
	Jennifer	On working from home	I was lucky because it was just me and my husband.
	Teresa	Engaging students	You know I'd shout out like a random question like in the chat box. If you're listening, tell me your favorite animal you know in the chat box, what's your favorite ice cream? Go!
Social-emotional/ Well-being	Colleen	Quarantine/ Home life	And my husband I were like, well, if we're going to be in quarantine, let's get a puppy.
	Jan	Teaching from home	I might have partaken in a little bit more adult beverages in the afternoons than I normally did. I have twins too, and they're trying to get their Zoom stuff and get them [set up] and be on. I was on all the time so by the time my wife got home from work I just wanted to implode.
	Jennifer	On teaching	I am the luckiest person in that I really love my work and even with Zoom did not have a single day where I was getting ready for school and ask do I have to do this today? I love the community.
	Teresa	Grading and assessment	We were supposed to provide feedback but no grades. The grades basically froze in time that day.

Table 9

RQ2: How Did STEM Teachers Perceive Equity and Access for EL Students in the Distance Learning Format?

Theme	Participant	Reference	In-vivo code
Adaptability	Colleen	Attendance	I had a lot of kids that just showed up because they wanted to see me or a teacher or an adult that's a friendly face that's not their family member—they had no one else to necessarily be with in their house because their parents were working, so they showed up just to hang out with me.
	Jan	Students who take AP bio	A lot of the [EL] kids that I see in AP bio chose to take the course already had a lot of English classes so they step into the class pretty [well].
	Jennifer	Kids' access to learning	And then you have kids who are equally intelligent but just don't have the tools in their toolbox and or the English as in the English learners or you know they've got situations at home.
	Teresa	Homework online learning platforms	The one great thing too about virtual learning is that stuff doesn't get lost. They can't use that excuse anymore "Dog ate my homework. No, I didn't. I can't find this."
Connection	Colleen	ELs worked offline	I almost did not see ELs [on Zoom] they chose to do all the work asynchronously and not show up on Zoom.
	Jan	Teaching in hybrid model	I tried to be very cognizant of going back and forth and making sure that both groups felt like they were part of the thing where they know other teachers.
	Jennifer	Reaching out	[The kids would] reach out to me Miss Jennifer because that was our relationship you know they were comfortable speaking to me.
	Teresa	Connecting with ELs	The other thing is you get them to practice English like say hey I want this answer in English you know as much as you can.
Social-emotional/ Well-being	Colleen	Not appearing on camera	This might be something where the families did not want us seeing their houses and the families did not feel comfortable with us.
	Jan	Feelings toward students	I love my students; they're my family and I spend the whole year [saying] you entered my room. I'm now your auntie. Your second mom, your dad. I don't care whatever you want to call me. I'm here for you. I'm here to help you navigate through this. We're a family and I try to get them to feel like they can go to each other, especially within their small groups. Try to engage in that. How to communicate properly.

Theme	Participant	Reference	In-vivo code
	Jennifer	Kids' home lives	You know it allowed for checking out for sure, but I think if the kids were home and if their first-grade sister was home mom was still at work and they were watching their 4-year-old sibling sometimes or that you know there's those are those kids I worry about those kids [who] didn't engage.
	Teresa	Protecting privacy	I never ask kids to turn their cameras on, and that is much to the dismay of a lot of teachers. I feel like it's an infringement on their privacy. Uhm, you don't know what's going on behind a kid you don't know about their house.

Table 10

RQ3: How Did STEM Teachers View Their Ability to Adapt, Innovate, and Differentiate Their Instructional Practices to Teach Both Native and Non-Native Speakers Remotely?

Theme	Participant	Reference	In-vivo code
Adaptability	Colleen	Digital homework	[Work was done] through online platforms, so I could just log into the online platform and check out their work so I could see what they were understanding.
	Jan	Teaching how to read a textbook	They're not taught how to use a textbook. They started to be in the chapter, and they read through it, and they don't have tools and techniques. So, things I [tried] to teach them.
	Jennifer	Re-thinking digital learning	Cause-and-effect or writing assignments or create some sort of visual model where we could use different modalities for them to create models within different tools that they found online and try to build a digital model.
	Teresa	On recorded lectures and videos	The beauty of virtual learning is that a kid can go back and revisit how I explained photosynthesis [view recordings]. . . . EL kids are so savvy that they'll take the captions from your recordings and translate them, run them through Google Translate.
Connection	Colleen	Engagement	Don't push [EL] families to be engaged if they're not . . . [reach out to principal].
	Jan	Innovative strategies	During the virtual part, I started off trying to be creative and build Pear Decks or Nearpods because we had a lot of that light coming at us to try and engage learners.
	Jennifer	Using discussion boards	We've been doing discussion boards a lot where they have to post a response to a prompt before they can see anybody else's response.
	Teresa	Connecting with ELs	They weren't that bad like there were some that were. They were surviving but there were a couple in there that had no English whatsoever.

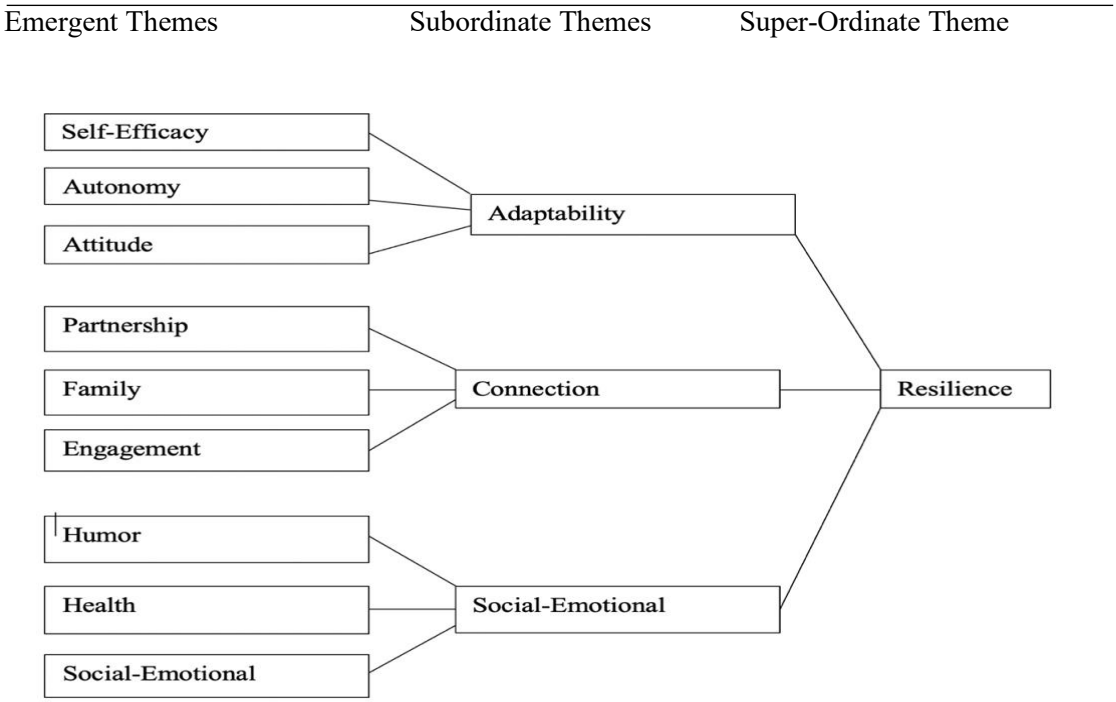
Theme	Participant	Reference	In-vivo code
Social-emotional/ Well-being	Colleen	Building community through games	We're going to have fun—I had 60–70 kids show up and actually play Kahoot with us . . . They wanted that community back.
	Jan	Checking in with kids	95% of the kids actually do the form and a lot of them give me some constructive feedback. I want honest feedback if they type in the chat, you're amazing, I love you, it doesn't really help-you have to give me something constructive or tangible to help me grow.
	Jennifer	On collaborating	They were working together a lot which on one hand could've been a positive that came out of this I think we are all thinking about collaboration now.
	Teresa	Checking in with students' feelings	I try to do it with all of my virtual learning classes. I'm like, you guys you know in the chat box on a scale of 1 to 5 how we are feeling today you know, and if those ones and twos come back to me, then I'll respond back to one on a one-on-one basis. Like hey, I see you.

Subsumption of Themes Into Super-Ordinate Theme: Resilience

The themes of adaptability, connection, and social-emotional/well-being were tethered by one super-ordinate theme that arose from the data: resilience (Figure 5). The data showed how resilience was the essence that came through the interviews and buoyed the most successful study participants. Figure 5 illustrates the subsumption of themes into the super-ordinate theme of resilience. Additionally, a background of the study of resilience is presented as evidenced by extant research that shows resilience is a learned skill and not an inherent trait.

Figure 5

Depiction of Emergent Themes Leading to Subordinate Themes Across Cases to Super-Ordinate Theme



Resilience Findings

To better understand the characteristics of resilience, I provide a brief overview of the resilience research. The word *resilience* is derived from the Latin verb *resilire* - *to bounce back*. Since the 1970s, the K-12 school system has been designed to teach students resilience and equip them with tools to "bounce back" from adversity (Zolkoski & Bullock, 2012). Previously, it was held that resilience was an innate personality trait that was genetically preordained (Tocino-Smith, 2021). Later it was established in the literature that resilience could be taught by providing students skills or "tools" to navigate through difficult and stressful situations (Zolkoski & Bullock, 2012).

Resilience theory has grown in scope and is considered an emerging theoretical framework (van Breda, 2018). Van Breda (2018) has been at the forefront of resilience research from his background in social work in South Africa. Van Breda and colleagues disputed a consensus definition of resilience but were in accordance with the notion that resilience is a process of obtaining successful outcomes after experiencing adversity.

Societal Resilience. Resilience research has gained traction recently in response to the stresses caused by the COVID-19 pandemic. For some people, the pandemic became a positive catalyst for change (E. Smith, 2021). The most recent publication on the subject was by Markus Brunnermeier (2021), economics professor at Princeton University titled "Resilient Society." Brunnermeier argued that "resilience can serve as the guiding North Star for designing a post-COVID-19 society" (Coy, 2021, para. 4). One of the themes Brunnermeier promoted is that there is much to learn from the experience of living through COVID-19. Brunnermeier posited that the pandemic has stimulated experimentation and innovation and that societal "shocks" like the pandemic can promote risk-taking and ultimately resilience. He admitted, however, that risk-taking and experimentation are much easier for the wealthy as they have more buffers to protect against the shocks.

This notion confirms the current study's findings on resilience. Participants with the highest levels of resilience were indeed spurred and challenged by the pivot to remote learning during the pandemic. These teachers took risks, experimented, and innovated their instructional strategies to teach science and math in a new modality.

The STEM teachers who participated in the study engendered many of the characteristics of resilience that were defined in the literature. However, in accordance

with Brunnermeier's (2021) sentiments, the teachers were "buffered" from the shock of the worst of the pandemic. The participants all had homes, up-to-date technology, language, and support. Conversely, this could not be said for the most vulnerable of their EL students. In the next sections, I present findings related to teacher resilience, including data extracts from the interviews as evidence followed by a contrasting narrative illustrating EL challenges to achieving resilience as a result of minimal "buffers" against the shock of the pandemic.

Teacher Resilience. One fundamental question that could not be immediately explained from the inquiry remained: How do we account for the long-term careers of the study participants against the high percentage of teacher burnout and attrition?

Answers point to teacher preparation or lack thereof as teacher education programs have historically focused on pedagogical skills over the social-emotional aspects of teaching (Wang, 2021). In analyzing the findings of the current study, I interpreted a connection between the participants' resilience with their skillsets which, according to the research, are important to being successful in the STEM subjects and by extension, STEM teachers. Indeed, the foundation of STEM learning is problem solving. It necessitates creative and critical thinking and the ability to synthesize new ideas and the desire to improve upon what has come before (NASEM, 2018). In the next section, I provide extracts from the interviews to illustrate teacher resilience followed by interpretive narrative reflections.

In-Vivo Codes Demonstrating Super-Ordinate Theme: Resilience (Teacher)

In this section, I present excerpts from the interviews depicting the characteristics of resilience demonstrated by the study participants along with situated narratives that contextualize the extracts.

Situated Narratives for Research Question 1. Research Question 1 was: How did STEM teachers experience the COVID-19 shutdown and pivot to online learning? Some of the participant responses are included here.

***Jennifer*.** "I didn't have a learning management system. I didn't know how to use it, set it up, and I was trying to get assistance from people who weren't using it at all. So, I just jumped in."

Jennifer is a seasoned veteran who has taught middle school science for more than 20 years. She displayed unwavering enthusiasm and exuberance in her descriptions of teaching and what she loved about her job. From my experience, many teachers say teaching middle school is one of the hardest jobs out there, but Jennifer has embraced this age group and her commitment to her students came through.

Jennifer also admitted that her situation was easier than her teaching partner's situation. She discussed how she was able to teach from home, but it was only her and her husband at home at the time as they had grown children who had moved away. Jennifer reflected that her teaching partner had small children and the experience was much more difficult. She did rely on her partner as they worked very closely in figuring out how to take their curriculum and transform it to an online format.

The excerpt above shows Jennifer had a willingness to try anything. She already had some favorite digital tools she could use with students, but she did not know how to

operate online learning specifically. There was much trial and error, and it was not without stress. In fact, Jennifer admitted she had suffered from stress and at one point had to wear a heart monitor to monitor her stress levels. Even so, she persevered and with time she figured out how to adapt her face-to-face teaching to an online format. But what was clear she did not relish in it.

Jennifer admitted she is a very social person and likes to be in front of the classroom. Jenifer enjoys interacting with students and seeing their faces. She likes to check in with them personally one-on-one to find out how they are doing. It was apparent that Jennifer was very much in touch with her students. For this reason, she found the online setting very limiting. She expressed how it was difficult to engage with students and found it difficult to sit as she was used to walking around and interfacing with students.

Jan. "We scrapped a bunch of things that my teaching partner and I had already set up that were harder to do online but we kept a lot of those collaborative pieces and put them in breakout rooms."

Jan came across as a very organized and prepared person. They (preferred pronoun) were also very technically savvy and had previously established instructional strategies to have their students work collaboratively even before the pandemic broke out. So, when the pandemic did hit and forced their face-to-face class to be moved to an online format, it was a much easier transition than the other participants experienced. Working online through Zoom video conferencing and also using Canvas for a class management system were pretty streamlined.

In addition, Jan recounted how their students were very prepared and technically savvy. Jan teaches AP Bio for Grades 9 through 12. It is considered an open access class as the student population where Jan teaches are very motivated and STEM-oriented students who are very eager to jump into AP classes at an early age. For this reason, the class is open to all students who want to take it. Traditionally, AP Bio is taken in Grade 11. This level of motivation by students makes teaching a little bit easier in some respects but more difficult in others because Jan has to be on their game at all times because the students have high expectations.

What was challenging for Jan, however, was to be at home alone with their 8-year-old twins. Jan's wife is a practicing nurse and was away from the home working most of the time, so it was up to Jan to assist their own children in their online learning, which was quite difficult to manage teaching and parenting at the same time. When Jan's wife came home, Jan was exhausted.

Colleen. "I understood that this was a really weird time and families might have been impacted in different ways that I'm not aware of and I needed to give everyone a little bit of grace."

Colleen was the most empathetic and circumspect of the participants. The above excerpt is a good representation of her attitude toward the abrupt changes and the subsequent stress and anxiety the pandemic caused. It was clear that she had reflected on her experience and even at the beginning of the shutdown, she had perspective on what was important and what was not. Her resilience was also manifested as a result of hard work, close collaboration with her teaching partner, and the general autonomy afforded to her by her district administration.

Colleen teaches sixth-grade math and has always relied on extensive preparation for each coming new school year during the summer hiatus. Colleen and her teaching partner would work throughout the summer getting everything organized and ready. When the pandemic forced the transition from in-person to distance learning, Colleen's preparation made the transition smoother.

In addition, Colleen teaches in the smallest school district represented in the study. As such, she was afforded greater autonomy and independence on how to handle the online teaching transition. She was only given general guiding principles for attendance, assessment, grading, and engagement.

***Teresa*.** "I loved it. I've been teaching online college classes for 20 years. If it's well done, virtual learning is a ticket to bring education to every kid and every part of the world."

Teresa had the most experience teaching online of the four participants. As such, it was no surprise that she expressed the most ease in the transition from in-person to remote teaching when the schools shut down. The above excerpt expresses her general attitude and "buy in" toward teaching online. She believed online teaching was the future in education and it could be the disruption needed to bring education to all students regardless of where they lived or other barriers to in-person learning.

Situated Narratives for Research Question 2. Research Question 2 was: How did STEM teachers perceive equity and access for EL students in the distance learning format? Some of the participant responses are included here.

Jennifer. "We couldn't do it because this was at home and kids didn't have the same supplies which breaks all the equity rules, we just didn't do it then so we will film it and they can watch it."

Jennifer seemed to know a lot about equitable access to instruction. She had participated in extensive PD over the years as she was the most senior teacher of all four participants. However, I interpreted that one of her challenges was that she did not have guidance from administration as to how to move forward to incorporate equity and access for all of her students in this new remote modality. In addition, Jennifer teaches in the largest school district of all study participants, and this is indicative of the top-down bureaucracy Jennifer faced in trying to manage her online classes. This kind of leadership stunted Jennifer's ability to innovate and take risks by trying new ways to adapt and adjust her teaching practices. I interpreted this because it was clear that she was ambivalent in trying new things for fear of breaking rules or infringing on the privacy or civil rights of her students. So, although she knew full well what equity looked like, she was limited in the way she could deliver it to her most vulnerable students, especially ELs.

Jan. "A lot of the kids I see in AP Bio that chose to take the course as a non-native speaker have already had a lot of English classes and they are able to step into it pretty well."

Jan did not have the same challenges with equity and access as the other three participants encountered as far as ELs were concerned. The above excerpt illustrates how Jan teaches AP Bio and the students who arrived in their classroom already had quite a bit of English in order for them to qualify even being in the class. Jan did mention in the

interview, however, that it was often difficult to communicate with the families of these students. Jan spoke about the kinds of families that came to the area with usually one spouse working in one of the tech companies nearby and the other spouse at home taking care of the children. It seems the spouse at home was the one with limited English. Jan did not seem to make a connection between equity and access that included the families of the students in addition to the students themselves.

***Colleen*.** "Another way for parents to get to see what we were doing in class and for them to get access to the materials because they could go and watch them too."

Colleen discussed how there was a gap in equity between her EL students and the rest of her native English-speaking students. She was quite aware of the differences, and she worked very hard to try to engage her more vulnerable students who often sat at the margins. Colleen found it very difficult when students did not show up for class and she was told by her administration to not pry into their personal lives for fear of adding more stress to an already stressful situation. For this reason, she really did not know what had happened to some of her students who did not attend. She did not know if they were in the country, or they were at home, or they were unable to connect due to subpar technology and connectivity.

***Teresa*.** Teresa said:

> I have been working with teachers about their grading for equity, grading schedules making sure that the platform they use is for the best interest of the kids and then it's synchronized for all teachers making sure that the parents have access to follow up on stuff if needed.

Teresa had the skills from her previous experience teaching online courses for the community college to engage her students using the technology. For this reason, she was able to adjust her teaching for the younger students she was teaching online during the pandemic and provide them with equitable instruction.

She did admit that her administration also mandated that she was not allowed to force students to have their cameras on so this did bring up the issue of "out of sight out of mind" when students were not engaged in the classes and only had their photo to represent their appearance on screen. Teresa developed creative ways to engage the students who did not participate readily in the class and usually this was through some sort of "gamified" way to get them to respond, such as a joke or a quiz or asking them to push her button just to let her know that they were there. Other than that, she had very little opportunity to find out why her students were not engaged and to adjust her teaching accordingly to meet the needs of those students, who were usually ELs.

Situated Narratives for Research Question 3. Research Question 3 was: How did STEM teachers view their ability to adapt, innovate, and readjust their teaching practices to teach ELs remotely? Some of the participant responses are included here.

***Jennifer*.** "Well, you just had to be really clear in all your instructions so like every Pear Deck had these really clear instructions everything was super visual."

Jennifer talked about how she was able to adapt her face-to-face instructional strategies to an online format and she learned many things by doing so. She told me that in order to re-create lessons online, she had to be extra meticulous when writing instructions for experiments or other activities. What she learned was that this facilitated the ELs in terms of their comprehension of what they were required to do. She reflected

that when she taught in person in previous years, she had the tendency to speak very quickly and animatedly, and she felt she may have lost some of her ELs because she did not necessarily repeat what she said.

For this reason, she felt learning how to make instructions very explicit and clear was ultimately a benefit for not only her native English speakers but mostly for the ELs. She even reported that these students did better than the native English speakers on some of the assignments and she was surprised at the quality of their work. She felt this was a direct result of her clear, concise, and simplified instructions.

Jan. "During the virtual part I started off trying to be creative and build Pear Decks or Near Pods because we had a lot coming at us to try to engage learners."

Jan expressed how they (preferred pronoun) were fortunate in some ways when the pandemic hit because they had previously set up a course management system through Canvas. Jan explained that they had the opportunity to select the system and they were very happy that they had chosen Canvas. Jan said that when the pandemic hit, they found it was really easy to adapt their instructional practices with the Canvas platform.

However, Jan lamented that it was very difficult to continue to practice "live" hands-on so-called "wet" experiments in an online format. For this reason, Jan recommended using the Howard Hughes Medical Institute software so students could have at least a simulation of experimentation through watching videos and interacting with the content online and producing hypotheses and explanations of the results of the experiment.

Colleen. Colleen said:

> I honestly don't know how to answer that, but I found out later we suggested that he [EL] student might have a learning disability and related to his reading comprehension issues we were seeing in math, and they were seeing in humanities

Colleen was somewhat fortunate in that her school district was on a different schedule than the other three districts in the study. This was beneficial because when the pandemic hit and the shutdown commenced, she was already on Spring Break. Therefore, she took the opportunity along with her teaching partner to re-tool their instructional practices and adapt them to an online format. She recounted how she was very familiar with technology and in fact was the head "techie" at her own house and was very adept with the technology to create a teaching platform that would work with the new online modality. In addition, she was aided by her partner, and they divided the labor and together they worked tirelessly throughout Spring Break so they could be prepared for when school came back in session. Nevertheless, even with all the preparation Colleen and her partner put in prior to school returning after Spring Break, Colleen expressed frustration with trying to understand some of the issues she had with some of her students, including her ELs.

The above excerpt is indicative of Colleen's frustration in that she had certain students she just did not know what to do with and she was limited with what she could use to assess them properly and diagnose their problems. She admitted that removing the assessment requirement for students was in some ways removing a layer of stress and worry from the situation, but she also stated there was no way to know what the issues were with certain students who were not performing at the requisite levels.

***Teresa*.** Teresa said:

> I have been working with teachers about their grading for equity and grading schedules, and making sure that the platform they use is for the best interest of the kids and then it's synchronized for all teachers making sure that the parents have access to follow up on stuff if needed.

Teresa had an interesting perspective on the topic of online cheating that became pervasive during remote learning. Her perspective was another example of how her experience with teaching online courses at the college level became very useful. She expressed how many teachers simply tried to put their live, in-person courses into an online format as they had no previous experience creating digital programs.

Teresa felt this kind of programming was conducive to cheating and students took advantage in many ways in using that to their benefit. Students were able to use their cell phones and look up information while taking quizzes. However, Teresa knew how to organize her material and coursework so students needed to show that they knew the material in different ways other than just "Googling" the answers. For this reason, she even told her students to "go ahead and Google as much as you want" because she knew how to create activities that required students to think critically to demonstrate their knowledge and not just look up the answers.

Teresa had some interesting perspectives on ELs and how they adapted with some of the technology themselves in order to get their work done. Teresa explained that Google Translate became very important to some students and she encouraged them to use this tool. Some of the instructions she provided the students they were able to download into Google Translate and read in their native languages. In addition, they were

able to write their classwork in their native languages and have the work translated back into English before they turned in an assignment.

Word Frequencies and Interpretation of the Findings

In this section, I present the findings of the language used by the participants through a corpus linguistics perspective. Corpus linguistics is the study of vast quantities of real language using computer-assisted software (Stubbs & Halbe, 2012). Linguists collect and study "corpora" or large bodies and types of language from all sectors of society, including academic language (Stubbs & Halbe, 2012).

Language became an integral part of the interviews as all were conducted via Zoom video conferencing and many of the characteristics involved in a face-to-face communication encounter were removed. Communication involved a two-dimensional screen and microphones and speakers that facilitated delivery.

Word frequencies revealed unique characteristics about each participant. Although there was a commonality of language and vocabulary involved with the subjects taught, participants' language demonstrated a personality or identity representative of each school district. Figures 6–9 include differentiating linguistic characteristics with respect to word choice as evidenced from the interviews. Using NVivo software, I used word count queries to investigate participants' word frequency and usage.

Figure 6

NVivo Software's Text Query Findings of Word Frequencies – Teresa

Word	Length	Count	Weighted Percentage	Similar Words
teresa	6	632	6.25%	teresa
researcher	10	299	2.96%	research, researcher
right	5	77	0.76%	right
teachers	8	67	0.66%	teacher, teachers
think	5	63	0.62%	think, thinking
really	6	55	0.54%	really
teaching	8	52	0.51%	teach, teaches, teaching
going	5	40	0.40%	going
student	7	40	0.40%	student, students
thing	5	39	0.39%	thing, things
learning	8	36	0.36%	learn, learned, learning
parents	7	36	0.36%	parent, parents
school	6	35	0.35%	school, schools
virtual	7	31	0.31%	virtual, virtually
science	7	28	0.28%	science
little	6	27	0.27%	little
'cause	6	27	0.27%	'cause, cause
interesting	11	27	0.27%	interested, interesting, interests
class	5	26	0.26%	class, classes
talking	7	25	0.25%	talked, talking, talks
still	5	25	0.25%	still
start	5	21	0.21%	start, started, starting, starts
grade	5	21	0.21%	grade, grades, grading
every	5	20	0.20%	every
gonna	5	19	0.19%	gonna

Figure 7

NVivo Software's Text Query Findings of Word Frequencies – Jan

Word	Length	Count	Weighted Percentage	Similar Words
researcher	10	159	2.42%	research, researcher
think	5	52	0.79%	think, thinking
going	5	44	0.67%	going
thing	5	36	0.55%	thing, things
school	6	35	0.53%	school, schools
college	7	35	0.53%	college, colleges
right	5	35	0.53%	right
content	7	27	0.41%	content
trying	6	27	0.41%	tried, trying
engage	6	25	0.38%	engage, engaged, engagement, engaging
class	5	24	0.37%	class, classes
teaching	8	23	0.35%	teach, teaches, teaching
really	6	23	0.35%	really
groups	6	21	0.32%	group, groups
teachers	8	20	0.30%	teacher, teachers
learning	8	19	0.29%	learn, learned, learning
person	6	19	0.29%	person, personality
'cause	6	18	0.27%	'cause
virtual	7	18	0.27%	virtual, virtually
always	6	17	0.26%	always
questions	9	17	0.26%	question, questions
course	6	15	0.23%	course, courses
english	7	15	0.23%	english
maybe	5	15	0.23%	maybe
understand	10	15	0.23%	understand, understanding

Figure 8

NVivo Software's Text Query Findings of Word Frequencies – Jennifer

Word	Length	Count	Weighted Percentage	Similar Words
jennifer	8	501	5.77%	jennifer
researcher	10	171	1.97%	research, researcher
right	5	110	1.27%	right
going	5	96	1.11%	going
think	5	94	1.08%	think, thinking
really	6	61	0.70%	really
thing	5	46	0.53%	thing, things
teachers	8	39	0.45%	teacher, teachers
something	9	36	0.41%	something, somethings
cause	5	35	0.40%	'cause, cause
always	6	33	0.38%	always
teach	5	31	0.36%	teach, teached, teaches, teaching
schools	7	27	0.31%	school, schools
class	5	26	0.30%	class, classes
gonna	5	24	0.28%	gonna
create	6	23	0.26%	create, created, creating
classroom	9	23	0.26%	classroom, classrooms
learning	8	21	0.24%	learned, learning
still	5	20	0.23%	still
engagement	10	20	0.23%	engage, engaged, engagement, engaging
working	7	19	0.22%	worked, working, works
getting	7	19	0.22%	getting
little	6	17	0.20%	little
happens	7	16	0.18%	happen, happened, happening, happens
alright	7	15	0.17%	alright

Figure 9

NVivo Software's Text Query Findings of Word Frequencies – Colleen

Word	Length	Count	Weighted Percentage	Similar Words
colleen	7	491	5.36%	colleen
researcher	10	289	3.16%	research, researcher
going	5	86	0.94%	going
students	8	65	0.71%	student, students
right	5	63	0.69%	right
school	6	54	0.59%	school, schools
things	6	52	0.57%	thing, things
think	5	50	0.55%	think, thinking, thinks
really	6	43	0.47%	really
teaching	8	37	0.40%	teach, teaches, teaching
parents	7	35	0.38%	parent, parenting, parents
families	8	33	0.36%	families, family
class	5	31	0.34%	class, classes
little	6	30	0.33%	little
learning	8	30	0.33%	learn, learning
teacher	7	29	0.32%	teacher, teachers
actually	8	27	0.29%	actually
every	5	27	0.29%	every
online	6	26	0.28%	online
curriculum	10	25	0.27%	curriculum, curriculums
different	9	23	0.25%	differences, different
grade	5	23	0.25%	grade, grades, grading
trying	6	22	0.24%	tried, trying
question	8	21	0.23%	question, questions
english	7	21	0.23%	english

Trying to find meaning and interpretation from word frequencies was an interesting exercise. It was almost like looking into Tarot cards to determine a person's

destiny. However, I think this was more of a refined exercise because I had conducted extensive interviews with each participant, so I was able to better understand the significance of the words the teachers used more frequently than others.

I paid particular attention to the top five or six most frequently used words by each participant. This was revealing because one participant, Colleen, had "students" as the most frequently used word during our interview. What was interesting about that was that Colleen was the most empathetic of all the participants and this revelation made perfect sense. During our interviews it was evident that she cared deeply for her students and was very concerned about their welfare. It was Colleen who mentioned that she wanted to provide understanding and grace for her students because she did not know how they were enduring the pandemic.

Both Teresa and Jennifer used the word "teachers" most frequently during the interviews. I interpreted that this was because both Teresa and Jennifer, as the most senior of the participants in terms of teaching experience, worked with other teachers and helped to train and prepare and guide them during their long tenure. In fact, it was Teresa, with her extensive online teaching experience, who mentored many of the less experienced teachers during the pandemic.

Jennifer also mentioned that her priority as a teacher was to put out an excellent product and she compared herself to other teachers who cut corners and did not put in as much effort as she did. Jennifer's comments hinted at a competitive nature. It seemed she was very aware of what other teachers were doing. It was interesting to note that Jennifer was also a member of a cluster of fellow teachers who worked at other school sites within

the district. This may explain why Jennifer was very interested in how other teachers at other sites were teaching.

Jan's most frequently used words were "school" and then "engage." The word "engage" seemed especially appropriate and emblematic of Jan's teaching philosophy, as Jan spoke about working tirelessly to engage their students when they taught in person. Jan expressed how they would go to great lengths such as jumping on desks and running around the classroom to get their students' attention, interest, and energy engaged.

Connecting Findings to the Theoretical Frameworks

In this section, I connect the findings from the study to theoretical frameworks that grounded the inquiry. I present the findings on how the study participants navigated through Mezirow's (1994) phases of transformational learning after experiencing the unprecedented "disorienting dilemma" of teaching remotely during the COVID-19 pandemic. In addition, I provide evidence of participants' perceptions on various issues through the lens of critical theory.

Transformative Learning Theory

Mezirow (1994) argued that adults possess frames of reference that encompass associations, values, feelings, and conditioned responses. These frames of reference define the adult worldview (Mezirow, 1994). COVID-19, for many, disrupted the "line of action" that Mezirow described as the automatic mental and behavioral actions adults use to negotiate their worlds. The disruption of the pandemic was the "disorienting dilemma" that Mezirow described as an event that profoundly shakes up existing "habits of mind" and "points of view" (Cranton, 2006, p. 26).

As schools were forced to shut down as the pandemic proliferated in the United States, teachers' "habits of mind" were shaken, questioned, and challenged at the prospect of transforming educational practices to a remote and digital modality. The belief that teachers teach in person to a group of live students in a classroom was undermined, which created a disorientation that called for fundamental change in the way educators educated. The term "pivot" became a buzz word that exemplified the haste required for the change.

The study revealed the degree to which teachers were able to adapt and overcome disorienting dilemmas and change long-held "habits of mind" and "points of view." The interview transcripts indicated the processes teachers underwent to adapt their teaching practices, which subsequently transformed their attitudes, beliefs, and values.

One of the actionable processes of transformational learning is what Mezirow referred to as *critical reflection*. This requires reflection on what was learned as one navigates through the phases of transformative learning. To promote reflection, Mezirow proposed working through a seven-stage sequence (Mezirow, 1994). Table 11 depicts the successive seven stages along with the participants' attainment of each phase.

Table 11

Participants' Navigation Through Mezirow's Learning Transformations (Seven-Stage)

Stages	Colleen	Jan	Jennifer	Teresa
Disorienting dilemma *Did the participant experience the pandemic as a disorienting dilemma?*	Y	Y	Y	Y
Self-examination with fear anger and guilt *Did the participants experience fear anger and guilt?*	Y	Y	Y	Y

Stages	Colleen	Jan	Jennifer	Teresa
A critical assessment of assumptions *Did the participants critically assess their assumptions?*	Y	Y	Y	Y
Recognition that one's discontent and the process of transformation are shared *Did the participants share in the transformation with others?*	Y	N	Y	N
Exploration of options of new roles, relationships, and actions *Did the participants explore options, new roles, relationships, and actions?*	Y	Y	Y	Y
Planning a course of action *Did the participants plan a course of action to navigate through the pandemic?*	Y	Y	Y	Y
Acquiring knowledge and skills for implementing one's plan *Did the participants acquire knowledge and skills?*	Y	Y	Y	Y

The findings showed all participants navigated their way through Mezirow's stages of transformational learning to some degree or another. All participants expressed that the pandemic was a disorienting dilemma that caught everyone off guard. One participant had followed the news of the pandemic when it was in China and had an inkling that it may reach the United States. This caused her to be more proactive and follow the news more closely. When the pandemic did hit and shut down the schools, Colleen, in particular, was ready.

This kind of preparedness was indicative of all four participants as they all demonstrated very organized and detailed critical thinking that was reflective of the STEM subjects they taught. Their critical thinking and organizational skills served them well and it goes to show that teaching students these kinds of skills, these kinds of problem-solving abilities, can really help them later in life or even as a career.

This is why the STEM fields, in my opinion, need to draw in more ELs who have otherwise been left out of this domain. STEM subjects can prepare students to tackle difficult situations through teaching them the resilience and wherewithal to find creative and innovative ways to change the status quo and make circumstances better for all.

Critical Theory

Critical theory was the lens I used to view ELs and their place within the existing societal power structures of the educational domain. Within the educational domain context, in Table 12, I present findings on how participants perceived critical pedagogy and how they challenged the inequalities of their marginalized EL students.

Table 12

Participants' Use of Critical Pedagogy to Support English Learners

Critical pedagogy assumptions	Jan	Colleen	Jennifer	Teresa
Assessments for English learners *Did the participants assess ELs to critically discern academic achievement?*	N	N	N	N
Equity and access for English learners *Did the participants provide for equity and access for ELs?*	N	N	N	N
Positioning of English learners *Did the teachers "position" ELs similar to native English-speaking students?*	N	N	N	N

Overall, the findings showed remote learning did not provide ELs with equitable access to the same instruction, technology, communication as their non-EL counterparts. The participants revealed they had limited abilities to provide equity to lift ELs to the equal footing of their peers. The participants expressed limited authority over making sure ELs were perceived and positioned at the same level of their classmates.

This inequity was evidenced during Zoom video classes as it was reported that most ELs kept their cameras off. Not "appearing" on camera caused EL students to be positioned at a lower level of importance than those students who actively participated with cameras on. The perceived disengagement by ELs, the findings showed, was interpreted as disinterest and participants reported limited attempts to engage these students. In fact, participants reported their administrations instructed them to "not put any undue pressure" on students. Though this mandate probably came from a place of sensitivity and compassion, it had the unintended consequence of leaving ELs behind.

Findings on Returning to In-Person Learning

I contacted the participants after the new school year began in September of 2021 and in-person learning resumed. The following excerpts represent Colleen's (sole respondent) experiences surrounding returning to in-person teaching. Colleen responded to questions designed to find out how she was experiencing returning to in-person learning. When I asked Colleen, "How is the new school year going?" some of her responses were as follows:

> This year is challenging. The students are not used to being students in a classroom and there are some academic holes to be filled. . . . It is nice to connect with kids each day and I am sure that they are emotionally better because of that. . . . The demands from parents seem to be more urgent and require more time and effort than they did in the past.

When I asked Colleen, "What kinds of students do you see live in person versus remaining online if any (online academy)?" some of her responses were as follows:

> I see 99% of my students in person. I only have four students that are in my online academy. Two of those individuals are at home due to medical concerns and two opted to stay at home (reason unknown). . . . I think that home distractions continue to play a role in students underperforming when learning at home.

When I asked Colleen, "What does it feel like to be back in the classroom?" some of her responses were as follows:

> I don't like it, actually. I forgot what it was like to police kids all day long. It is easier to check for understanding and to help students, but I do not enjoy the classroom management portion of my job.

When I asked Colleen, "How are the students' social-emotional welfare?" some of her responses were as follows:

> The students are resilient. I think that they are happy to have interaction everyday with people outside of their family. . . . They seem a little more respectful towards me (possibly even grateful for the work us teachers do in terms of connecting with them). . . . "However, their social skills are very immature after not having been in a classroom for a few years.

When I asked Colleen, "What perceptions do you have about "learning loss" if any?" some of her responses were as follows:

> There are things that will need to be retaught and there are kids that need extra support in some areas. . . . We have transitioned to supporting the entire class in reviewing/ reviewing skills. . . . The main thing is that this is no different than what teachers do every year (every year!), there may just be more students who need a little refresher this year.

When I asked Colleen about using remote learning software in the classroom, some of her responses were as follows:

> All lessons we made during virtual instruction are being used this year in person and all methods of assessing students have remained the same. . . . This may be due to our continued monitoring of COVID and wanting to make any necessary transition back to virtual learning seamless for kids (should that happen), but it is also related to the need to educate our students in our online academy. . . . "This structure is also helpful for when we have students who need to quarantine - they also join our class virtually via Zoom and can continue to participate in our activities from home.

When I asked Colleen about ELs and the achievement gap, some of her responses were as follows:

> I do not know how my current second language learners were in March of 2020, so I am not sure of their achievement gap. . . . [English] language learners have scored lower on the ELPAC this year, but that may not be a reflection of their achievement gap, but rather a reflection of the amount of time that they have had exposure to English.

Finally, when I asked Colleen for her overall thoughts on teaching remotely, some of her responses were as follows:

> I miss the focus on the math learning. . . . I didn't need to focus on classroom management, which is a big problem in our country. . . . When you force students to go to school, you create an atmosphere where there is conflict. In countries where having an education is a privilege, the goal for the student is knowledge. . .

> . It was obvious toward the end of the 2020–2021 school year that parents needed kids in school for the babysitting aspect, and it is clear that parents and students view us as such at times.

Researcher Reflection

During Colleen's initial interview, she had reported her contentment with teaching from home as she was able to help her own children with distance learning in addition to addressing the technical needs of her husband. She also reported the family got a puppy as puppies required a lot of training and care and could not be left alone. Colleen's candid responses to the questions on returning to the classroom revealed insight that reflected mixed feelings with negative sentiment chief among them.

One of the most notable responses that stood out was about classroom management. Colleen stated emphatically,

> I don't like it, actually. I forgot what it was like to police kids all day long. It is easier to check for understanding and to help students, but I do not enjoy the classroom management portion of my job.

This comment was consistent with other participants who, during the initial interviews, had reported that "classroom management" was easier online. Colleen's comment on classroom management showed teaching remotely had the advantage of a "mute" button that gave the teacher "control" over classroom behavior and management. It could be argued that a push of a button reinforced a tacit positioning bias in a digital modality (Harré et al., 2009).

Technology provided teachers the power to pick and choose the students they wanted to attend to and the ones they wanted to silence. Adapting to the technology to

"manage" behavior and interactions illuminated Research Question 3 that I designed to understand how STEM teachers viewed their ability to adapt, innovate, and readjust their instructional practices to teach ELs remotely.

Summary of the Results

In this chapter, I presented the findings from participant interviews that served to situate STEM teacher perceptions teaching remotely during the pandemic within the frameworks of critical pedagogy and transformational learning. In addition, I thematically organized the teachers' perceptions to provide an interpretive lens with which to illustrate the perceptions in response to the research questions that guided the study.

The super-ordinate theme of resilience was the overarching quality that all participants shared. Findings illustrating resilience were presented through transcript extractions and interpretations grounded in current research. Resilience was the underlying trait that buoyed the participants and sustained them through the trials and tribulations of teaching through the pandemic. However, the results also revealed a lack of resilience for ELs as the findings exposed how these students often fell through the cracks and did not live up to the ideals of equity and access that schools have striven for all students as mandated by both state and federal guidelines.

In looking at pandemic learning through the lenses of critical theory and critical pedagogy and the works of Paulo Freire and Donaldo Macedo, I could see a reinforcement of the marginalization of our most vulnerable students, particularly ELs. The following chapter provides an overview of the study, including in-depth discussions of the implications of the findings with respect to future research and practice.

CHAPTER 5: DISCUSSION

The NASEM consensus study report published in 2018 showed there were limited large scale systematic studies on ELs in STEM subjects. The committee drew upon case examples to look for emerging themes of promising strategies and approaches. The current study adds to the body of research and extends the knowledge to include strategies and approaches for teaching STEM to ELs in a remote modality. The following discussion of the data provides an overview of lessons gleaned that both helped and hindered the STEM learning of ELs during remote instruction with recommendations for future research.

The purpose of the study was to explore STEM teachers' perceptions of teaching STEM to ELs and native English speakers remotely during the COVID-19 pandemic. The research questions were the following:

1. How did STEM teachers experience the COVID-19 shutdown and pivot to online learning?
2. How did STEM teachers perceive equity and access for EL students in the distance learning format?
3. How did STEM teachers view their ability to adapt, innovate, and readjust their instructional practices to teach ELs remotely?

Thematic Interpretation of Lived Experiences

To get to the essences of the lived experiences, I analyzed and compared the participant interviews and the findings gave way to several themes that encapsulated the experiences and helped illuminate answers to the research questions. Emergent themes of self-efficacy, autonomy, attitude, partnership, family, engagement, humor, and health

were then distilled into recurrent cross-case themes. The recurring themes of adaptability, connection, and social-emotional/well-being informed the super-ordinate theme of resilience that became emblematic of the participants' lived experiences of teaching STEM remotely during the COVID-19 pandemic.

Resilience

The resilient teachers in the study were all seasoned veteran teachers. I interpreted this to indicate that the longer teachers were in the profession, the more resilient they become. Some of the characteristics of resilience, such as protectiveness and connection, were demonstrated by the participants. Study participants also displayed attitudes of "can do" versus "give up." It should be no surprise that the very skills that are required to be successful in STEM subjects, such as experimentation, critical thinking, problem solving, and open mindedness, are the same qualities and skills the teachers in this study displayed, which strengthened their resilience.

However, it should be noted that even as resilient as the participants were, teaching in a remote setting was not without sacrifice and stress. Each spoke about physical and emotional ailments. Coping mechanisms such as increased alcohol consumption that went toward stress management were reported. It is important to remember that teachers are also parents, spouses, and caretakers, and teaching remotely from one's own home can have serious consequences for the family dynamic, relationships, and social-emotional well-being.

Discussion of Resilience in ELs: Reading Between the Lines

This study was about teachers and how they taught remotely through the COVID-19 pandemic. However, the study was also about the students they taught and most

specifically the ELs. What I learned about the students came through in the interviews and the meaning and significance interpreted during the process of data analysis.

The theme of resilience arose from the interviews and represented how the teachers not only survived but thrived teaching through nearly 2 years of remote learning. However, the data also revealed a glimpse into the life worlds of the ELs. Though it is difficult to know exactly how these students perceived learning remotely during the pandemic, their teachers provided some contextual evidence that deserves comment.

The following is a discussion on resilience in children grounded in the research of Kenneth Ginsburg (2020). The purpose of the discussion is to contrast Ginsburg's *components* of resilience with evidence reported by the participants as to how the ELs appeared to them. Ginsburg developed the "7 Cs of resilience" to represent the seven components that make up being resilient. Though the participants in the study demonstrated many characteristics supported by the literature that define resilience, teacher testimonials suggested this was not the case for their students, especially ELs.

The interview data showed the opposite was true for many of the EL students learning remotely during the pandemic. Indeed, the "resilient" students were those with the most supports, including familial, tutorial, financial, technical, and linguistic. Using Ginsburg's 7 Cs of resilience, I provide a discussion of what the participants tacitly revealed about the lived experiences of their most vulnerable EL students.

Competence. The first of the 7 Cs is competence. According to Ginsburg (2020),

> Children need to be seen when they are doing something right and to be given opportunities to develop specific skills. If children in our class display a particular

> passion for something or aptitude for a specific skill, activity, or sport, we need to recognize this and let them know we've noticed and encourage them. (p. 67)

Teachers in the study shared many similar experiences related to working with ELs remotely. All reported that it was common for ELs to fall into one of several categories: present in class (Zoom) with cameras off, missing from class with no explanation, missing from school and out of town or country with permission, or sporadically attending class with varying degrees of internet connectivity.

What was clear from the data was that ELs were often not seen. Based on this, there was no way for teachers to "see them doing something right" (Ginsburg, 2020, p. 67). In addition, in keeping with Ginsburg's "competence" requirement to building resilient children, ELs were not given opportunities to develop specific skills or display their passions or aptitudes.

Confidence. The second of the 7 Cs is confidence. According to Ginsburg (2020),

> The solid belief in one's own abilities is everything. As we teach and nurture, we build children's confidence. We need to be careful not to undermine confidence but develop it by pushing children to achieve and creating age-appropriate opportunities for experiencing success. (p. 67)

Belief in one's own abilities is everything—this was not evident for the ELs referenced in the study. Participants in the study reported ELs had less engagement online than during in-person classes. ELs were often disengaged, had their cameras off, and were mostly incommunicative. Teachers were instructed to not pressure students to turn on their cameras and generally maintained a laissez-faire approach to engaging with ELs. The students with the most communicative competence often dominated the online

engagement. These were generally the same students who seemed to be comfortable on camera, spoke clearly, and had proper equipment and Wi-Fi connections. This competence demonstrated a belief in ability for some, but not for most of the EL students.

Connection. The third C is connection. According to Ginsburg (2020),

> When children are part of a community (class, team, club) they know they aren't alone if they struggle and that they can develop creative solutions to problems. Close ties to family, friends, school, and community give children a sense of security. (p. 68)

The findings revealed a missed opportunity to connect with ELs to promote community and give children a sense of security. It was reported by all participants that there was an explicit or implicit "policy" for engaging with students during remote instruction. One participant insinuated there was a fear at the district level of lawsuits if the pressure to engage students online was perceived as infringing on students' privacy. This hands-off approach had the unintended effect of weakening community ties, which goes against Ginsburg's "connection" requirement for building resilience.

Character. The next C is character. According to Ginsburg (2020),

> Children need an understanding of right and wrong and the capacity to follow a moral compass. A fundamental sense of right and wrong helps children make wise choices, contribute to the world, and become stable adults. (p. 69)

During remote learning, students were often left alone at home without any guidance or parental support. Participants reported many of their ELs were often in care of other siblings or at a parent's place of work, or even out of the country at times.

Contribution. The fifth C is contribution. According to Ginsburg (2020),

> The experience of offering their own service makes it easier for children to ask for help when they need it. Once children understand the feel-good factor of helping others, it becomes easier to ask for help when it's needed – being willing to ask for help is a big part of being resilient. Children who learn to cope effectively with stress are better prepared to overcome life's challenges. (p. 69)

The study exposed varying degrees of disengagement on the part of ELs. As mentioned previously, teachers were cautioned to not force students to have their cameras on and thus, these students tended to not participate or ask for help during synchronous online class time.

Coping. The sixth C is coping. According to Ginsburg (2020),

> Children need healthy coping strategies to manage their stress. Some strategies involve engaging and disengaging such as breaking down seemingly impossible problems and challenges into smaller, achievable pieces, avoiding things that trigger extreme anxiety, and just letting some things go. (p. 71)

It became evident through the participants' testimonials that many ELs' coping strategies were that of disengaging and remaining in the shadows during class time. Some participants revealed it was easier to interact with ELs during in-person classes because they could read their facial expressions and body language and know when it was safe to call on them or even when a student appeared to want to participate. However, online learning made it difficult to ascertain the moods or feelings of the students during a Zoom session especially if their cameras were off. There was no way to tell if they wanted to be called on or not.

Control. The final C is control. According to Ginsburg (2020),

> Children need to feel like they have a degree of control over their lives and their environment. When they realize that they can control their decisions and actions, they're more likely to know that they have what it takes to bounce back. (p. 71)

It was clear from the participant interviews that there was very little control exercised by teachers, families, and students alike. At the onset of COVID-19 pandemic, learning was fraught with chaos and disorganization. The level of control anyone had during this time was minimal.

RQ Findings Contextualized Within the Frameworks

In the following section, I provide a discussion of the findings to answer the research questions and interweave a narrative supported by the theoretical frameworks. Critical theory and transformative learning theory grounded the findings and situated participants' experiences within the theoretical frameworks.

Mezirow's Transformative Learning Theory

Mezirow's (1994) transformative learning theory informed the study with its parallels to his original research on women returning to the workforce after lengthy absences and needing to re-educate themselves for a new paradigm. The transformation, according to Mezirow, is preceded by a "disorienting dilemma." Mezirow outlined phases that must be undertaken in order to transform one's learning.

The participants in the current study all experienced a disorienting dilemma when COVID-19 suddenly became a global pandemic and schools were abruptly shut down. The findings showed how the participants progressed through Mezirow's (1994) phases with varying degrees of success to attain a learning transformation. Ultimately though, it

was the participants' resilience that buoyed them through this tumultuous time and gave them the strength and resolve to stay committed to their profession and their students.

Critical Pedagogy

The findings exposed great inequity for the most vulnerable ELs as reported by the participants and demonstrated in continued marginalization and neglect. One of the topics in the NASEM (2018) report was positioning and how teachers play an important role in positioning ELs equitably within the STEM classroom. The current study extends the findings to encompass positioning within the virtual classroom.

Results showed participants who positioned their ELs equitably within the live Zoom classroom did so by encouraging peer partnerships and providing ample opportunities for social interaction and group work via "breakout rooms." Examples of deficit positioning in the digital classroom were demonstrated by disengagement with the EL students through limited interaction via "camera off" selection. This created an "out of sight, out of mind" situation as EL students were rarely called on or seen.

Equitable partnerships are fostered by teachers (Pinnow & Chval, 2015) who use criteria for partner selection. One participant in the current study used a personality survey at the beginning of the year that helped create both equitable and cohesive personalities within partnerships. This teacher (Jan) created a system that repositioned students as "agents of knowledge construction who collectively move toward a common goal" (NASEM, 2018, p. 94). Jan felt these connections were valuable and even more important within the isolating realm of the online classroom.

Interpretation of the Key Findings Through the Literature

In this section, I present a discussion and interpretation of the key findings from the study supported by the extant literature.

The Hybrid Model

In the Fall of 2020 at the start of the new school year, many schools were able to hold in-person learning while following strict safety protocols. The COVID-19 vaccine became available and was distributed through a tiered system of eligibility based on those who were most vulnerable or at the most risk of exposure to the virus. First responders and essential workers were at the top of the priority tier, followed by teachers.

Many schools allowed teachers with compromised immune systems to remain at home and to continue to teach remotely. As well, many families chose to keep their children at home and continue with the distance learning model. Thus, the hybrid model was developed to allow for both in-person teaching and learning with simultaneous live streaming for remote teachers and students. Teaching in a hybrid format was unanimously the most disliked modality among the study participants. Technological challenges, combined with the division of attention between remote learners and in-person learners, made it difficult to teach effectively.

It is interesting to note that the hybrid model may prove to be a lasting modality. The proliferation of the vaccine has made it possible for anyone age 12 years and older to receive it without cost. In addition, undocumented immigrants can receive the vaccine without fear of deportation and without having to provide evidence of legal status such as a drivers license, Green Card, or Social Security number (Kates et al., 2021).

Vaccinations have been voluntary for the most part but the new "Delta Variant," a fast moving and highly contagious strain of COVID-19, has demonstrated that the unvaccinated are responsible for the continued spread of the virus by preventing herd immunity from being achieved (Kates et al., 2021). Many of the unvaccinated resist the vaccine for a variety of reasons, including political, religious, fear, and compromised health. This has created a "vaccine divide" that could further affect the way teachers deliver instruction in the future (Kates et al., 2021).

Many higher education institutions have required proof of vaccination to attend. However, with the exception of California, most K-12 public schools in the United States at the time of this writing do not require students and teachers to prove they are vaccinated. If this changes, as with other required vaccine mandates for polio, Rubella, MMR, and others, the COVID-19 vaccine may be required, which could also cause some children to continue learning remotely.

Access and messaging have been lacking in getting the word out to immigrant and underprivileged communities (Kates et al., 2021). This gap could be exacerbated if vaccination requirements become a barrier to entry for underrepresented immigrant communities who hold deeply rooted mistrust in governmental programs and initiatives. This may prompt some unvaccinated to remain home and have their children learn remotely. If this comes to pass, the hybrid model will most likely be here to stay.

Multi-Modalities

The NASEM (2018) report showed multiple modalities (e.g., diagrams, manipulatives, gestures, multiple representations, technology) are important for both STEM disciplines and EL education. As such, remote online instruction provides unique

learning opportunities for ELs. Participants reported marked improvement in EL student engagement through the technology that allowed them to communicate their ideas in new and creative ways. Participants described how ELs adapted and overcame many obstacles using translation software, video recordings, and other modes to communicate their ideas.

Google Translate. Teachers reported how the translation software Google Translate made a significant impact on EL students' learning during remote instruction. Google Translate translates text into a target language and can be used for dictation and writing. Participants reported students who used this application produced better quality work. It was surmised that these students were able to better understand instructions for assignments when they translated them into their native languages.

Recordings. Teachers in the study extolled the benefits of having recorded material available within their course management systems that became particularly efficacious for ELs. Teachers reported some EL students demonstrated improvement in work quality when they were able to access recorded lectures and experiment directions that they could watch on their own time after school. Teachers found ELs were able to watch the content repeatedly, with the ability to start, stop, and rewind in addition to using closed caption subtitles. This greatly improved EL students' comprehension.

Synchronous Versus Asynchronous Learning

All participants reported that their school districts would be offering a dedicated remote learning program for students who chose to continue with the online model. This separate learning program has been called by many "online academy" and has grown in popularity throughout school districts across the United States.

Heterogeneity of ELs

This study revealed important differences in EL populations from the representative school districts where the participants taught. These differences made for unique perspectives and challenges as reported by the participants as to how to support ELs of differing linguistic and cultural backgrounds. The findings showed no two ELs were alike. Each was unique even when students spoke the same native language.

The differences among ELs in the study were borne in prior schooling, cultural heritage, and, most notably, socioeconomic status (NASEM, 2018). The research also confirmed that the stereotyping of ELs can be both positive and negative but still results in lumping them into groups versus considering each student a unique individual.

It was found that there were positive stereotypes used to label ELs from Asia with what has come to be known as the "model minority" or "model Asian stereotype" (Hsu, 2017). The participants shared similar attitudes of a "halo effect" when referring to their Asian EL students. The presumptions were that they were all good at science and math and all got excellent grades. Though there may be statistics supporting this stereotype, it was unclear whether the participants knew anything about these students as individuals.

Leadership

The most successful of the participants, as per their testimonials, were supported by strong and organized leadership from school administrations. This style of leadership encouraged autonomy and independence from teachers. The space given to the teachers for creativity and agency in the design and implementation of prescribed curricula proved to be advantageous when COVID-19 caused an immediate pivot to remote learning. This

promoted experimentation and made the pivot to digital platforms smoother and more efficacious.

Partnership

All four participants reported the value of having a teaching partner. They explained that partnerships with teachers of the same subject area were helpful and supportive under normal circumstances, and became invaluable during the pandemic. The teaching partners provided support, connection, and even friendship during what became a very isolating and difficult time for many. Partnerships also served to reduce the amount of preparation required to set up classes. Participants reported they were able to divide tasks between their partners, which made curriculum design not only easier, but more consistent between classes.

Implications for Practice

The implications for practice as a result of this study are numerous. Teaching STEM to ELs remotely can, if done correctly, be extremely supportive and successful. There are a number of recommendations that came out of the research that could inform future PD in training STEM teachers to teach remotely to differentiate instruction for EL student success. The following is a list of recommendations for future PD or practice:

- Professional development: Teachers should be provided with instructional technology training in all software and remote learning platforms.
- Multilingual/Cultural training: Teachers should be equipped with the knowledge to understand how to better serve their EL students. Multilingual cultural education should be at the forefront of professional development for all teachers. In particular, STEM teachers should receive adequate training to

work with multilingual and culturally diverse students and have experience with speaking a foreign language.

- Asset versus deficit views: ELs should be afforded the respect to be viewed through asset-based lenses to appreciate the multicultural backgrounds they bring to STEM learning. Previously, it was held that ELs were regarded as deficient, behind, and below standard.
- Partnership: The data showed teachers in this study were more successful when they had close partnerships with fellow teachers. These partnerships allowed the teachers to work together, brainstorm, dialogue, and share the labor in preparing lessons. In a remote setting, these partnerships also provided connection that was much needed in a time of isolation. Therefore, going forward, teachers should be paired into remote teaching partnerships.
- Autonomy: The successful teachers in this study also had a level of autonomy afforded to them by their administrations that provided them opportunities to innovate and adapt and be creative in designing curricula within the new online modality. This level of independence promoted self-esteem and confidence and allowed the teachers to have agency over what they were teaching. The less successful of the participants did not have the same autonomy and instead relied on a top-down authoritative administration where they were limited by the rules and protocols. This promoted less experimentation, less innovation, and less creativity. Therefore, the recommendation is to give teachers the independence to design and innovate within a prescribed curriculum.

- Technology for students: It should go without saying that all students should have the best and latest technology and software in order to fully and equitably learn in a remote setting. The study showed ELs specifically benefited from software that allowed them to translate and listen multiple times in the case of recordings and videos. This kind of technology should be explored more as a support for ELs going forward. As was mentioned in the findings chapter, software like Google Translate was instrumental in allowing students to do their work in their own native language and have it translated and then sent to their teachers. Studies have shown learning content in one's own native language has greater transferability and permanence of knowledge than learning in a target language that is not fully formed (A. L. Perez & Ericson, 2018).

Recommendations for Future Research

There is still much to be learned about living and working through the pandemic. Indeed, there is still so much we do not know about the disease itself. It continues to be a fluid situation that presents challenges in trying to plan for a life of normalcy in a "post-COVID" world.

However, much has been learned from this study about teaching and learning through what has been the most tumultuous time in recent memory. As we dissect and study the ramifications of teaching students through a digital modality, there is much to be researched to better understand the implications for both teachers and students.

It is especially important to study the consequences of nearly 2 years of learning in a remote format for our most vulnerable, especially our ELs. The study revealed ELs

suffered inordinately under particularly harsh circumstances, and it is still unknown to what extent their social-emotional as well as academic lives have been affected.

Future research should focus on how to better serve ELs in an online modality. The study revealed the technology involved in teaching in a digital format can provide beneficial instructional adaptive strategies for ELs, but it must be properly understood and learned by practitioners.

The so-called achievement gap remains and most likely has increased as a result of living and learning through this pandemic. Because assessments were suspended, it is unclear to what extent the gap has grown. Future researchers should endeavor to find out how to bring ELs closer to their native-speaking counterparts in order to be on footing that is equitable and inclusive.

Future researchers should also find ways to include ELs and immigrants alike in the STEM subjects and in future STEM fields. According to the NASEM (2018), ELs are underrepresented in the STEM fields. Future research should focus on getting more ELs into STEM subjects so they also can be represented in STEM research and benefit from the science. The following is a discussion of specific recommendations for future research.

Intersectionality

The scope of the current study was limited to teacher perceptions on teaching linguistic minority students in addition to native English speakers remotely during the pandemic. The findings of the current study showed a continued marginalization of the most vulnerable ELs through remote teaching practices and perceptions that reinforced inferior positioning of these students in comparison to their non-EL classmates. Beyond

the scope of the study, there exists the intersection of race, gender, SES, and age, and the confluence of these factors influences teacher perceptions and practices (Carbado et al., 2013).

The four STEM teachers who participated in the study were White, female (1 non-binary), and middle aged (30s–60s). The students they taught were diverse with the ELs representing multi-racial and multi-linguistic backgrounds. Future researchers should delve into the intersectionality of these demographics to understand the influences they play in the power dynamics and positioning that perpetuate marginalization (Carbado et al., 2013, p. 303).

The theory of intersectionality began in 1989 after the seminal essay written by Kimberlé Crenshaw introduced the term to express the multi-faceted influences that contributed to the marginalization of Black women. The theory is considered a "work in progress" (Carbado et al., 2013, p. 305), as the authors admitted that we as a society should investigate the intersectionality of marginalization to "unexplored places" (p. 305).

The intersections of race, gender, age, and SES with the inclusion of linguistic background should be explored in a meaningful way to illuminate how these factors manifest and contribute to ELs' equity gap in Grades 6–12 STEM learning, STEM programs in higher education, as well as subsequent STEM careers.

Critical Pedagogy

Paulo Freire (1968, 2020), in his seminal book, *Pedagogy of the Oppressed*, described how his own upbringing caused him to identify with the oppressed. His lived experiences, as his friend and colleague Donaldo Macedo described, of poverty and

hunger after his middle-class family became economically disadvantaged, prompted Freire to empathsize and form a "solidarity" (p. 13) with the poorer Brazilian classes. However, he also became aware that even though his family had fallen into financial difficulties, Freire knew he was still a member of a higher class. This realization made Freire acutely aware that we do not live in a classless world.

Even so, Freire's lived experiences acted as a catalyst in promoting literacy of the oppressed and we can draw upon the parallels from his work in Brazil as a cautionary tale for the marginalized in the United States. Teachers, and specifically STEM teachers, should adopt a Freirean stance and transform their approach to teaching ELs—instead of teaching "to" them, they should be teaching "with" them as partners (Featherstone, 2020, para. 3).

This cooperative approach would encompass students' own life worlds, including their multi-cultural and linguistic backgrounds, to make STEM learning relevant for ELs. If students can see themselves in the science and participate in a shared dialogue, then the work becomes more meaningful.

Future researchers should endeavor to make STEM learning accessable to ELs by incorprating multiliteracies that engage the students holistically while at the same time bringing into the equation the background knowledge of the students to make the math and science tangible, attainable, and less abstract.

Limitations

As is the case with nearly every phenomenological study, sample size and generalizability are the most prominent limitations for this kind of research. Therefore, it is recommended that future research include a larger sample of STEM teachers to see

whether the findings of the current study are in accordance. However, I would argue that generalizability was not the goal for this study. The goal was to try to understand the lived experiences of a cohort of STEM teachers who lived and taught through the pandemic. Though the sample size was small with four participants, I was able to delve deeply into their "life worlds" to get to the essences of how they experienced teaching during the pandemic.

Bias

An important limitation inherent in conducting an IPA study is bias. The objective of the study was to interpret the meaning of the lived experiences of the participants. However, it was challenging to "bracket" my own biases while interpreting the participants' meanings and intentions. Thus, I employed the double hermeneutic circle to negotiate and question my interpretation of participant intention and meaning (J. A. Smith et al., 2009).

The use of IPA as a method to analyze and interpret lived experiences also included me, the researcher, and how my "personhood" influenced the research process and subsequent interpretations using my own "reflective awareness" (Halling, 2021). This engendered an agency of knowledge, for me, the novice researcher. It freed me from the binds of what seemed like a White male canon of scholars vying for dominance of the prevailing theories.

To mitigate bias, I used the IPA approach as a guide or set of instructions for how to navigate through the research process. It also allowed space for me to be present in the process. In his groundbreaking book, *The Structure of Scientific Revolutions*, Kuhn (1962) wrote about the nature of perception and the incommensurability of individual

perception. This implies that there is no common paradigm when there are multiple perceptions. What this meant to me, the researcher, is that there was room for my interpretation. Kuhn himself would probably agree that even a novice researcher can be an instrumental force for change in what he referred to as a *revolution*. Doing one's own research outside the prevailing, established framework is the impetus for potential change to the status quo or as Kuhn termed, a paradigm shift (Kuhn, 1962).

Zoom Fatigue

For a study about the pandemic, the biggest challenge that limited the study ironically was the pandemic itself. Safety protocols by city, state, federal, and university IRB limited in-person contact, thereby limiting the scope of the research and the method for data collection. Interviews were conducted through the ubiquitous Zoom video conferencing. Conducting interviews via Zoom was difficult, arduous, and, at times, frustrating.

Zoom fatigue is real. Though research on the subject is only just beginning to uncover the ramifications of sitting in front of a live streamed camera for hours on end, we can all agree that it can be tiring and stressful. Psychologists have begun to report on the deleterious effects of video conferencing, be it for work or educational purposes (Sander & Bauman, 2020). The following are some current admonitions from those in the field of psychology:

- Missed nonverbal communication: Nonverbal cues like facial expressions, tone of voice, gestures, posture, and the distance between speakers are harder to understand and process in a Zoom video format. Sander and Bauman

(2020) argued that relying mostly on verbal information to infer emotion can be very tiring.

- Looking at our own face is stressful: According to Sander and Bauman (2020), the ability to see oneself somewhat like a mirror reflection is very stressful.
- There is no actual eye contact: Eye contact is very important in our culture. It expresses sincerity and lets the speaker know the listener is paying attention. However, on Zoom, there is no actual eye contact as attention is focused at the person's face on the screen rather than looking into their eyes.
- Glitchy connections and interruptions: There is endless frustration trying to communicate with someone when their connectivity is slow and glitchy or the video pauses or freezes. This can make the communication fraught and stressful.

Conclusion

Through this investigation, I provided a detailed analysis of the life worlds of four participant STEM teachers who shared with me how they lived and taught through a remote modality during the COVID-19 pandemic. The results revealed that through it all, these teachers were able to demonstrate resilience and pivot their instruction to teach live classes synchronously via Zoom video conferencing. They provided examples of what worked and what did not work in terms of their instructional strategies and STEM learning software.

The study also exposed the continued marginalization of vulnerable ELs as they were kept at arm's length during instruction. Digital learning, with its many advances in

software and course management systems, does little to promote student engagement the way EL students in the study needed. The study showed the most successful EL students were those with the most supports. Indeed, the most fortunate remote learners had family, technology, tutors, and, above all, a strong grasp of the target language and culture.

It is my hope that future online teaching in the K-12 domain will include PD for teachers to become knowledgeable in the skills and resources the STEM teachers in the study demonstrated and recommended. In addition to the technological skills necessary to teach in the "new normal" of learning during the pandemic, teachers must be taught to understand the cultural and linguistic backgrounds of their EL students.

My other hope is that EL students become revered and celebrated for the assets they possess. Being multi-lingual and multi-cultural are incredible gifts that should be valued and acknowledged. I would like to see these "emergent bilinguals" viewed through a new lens and reject the ethnocentric deficit thinking that is pervasive in schools.

As a final thought, as I reflect on the experience of interviewing teachers for this study, I come back to a common reaction the participants displayed when I approached them about sharing their experiences with teaching during the pandemic: surprise. The teachers were genuinely surprised to be asked to share their opinions and experiences—that someone wanted to listen to them. It became clear that teachers are not often asked their opinions about their practices let alone how they lived and survived through a pandemic. I end with a call to action for more research to be conducted on teacher perceptions and attitudes for they are the ones in the field doing the work.

APPENDIX A

Recruitment Email to Educators

To:	STEM Teachers in grades 6-12
From:	Michelle Figueiredo-Doctoral Candidate. St. John's University
Subject:	Invitation to participate in Research Project
Name of Study:	From A Distance: An Interpretive Phenomenological Analysis Of STEM Teachers' Perceptions Toward Teaching English Learners Remotely During the Covid-19 Pandemic.

Dear Teacher,

You have been selected as a potential participant in a study investigating teacher perceptions on teaching during the pandemic. This study is looking into the impact of STEM teachers who taught remotely and their perceptions on teaching English language learners through this modality.

You and other participants of this study can provide unique and valuable insight into understanding how teaching and learning affected STEM learning for English learners. Participation in the study is voluntary, anonymous, and confidential. It will require 1-2 interview sessions with potential for 1 additional follow-up session.

If you are willing to participate in this study, you will be sent an informed consent, so you know your privacy rights and responsibilities.
Thank you in advance for your consideration in participating in this important work. The COVID-19 pandemic is an unprecedented crisis in our country and the ramifications on our educational systems will be felt for years to come. Your help in providing perceptions and insight into your experiences teaching during this time will be of the utmost value.
I look forward to hearing from you.

Sincerely,

Michelle Figueiredo
PhD Candidate
St. John's University

APPENDIX B

Teacher Consent Form

Dear Participant:

You have been invited to take part in a research study to learn more about the effect of the iPad to increase literacy skills and academic engagement. This study will be conducted by Colleen Keating, Department of Education Specialties and Counseling, St. John's University, as part of her doctoral dissertation work. Her faculty sponsor is Dr. Lawrence, Department of Education Specialties and Counseling.

If you agree to be in this study, you will be asked to do the following: Take part in an interview to help the researcher understand the availability of technology in your classroom, how much time your students have access to the iPad, if your students interact with others while on the iPad, and how the iPad is used (e.g., recreation, education purposes, etc.). Your interview answers to the interview questions will be recorded in writing. Participation in this interview will involve a minimum of twenty minutes of your time to complete.

Federal regulations require that all subjects be informed of the availability of medical treatment or financial compensation in the event of physical injury resulting from participation in the research. St. John's University cannot provide either medical treatment or financial compensation for any physical injury resulting from your participation in this research project. Inquiries regarding this policy may be made to the principal investigator or, alternatively, the Human Subjects Review Board (718-990-1440).

Although you will receive no direct benefits, this research may help the investigator understand the effects of the iPad on literacy instruction for children with autism and it may benefit teaching procedures used with your students.

Confidentiality of your research records and your child's records will be strictly maintained by removing your name and any identifiers will be replaced with a number. Consent forms will be stored in a separate location from the interview documentation and will be stored in a locked file. Your responses will be kept confidential with the following exception: the researcher is required by law to report to the appropriate authorities, suspicion of harm to yourself, to children, or to others. Your responses will be kept confidential by the researcher, but the researcher cannot guarantee that others in the group will do the same.

Participation in this study is voluntary. You may refuse to participate or withdraw at any time without penalty. For interviews, questionnaires or surveys, you have the right

to skip or not answer any questions you prefer not to answer. Nonparticipation or withdrawal will not affect your grades or academic standing.

If there is anything about the study or your participation that is unclear or that you do not understand, if you have questions or wish to report a research-related problem, you may contact Colleen Keating, keatingc@stjohns.edu, St. John's University 8000 Utopia Parkway, Queens NY, 11439 or the faculty sponsor, Dr. Salika Lawrence, at lawrens1@stjohns.edu, St. John's University, Sullivan Hall 4th Floor, 8000 Utopia Parkway, Queens NY, 11439.

For questions about your rights as a research participant, you may contact the University's Institutional Review Board, St. John's University, Dr. Raymond DiGiuseppe, Chair digiuser@stjohns.edu 718-990-1955 or Marie Nitopi, IRB Coordinator, nitopim@stjohns.edu 718-990-1440.

You have received a copy of this consent document to keep.

Agreement to Participate

Yes, I agree to participate in the study described above.

Subject's Signature	Date

APPENDIX C

Interview Protocol Script

Interviewer: _____Date_____Time_____Duration_____

Instructions for Interviewer:

1. Establish a Zoom connection and ask the participant if he/she would prefer the camera on or off.
2. Make sure the sound and internet connection are strong.
3. Inform participant that his/her responses will be recorded, and participant's identity will not be revealed.
4. Ask participant if he/she has any questions.
5. Before Interview begins read interview procedures script (See below)
6. Commence interview. Follow the questions in order. Take notes in the spaces provided

Protocol Script

"Hello_____(participant)

I want to take the opportunity before we begin to thank you for participating in this research project. The COVID-19 pandemic has been an unprecedented event and it is vital we learn how educators were able to manage throughout the school shut down. You have been chosen to participate in this research specifically because this study seeks to understand the perceptions of STEM teachers who taught both native English speakers and English learners simultaneously in an online format during the distance learning period.

This study is using in-depth interviews as part of a research design known as The Interpretive Phenomenological Approach (IPA). This approach seeks to understand participant's lived experiences during a period of time. Your candid and unfiltered responses will help scholars to understand how you lived, taught, and managed throughout this difficult time.

Your responses will be valuable and will help build a body of research to better support STEM educators to teach English learners."

Interview Questions

1. How did you pivot and move your classes online after the pandemic shut down of schools?
2. What has been the biggest challenge and why?
3. What kind of support or guidance did you receive from your administration?
4. How do you think your students have adapted?

5. How equitable do you feel the technology and access to learning was for your students?
6. What did you miss about teaching in person?
7. What are your biggest concerns about online teaching?
8. How did you promote student engagement?
9. How have English learners (ELs) adapted to online learning?
10. What are the challenges in teaching ELs online?
11. How did you incorporate instructional strategies for ELs and for native English speakers during remote teaching?
12. What kind, if any, EL specific training has study participants (STEM CA teachers) received?
13. What perceptions did you take away from teaching ELs remotely?

Interviewer Notes:

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