Building Science Teachers' Empathy and Perspective-Taking through Continuous Professional Development to Improve Support for Multilingual Learners

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Abstract

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School districts across the United States are experiencing a rapid increase in multilingual learner (ML) enrollments, prompting school leaders to seek effective ways to support teachers in meeting these students' needs. In-service teachers require comprehensive preparation to instruct MLs effectively. However, general education teachers, particularly science teachers, often report feeling underprepared to teach culturally and linguistically diverse students and lack the pedagogical knowledge and strategies necessary to support them. One approach to fostering professional growth and instructional transformation is positioning educators as learners through immersive language experiences, where they encounter a language in which they are not yet proficient. Such experiences can heighten empathy for MLs' linguistic challenges while shaping teachers' perceptions, attitudes, and instructional practices. A lack of empathy can hinder teachers' ability to understand and address MLs' unique needs, making it a critical disposition for effectively educating culturally and linguistically diverse students. This study examines how a language immersion experience influences science teachers' empathy, reflection, and instructional transformation. Specifically, it explores how immersion fosters greater awareness of MLs' experiences, promotes instructional shifts, and supports the development of more inclusive teaching strategies in science classrooms.
Keywords: multilingual learners, empathy, transformational learning, language immersion, professional development

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Chapter 1: Introduction

The increasing presence of multilingual learners (MLs) in American classrooms presents challenges and opportunities for educators. A recent incident at my former school involving two MLs, sent to the office by a Family and Consumer Science teacher for speaking Spanish during a group project, underscores the urgent need for a shift in pedagogical approaches. Additionally, a technology teacher's remark during an English as a New Language (ENL) workshop, "Why are these non-English-speaking children in my classroom? I can't communicate with them," reflects a concerning sentiment toward linguistic diversity that is prevalent among some educators. Such attitudes highlight the necessity for comprehensive professional development and a reevaluation of instructional practices, particularly in content-area classrooms such as science, to better serve culturally and linguistically diverse students.

According to the National Center for Education Statistics (2021), over 5 million children in U.S. public schools are currently learning English. Since 2000, the enrollment of MLs in K-12 schools has surged by over one million, as reported by the U.S. Department of Education (NCES, 2021). Despite this demographic shift, many MLs continue to experience systemic barriers to academic achievement, particularly in content areas such as science. Research shows that MLs perform significantly lower than their non-ML peers on standardized science assessments (Lee, 2005). This achievement gap is not due to a lack of ability or interest in science but rather a lack of instructional support that integrates language development with content mastery (Hansen-Thomas et al., 2016).

Science education presents unique challenges for MLs due to its reliance on specialized academic language, abstract concepts, and technical vocabulary. Unlike other subjects, science requires students to engage in hands-on inquiry, laboratory procedures, data analysis, and scientific discourse, all of which demand conceptual and linguistic proficiency (Lee et al., 2013). However, many science educators receive little to no training to scaffold instruction for MLs, leaving students struggling to access classroom content that prioritizes scientific accuracy over linguistic accessibility (Swanson et al., 2014). This lack of preparation leaves science teachers feeling ill-equipped to support MLs, further widening the opportunity gap for linguistically diverse students pursuing STEM fields.

Although New York mandates that future educators complete six units of coursework on general language acquisition and literacy development, these classes frequently do not address the unique linguistic demands of science instruction (Rodriguez et al., 2010). This gap in training means that science teachers are often unaware of effective instructional methods, such as translanguaging strategies, which allow MLs to fluidly use their home languages alongside English to process and express scientific concepts, as well as multimodal representations, and structured academic discussions, that can make science content more accessible to MLs (Garcia & Kleifgen, 2018; Hansen-Thomas et al., 2016). By leveraging translanguaging, educators can create an inclusive environment where MLs can draw on their full linguistic repertoire to engage in scientific reasoning, discuss their ideas with peers in multiple languages, and develop a deeper understanding of complex concepts. Without such approaches, MLs are frequently excluded from meaningful participation in science classrooms despite their ability to engage in scientific thinking and reasoning when given appropriate support (Silva & Kucer, 2016).

As a school administrator and former science educator, I have observed firsthand how language barriers impact MLs' ability to engage in scientific inquiry, collaborate with peers, and demonstrate their understanding of key concepts. MLs often struggle to participate in hands-on activities without intentional scaffolds, leaving them marginalized in science learning environments. My commitment to this study stems from the urgent need to prepare science teachers to implement instructional practices that foster scientific literacy and linguistic accessibility for all students, especially MLs. However, ensuring that science educators fully embrace these instructional shifts requires more than just training on pedagogical strategies; it necessitates an empathetic understanding of what it means to be an ML in a rigorous academic setting. Without this awareness, teachers may not fully appreciate the cognitive and emotional demands placed on MLs, making it less likely that they will commit to meaningful instructional changes. Therefore, professional development must go beyond theoretical frameworks and immerse teachers in language-learning experiences that mirror those faced by MLs in their classrooms. Moreover, ongoing PD is essential for teachers' continuous professional growth, equipping them with evolving strategies that enhance instruction for all students. By engaging in sustained learning opportunities, educators refine their practice, stay informed about research-based methodologies, and develop a deeper capacity to support MLs effectively. When teachers receive sustained professional learning experiences, they become more adept at fostering inclusive, language-rich science environments where all students can thrive.

Empathy is critical for educators working with culturally and linguistically diverse students (McAllister & Irvine, 2002). Defined as the ability to understand and perceive another person's experiences (Aldrup et al., 2022), empathy plays a vital role in shaping teachers' attitudes toward MLs. Science educators without empathy for MLs may interpret linguistic struggles as a lack of effort or ability, leading to lower expectations, reduced engagement, and fewer opportunities for MLs to succeed (Warren, 2018). Understanding each student's lived experiences and linguistic challenges is essential for developing effective instructional strategies that support learning in diverse classrooms.

Effectively supporting MLs in science classrooms requires moving beyond traditional professional development (PD), often one-time workshops or generalized training sessions lacking sustained, practice-based engagement (Darling-Hammond et al., 2009). Instead, they should participate in experiences that allow them to understand the challenges faced by language learners firsthand. Since most teachers in contemporary schools are monolingual and predominantly White, they must participate in language-related activities that deepen their comprehension of MLs' needs (Bireda & Chait, 2011). Molle (2021) found that many teachers continue to prioritize disciplinary content over language development, suggesting that without direct engagement in immersive language experiences, educators may struggle to fully integrate linguistic support into their instruction. This underscores the need for professional learning opportunities that actively engage educators in language learning themselves, fostering the empathy and instructional shifts necessary to better support MLs in science classrooms. By immersing themselves in a language they do not yet speak fluently, science educators can experience the daily frustration, anxiety, and cognitive overload that MLs face, ultimately fostering greater professional growth and transformation in their teaching practices.

This study seeks to examine the role of immersive language experiences, which involve sustained engagement with a target language in authentic and interactive contexts, in fostering empathy among science educators (Porter & Sofia Castillo, 2023). Similar to structured language learning experiences (SLLEs), in which prospective teachers engage in learning a new language as part of a course on language teaching or second language acquisition (Ellis, 2006), immersive experiences provide educators with firsthand insight into the challenges faced by multilingual learners (MLs). Research suggests that immersive environments enhance language acquisition by allowing individuals to process linguistic input in meaningful, real-world situations (Porter &

Sofia Castillo, 2023). By directly experiencing the cognitive and emotional demands of language learning, educators can gain a deeper understanding of the barriers MLs face in science classrooms, fostering empathy that translates into pedagogical adjustments. As the population of linguistically diverse students grows, science educators must integrate language and content support into their instructional practices, ensuring that all students, regardless of their linguistic backgrounds, have equitable access to high-quality science education.

Instructing Multilingual Learners

Interventions designed to enhance educators' ability to support multilingual learners' cultural, linguistic, and academic needs are paramount, particularly in science education. de Jong and Harper (2005) emphasize that general education teachers, including science educators, often have not had the pedagogical training to effectively support MLs, making focused professional development a crucial component of teacher preparation. Research has demonstrated that professional development centered on multilingual learners increases in-service teachers' awareness of the linguistic and academic challenges faced by MLs, leading to improved student engagement and outcomes (Spezzini et al., 2015).

Science education requires a specialized approach to ML instruction, as students must navigate complex vocabulary, abstract concepts, and discipline-specific discourse while simultaneously acquiring English proficiency (Lee et al., 2013). Professional development (PD) initiatives that bring together science and language teachers to collaborate on instructional strategies must be integrated into statewide educational frameworks to ensure MLs receive equitable access to high-quality science instruction (Lee et al., 2022). Despite the increasing population of multilingual learners in secondary education, there remains a significant gap in science teacher preparation programs addressing these students' cultural, linguistic, academic, and social-emotional needs. Research indicates that many existing programs lack comprehensive training that integrates language development with science instruction, leaving teachers underprepared to effectively support MLs in the classroom (González-Howard et al., 2024). This deficiency underscores the need for enhanced professional development that equips science educators with strategies to meet the diverse needs of MLs.

Cultivating empathy is one of the most effective ways to shift educators' perspectives and teaching practices. Dolby (2012) found that empathy enhances student-teacher relationships, promotes culturally responsive teaching, and improves student outcomes in multicultural classrooms. However, empathy cannot be developed if science teachers harbor misconceptions about MLs or are unaware of these students' daily linguistic and cognitive challenges.

Research Questions

This study explores the impact of immersive language experiences on science teachers' empathy, reflections, and instructional transformations. Within this context, the following research questions guide this investigation:

1. In what ways can a language immersion experience foster empathy and perspective-taking to initiate the transformation of science teachers' dispositions toward MLs?
2. How does a language immersion experience followed by ongoing focused professional development encourage science teachers to develop empathy and perspective-taking as they reflect on MLs' needs and transform their teaching practices?
3. How does a language immersion experience followed by continuous professional development cultivate empathy and perspective-taking that support the transformation of science teachers' practices to create more inclusive learning environments and better support ML learners?

Organization of the Dissertation

This document is organized into several key sections to comprehensively explore immersive language experiences and their impact on science educators. Chapter 1, the introduction establishes the significance of linguistic diversity in science education and outlines the need for pedagogical approaches that integrate language and content learning. Chapter 2, the literature review, examines existing research on immersive language experiences, empathy development in educators, and best practices for supporting MLs in science classrooms. Chapter 3, the methodology section, details the research design, data collection methods, and analytical framework used to investigate the role of immersive language experiences in shaping instructional practices. The findings section, Chapter 4, presents the study's results, highlighting key themes and insights. Finally, the discussion and conclusion, which is Chapter 5, synthesize the findings, explore their implications for teacher education and policy, and offer recommendations for future research.

Chapter 2: Literature Review

Evolution of Multilingual Learner Policy and Terminology

Prior to 1968, federal educational guidelines were virtually non-existent in addressing the needs of language-minority children in the United States. Many schools disregarded these students' needs, often enrolling them in English immersion or "sink-or-swim" programs that offered little to no support for their language development (Crawford, 1999). However, the Civil Rights Movement and Title IV of the 1964 Civil Rights Act brought attention to the growing population of language minority students, prompting educators and legislators to address their educational needs (Crawford, 1999). By 1966, the National Education Association (NEA) advocated for the use of students' native languages in education, recommending dual-language instruction in the early grades and structured English as a Second Language programs (National Education Association, 1966). This advocacy led to the 1968 Bilingual Education Act (BEA, Title VII) and the Elementary and Secondary Education Act (ESEA), marking the first significant federal effort to support language-minority students. These initiatives identified the target population as "children of limited English-speaking ability" (LESA), defined as those from environments where English was not the dominant language (National Center for Education Statistics, 2021). While these changes aimed to include language-minority students, the terminology and program structures often emphasized remediation and framed these learners as "limited" or "deficient" in English (Lyons, 1995).

Since its enactment, the ESEA has undergone multiple revisions (1974, 1978, 1984, 1988, 1994, and 2001), leading to BEA (Title VII). The target population definitions, and types of programs to serve this demographic, and the purposes and objectives of the programs were modified. In 2001, Title VII was replaced by Title III under the No Child Left Behind (NCLB)

Act, which introduced “Language Instruction for Limited English Proficient and Immigrant Students,” resulting in a significant shift in federal policy towards language minority students learning English (González, 2008).

The term “English language learner” was adopted in the NCLB and was brought into schools and the public discourse. “English learners” or “English language learners” are the terms most often used in state policies to refer to students whose first language is not English (Wright, 2005). There has been a long-standing concern over the terminology that is used to label these students. Changes in terminology can cause confusion and disagreement among educators, administrators, and legislators. Before the NCLB Act of 2001, many educational publications referred to these students as bilingual or English as a Second Language. Some states still use some form of limited English proficient (LEP) students. However, identifying students as LEP or English language learners might have a negative impact on how instructors evaluate their potential (Martínez, 2018). While widely adopted, the ELL label has faced criticism for its deficit-oriented perspective, emphasizing what students cannot do rather than their linguistic and cultural assets. Research indicates that such labels can negatively influence educators’ perceptions, often resulting in lower expectations and limited access to advanced learning opportunities like college-level coursework (Umansky & Dumont, 2019). These perceptions can reinforce a hierarchy where English is granted greater legitimacy over students’ native languages, further marginalizing their linguistic identities (Martínez, 2018). For over two decades, the term “English language learner” continues to be present in education policies, with numerous textbooks specifically intended for teachers and educators. Precisely because this term is prominent and familiar in the literature, it can be limiting.

Asset-based Framing

In recent years, there has been a gradual shift toward more asset-based terminology and approaches for linguistically diverse learners. The term "asset-based" in educational contexts has evolved over time, with various scholars contributing to its development. In the early 1990s, Moll and González (1992) introduced the concept of "Funds of Knowledge," emphasizing the rich cultural and cognitive resources that students from diverse backgrounds bring to the classroom. This perspective encouraged educators to recognize and build upon these assets in their teaching practices. Building on this foundation, Ladson-Billings (1995) developed "Culturally Relevant Pedagogy," advocating for teaching approaches that affirm students' cultural identities while promoting academic success. These foundational works significantly influenced the shift toward asset-based terminology and approaches in education. More recently, González et al. (2005) expanded on the Funds of Knowledge framework, reinforcing the importance of leveraging students' lived experiences as valuable learning resources. In science education, this shift has gained momentum, with researchers emphasizing the integration of students' cultural and linguistic assets to improve engagement and learning outcomes (Brown & Crippen, 2016). This includes designing curricula that acknowledge multilingual learners' knowledge systems and promoting instructional strategies that affirm linguistic diversity as an asset rather than a barrier to learning.

This asset-based perspective has also influenced the terminology used to describe students acquiring English, shifting from deficit-framed labels such as "English language learner" (ELL) to the more affirming term "multilingual learner" (ML). The term "multilingual learner" is increasingly used to encourage positive discussion of these students as beginner English learners and to highlight students' linguistic and cultural strengths, positioning their diversity as a resource rather than a challenge (Gottlieb, 2021). Multilingual learners bring rich linguistic repertoires and cultural insights to the classroom, which can enhance the learning environment when properly acknowledged and utilized by educators. However, systemic barriers still exist, and bilingualism is often viewed as a challenge rather than an asset in many educational settings. To foster inclusive learning environments, educators must leverage the unique strengths of multilingual learners (Andersen et al., 2022). When teachers encourage MLs to draw on their natural ways of thinking, communicating, and knowing, students become more engaged and can make meaningful contributions to their classrooms and communities (Umansky & Dumont, 2019).

Multilingual learners face significant challenges in education, particularly in science, where academic language often serves as a barrier to understanding (Atobatele et al., 2024). Traditional educational policies have often focused on either assimilating MLs into English-only instruction or framing their linguistic abilities as deficits rather than assets. This approach has contributed to limited support structures for these learners (Crawford, 1999; Lyons, 1995). Recent research, however, suggests a shift toward recognizing multilingualism as a strength. For example, Atobatele et al. (2024) argue for approaches such as CLIL (Content and Language Integrated Learning) to simultaneously support language development and content mastery, particularly in technical disciplines like science, where traditional instruction often creates barriers to understanding. Recognizing multilingualism as a strength rather than a limitation reflects the ongoing shift toward equity and inclusivity in education policy (Atobatele et al., 2024).

Multilingual Learner Challenges in Science Education

Multilingual learners (MLs) encounter significant challenges in achieving success in science education due to the linguistic demands of the subject. They must navigate the gap between their everyday language and the specialized academic vocabulary required to learn science. Beyond mastering domain-specific terms, MLs must also understand complex language structures essential for posing questions, hypothesizing, inferring, and concluding. The academic language of science often differs significantly from everyday interactions, leaving MLs without critical linguistic support (Cummins, 2008). This challenge is compounded when familiar words acquire new, discipline-specific meanings. Words such as “plate,” “cell,” and “tissue” illustrate how science terminology can create confusion for MLs, as these terms hold different meanings in general and scientific contexts (Bensoussan & Laufer, 1984).

The complexity of scientific language extends beyond terminology to include abstract concepts and relationships, such as cause and effect or generalization versus specificity. These linguistic structures can be particularly burdensome for MLs, who must simultaneously process new content and develop proficiency in a second language (Rutt et al., 2020). Many educators mistakenly believe that English proficiency should precede science instruction, yet research indicates that delaying science learning until full language proficiency is achieved is counterproductive (Harper & de Jong, 2004). Since MLs may take four to ten years to develop academic English fluency (Collier & Thomas, 2002), they benefit most when language and content instruction occur simultaneously (Lee et al., 2013).

Given these linguistic challenges, science instruction for MLs must incorporate approaches that integrate both language and content learning. Three-Dimensional Learning (3DL) within the Next Generation Science Standards (NGSS) provides a promising framework by emphasizing science and engineering practices (SEPs) that inherently require active language use in authentic scientific contexts (Lee et al., 2013). Research indicates that when MLs engage in scientific practices, such as argumentation from evidence, developing models, and constructing explanations, they strengthen their academic language skills while simultaneously deepening their scientific understanding (Lee et al., 2013). Inquiry-based science instruction, aligned with NGSS, provides MLs with structured opportunities to develop scientific literacy while actively using language in meaningful ways (Stoddart et al., 2002). By aligning SEPs with English language proficiency standards, educators can ensure that MLs participate in discourse-rich activities that facilitate both content mastery and language acquisition (Wilmes & Siry, 2018). Zhang et al. (2017) further highlight that engaging MLs in scientific argumentation fosters disciplinary thinking while expanding their ability to express complex ideas in English. Embedding science instruction within language-rich, hands-on investigations allows MLs to apply and articulate scientific concepts, transforming science classrooms into equitable learning spaces that leverage students' cultural and linguistic assets (Grapin et al., 2022).

ML Classroom Support

Culturally Relevant Pedagogy (CRP) is a foundational framework for supporting multilingual learners, as it centers students' cultural, linguistic, and experiential backgrounds in the learning process. Initially conceptualized by Ladson-Billings (1995), CRP promotes three core goals: academic success, cultural competence, and critical consciousness. For MLs, these goals are particularly vital as they navigate rigorous academic content and new cultural and linguistic environments. A culturally relevant science classroom affirms students' identities, incorporates community-based knowledge, and frames diversity as an asset rather than a challenge. This approach shifts instructional practice from simply accommodating MLs to deliberately valuing their lived experiences as tools for meaning-making and engagement. CRP is also aligned with translanguaging practices and scaffolded instruction, as it promotes inclusive strategies that integrate language and content while reflecting students' sociocultural realities. By implementing culturally relevant pedagogy, educators move beyond surface-level differentiation to foster inclusive, affirming, and academically rigorous environments that support MLs' holistic success (Paris & Alim, 2017).

Multilingual learners often require specific instructional strategies that simultaneously develop linguistic and content-area knowledge. One of the most effective ways to support MLs in academic settings is by leveraging their home languages as cognitive tools to facilitate comprehension and fluency in academic English (Swanson et al., 2014). Translanguaging is a dynamic process wherein multilingual students use their full linguistic repertoire to make meaning, access content, and express understanding (García & Wei, 2014). Rather than expecting strict separation of languages, translanguaging supports fluid language use across home and academic contexts. In science classrooms, where students often encounter complex vocabulary and unfamiliar discourse patterns, translanguaging allows them to use familiar linguistic tools to access difficult content. It can serve as a bridge to understanding, promoting deeper cognitive processing and sustained engagement (Karlsson et al., 2019).

Incorporating translanguaging into classroom instruction also requires a pedagogical shift on the part of the teacher. Educators must move beyond traditional language-separation models, which are grounded in the belief that students should learn academic content exclusively in the target language, typically English, while minimizing or prohibiting the use of their home language(s) (García & Wei, 2014). These models treat languages as compartmentalized and operate under the assumption that mixing languages may hinder language acquisition or cognitive development. In contrast, translanguaging embraces the fluidity with which multilingual learners navigate their linguistic repertoires and encourages students to draw on all their language resources to support understanding and expression. This shift involves planning opportunities for students to use their home languages during scientific discussions, writing, or group work and incorporating multilingual materials and visuals to support comprehension. (Karlsson et al., 2019).

While translanguaging emphasizes the strategic use of students' full linguistic repertoires, it must be paired with intentional instructional support to ensure all learners can access rigorous academic content. In this context, scaffolding is a complementary pedagogical approach that provides the structured support necessary for multilingual learners to engage meaningfully with complex scientific ideas while developing language proficiency.

Scaffolding is an instructional practice rooted in Vygotsky's (1978) theory of the Zone of Proximal Development (ZPD), which describes the difference between what a learner can accomplish independently and what they can achieve with appropriate support. Scaffolding provides temporary, targeted assistance that enables students to engage in tasks slightly beyond their current level of competence, gradually removing that support as students gain independence. For MLs, particularly in linguistically demanding disciplines like science, scaffolding is essential to ensure access to complex content without compromising academic rigor.

Effective scaffolds for MLs involve both linguistic and conceptual dimensions. Instructional tools such as visual aids, sentence frames, graphic organizers, modeled responses, realia, vocabulary charts, and interactive simulations help bridge language barriers while maintaining high cognitive expectations (Gibbons, 2015). When implemented thoughtfully, scaffolding allows MLs to participate more fully in inquiry-based science learning and develop conceptual understanding and academic language proficiency. Personalized scaffolding should be based on students' current English proficiency levels and conceptual knowledge and then gradually released as they gain linguistic and conceptual mastery (Im & Martin, 2015). Furthermore, integrating structured academic discourse, such as collaborative inquiry, argumentation, and discussion, serves as a form of linguistic and cognitive scaffolding that amplifies language acquisition and disciplinary learning by promoting active engagement in scientific practices (Lee, 2004).

Building on these principles, effective science instruction for MLs must purposefully integrate both language and content to ensure equitable access to learning opportunities. Approaches such as next-generation sheltered instruction approaches, which focus on disciplinary language development, help create an inclusive learning environment that supports MLs' science engagement (Buxton & Caswell, 2020). Scaffolding strategies incorporating visual representations, multimodal learning, and structured peer discourse provide additional support, helping MLs process and communicate scientific ideas more effectively (Zhang et al., 2017). Collaborative discourse also plays a crucial role in reinforcing vocabulary acquisition and disciplinary thinking, as peer interactions provide opportunities for MLs to articulate and refine their scientific understanding (Wilmes & Siry, 2018).

Research from the National Academies of Sciences, Engineering, and Medicine [NASEM] (2018) emphasizes that MLs benefit most from interactive, discourse-rich STEM activities that promote collaborative meaning-making. Such environments enable MLs to translate learning into new contexts by applying scientific knowledge to real-world problems and interdisciplinary projects, reinforcing their ability to think critically and make meaningful connections across disciplines (Seah & Silver, 2018). By embedding science instruction within meaningful, interactive, and linguistically inclusive activities, educators ensure that MLs learn science and develop the language tools necessary to articulate and apply scientific concepts effectively.

Despite these promising instructional practices, systemic barriers continue to hinder ML success in science education. The pressure to improve standardized test scores often leads teachers to prioritize test-related content over the linguistic and cultural needs of MLs. This narrow focus frequently results in instruction dominated by textbook reading and lectures, which disproportionately disadvantages MLs. Instead, educators must balance the dual goals of teaching science content and supporting English language development. Science classrooms should serve as spaces where MLs learn English through science and use scientific inquiry as a means to strengthen their English proficiency (Bresser & Fargason, 2013).

Teacher Preparation and Dispositions towards MLs

In the United States, data show that one out of every four students comes from a migrant family whose native language is not English (Batalova & Zong, 2016). This demographic reality means that most public school classrooms include multiple MLs with diverse linguistic and academic needs. Addressing these needs requires adequately trained and equipped teachers to provide robust language and academic development opportunities. However, teachers often graduate from teacher preparation programs with inconsistent levels of readiness to instruct MLs in mainstream classrooms (Durgunoğlu & Hughes, 2010). Research indicates that without explicit training on integrating language and content instruction, many preservice teachers struggle to effectively support MLs (Shaw et al., 2014). To meet the unique cultural and linguistic demands of MLs, educators require specialized knowledge and skills that extend beyond standard pedagogical training (Silva & Kucer, 2016).

Teacher preparation plays a critical role in determining MLs' success in science education. However, many educators have not developed or received the cultural competence and specialized training necessary to support MLs effectively (NASEM, 2018). Research indicates that teachers often feel inadequately prepared to instruct MLs, with deficiencies particularly pronounced at the secondary level (Darling-Hammond et al., 2002). Teachers report feeling unprepared to navigate the dual demands of language development and content delivery, leading to lower confidence in their ability to teach MLs effectively (Durgunoğlu & Hughes, 2010).

A teacher's attitudes, beliefs, and expectations about MLs' ability for grade-level learning can impact the teacher's approach to and engagement with MLs in science instruction. Şener and Korkut's (2017) study revealed that teacher attitudes toward teaching MLs reflect insufficient preparation for effectively teaching these diverse learners. When untrained teachers encounter difficulties when working with MLs, negative attitudes emerge. If a teacher does not have the necessary skills to successfully assist an ML student in achieving academic achievement, they may quickly get frustrated and overwhelmed (Walker et al., 2004) and blame students, and many teachers tend to hold the "deficit" view of MLs.

By contrast, an asset-oriented view promotes learning. Being linguistically diverse means having an expanded view of language encompassing students' cultural languages and linguistic styles and a broad understanding of the linguistic diversity of the content area. An asset-based approach, which recognizes MLs' cultural and linguistic diversity as strengths rather than obstacles, fosters an inclusive learning environment where all students actively engage in scientific practices (Llosa et al., 2016). When science teachers shift their deficit-based view of linguistic diversity, home language, and differences in language to an asset-based perspective, they can use those aspects to improve learning outcomes (Moore, 2008). Teachers must begin to regard linguistic diversity as a resource, as opposed to a disadvantage, and should reframe the benefits of linguistic diversity for all children.

Teacher perceptions shape their values and beliefs, significantly influencing their expectations for MLs. For instance, some science teachers may perceive MLs as having lower academic capabilities compared to their native English-speaking peers. This perception can lead to reduced expectations and less rigorous instruction, limiting MLs' opportunities to engage in meaningful scientific inquiry and experimentation (Lee & Buxton, 2013). Such lowered expectations have been widely documented to negatively affect student performance.

Conversely, when teachers maintain high expectations for MLs, they create a more equitable, inclusive, and positive educational experience, ensuring that MLs are provided with the same rigorous and challenging learning opportunities as their peers (Nieto, 2013). Positive teacher attitudes and dispositions are critical in shaping effective instructional practices for MLs. Teachers with an inclusive and optimistic mindset are more likely to offer meaningful and engaging learning experiences, which directly contribute to improved outcomes for MLs (NASEM, 2018). Transforming teachers' beliefs about MLs can lead to substantive changes in their instructional practices, ultimately enhancing student learning and fostering inclusive classroom environments (Stewart, 2010). Therefore, cultivating positive attitudes and asset-based dispositions among educators is essential for improving science instruction and overall academic success for MLs.

Empathy

Empathy is defined as the ability to perceive, understand, and respond to the emotional experiences of others. It consists of both affective components, experiencing another's emotions, and cognitive components, comprehending another's viewpoint without necessarily sharing their feelings (Decety & Jackson, 2006). Empathy, a fundamental human characteristic, supports prosocial behavior, enhancing social cohesion and moral development (Eisenberg et al., 2010). It is fundamentally ingrained in the essence of humanity, as it fosters interpersonal connections and mutual comprehension across varied circumstances. Neuroscientific research has demonstrated that brain regions, including the anterior insula and the anterior cingulate cortex, are active during empathic responses, suggesting a biological foundation for this social emotion (Singer et al., 2004). Furthermore, empathy is associated with compassion and moral reasoning, indicating that our capacity to connect with others' feelings is not advantageous but vital for the operation of a civil society (Batson, 2009). Empathy enables humans to rise above self-interest, cultivating a shared humanity that prioritizes compassion, justice, and ethical accountability.

Empathy's most advanced manifestation transcends individual viewpoints, enabling individuals to adopt a sense of collective accountability and rise above self-interest. It fosters a collective humanity that emphasizes compassion, justice, and ethical responsibility as foundational elements of a humane and equitable society. As Decety and Cowell (2015) note, empathy is not only a basis for interpersonal connection but a core mechanism driving moral behavior and the pursuit of justice.

Teacher Empathy

Empathy is a fundamental characteristic that should be cultivated in teacher education programs to benefit students and society (Warren, 2014). For teachers of language learners, empathy plays a particularly crucial role, enabling them to develop cultural understanding and effectively navigate the complexities of diverse classrooms (Washburn, 2008). Unlike sympathy, which often stems from a sense of pity or response to adverse situations, empathy empowers teachers to approach new situations without such connotations, fostering a more constructive and inclusive perspective (Gladkova, 2010). Empathy allows teachers to deeply understand and respect cultures different from their own by engaging their hearts, minds, and beliefs (Cruz, 1997).

In education, empathy bridges the gap between teacher-student relationships by enhancing the ability to recognize and respond to students' emotions, thoughts, and experiences appropriately. As a human attribute, empathy is essential to teaching and learning (Cooper, 2004). Empathetic teachers are more motivated to teach diverse populations effectively and to nurture the potential of MLs. Warren (2014) highlighted empathy as a vital professional disposition for effective teaching in urban settings, noting that empathetic teachers create meaningful connections with their students' experiences, cultural norms, and values outside of school. By perceiving the world from their students' perspectives and responding with compassion, empathetic teachers can design pathways that optimize learning opportunities for all students.

Developing teacher-student relationships is critical for fostering student motivation and classroom engagement. Empathetic teachers establish trust and create a safe, supportive classroom environment where students feel valued and understood (Rivers & Brackett, 2010). Research on preservice teachers has shown that positive field experiences with diverse student populations can enhance empathy and foster caring attitudes (Ukpokodu, 2004). Medina et al. (2015) also found that preservice teachers returned from study abroad experiences with increased empathy towards MLs, a greater passion for teaching, and an enhanced sense of competence in instructing MLs.

Teacher preparation programs must provide opportunities for candidates to experience the challenges and rewards of language learning in academic settings. Brisk et al. (2002b) emphasized that teacher preparation should provide teacher candidates with opportunities to experience the difficulties and benefits of language learning in an academic environment. Through short classroom exercises, teacher candidates may develop empathy, leading to a high-level, culturally appropriate curriculum and instruction. These experiences can inform culturally responsive curricula and instructional practices. Miller (2001) argued that when teachers share or closely relate to the emotions of students navigating language and communication barriers, their empathy directly influences classroom decisions and interactions with MLs. As Miller eloquently stated, 'While knowledge may be the key to eroding ignorance, it takes a good dose of empathy to move from intellectual understanding to compassionate action' (p. 381). Empathy is more than desirable for teachers; it is an indispensable tool for fostering inclusive, effective teaching practices. By cultivating empathy, teachers are better equipped to support the academic and emotional needs of their MLs, leading to more equitable and enriching educational experiences for all students.

Empathy alone does not always translate into instructional change. While empathy allows teachers to recognize students' struggles, perspective-taking enables them to actively step into their students' experiences, leading to meaningful pedagogical shifts (Gehlbach, 2017). Perspective-taking is a cognitive process that allows teachers to analyze learning environments from the viewpoint of MLs, prompting them to modify instructional approaches to meet diverse student needs (Todd & Galinsky, 2014).

Perspective-Taking in Teacher Education

Perspective-taking refers to the ability to cognitively and emotionally adopt another person's viewpoint, allowing individuals to understand and interpret experiences from that perspective (Gehlbach, 2017). Unlike general empathy, which primarily involves feeling for another person, perspective-taking requires actively thinking through their experiences, often resulting in behavioral changes (Todd & Galinsky, 2014). Teachers who develop strong perspective-taking skills in education become more attuned to students' challenges, particularly multilingual learners, whose linguistic and cultural backgrounds shape their academic experiences (Lucas et al., 2008).

Perspective-taking plays a critical role in reducing implicit biases in classrooms. When teachers lack opportunities to engage in perspective-taking, they may misinterpret MLs' silence, disengagement, or difficulty with academic tasks as a lack of effort rather than a linguistic challenge (Abacioglu et al., 2020). Research indicates that teachers who actively engage in perspective-taking are more likely to use equity-driven instructional approaches, such as scaffolding, multimodal teaching, and culturally responsive pedagogy (Nieto, 2013; Warren, 2018).

Perspective-Taking and Multilingual Learners (MLs)

Perspective-taking in teachers is particularly essential for MLs, as these students must navigate both linguistic and cognitive challenges while learning subject-specific content (Cummins, 2008). Without understanding MLs' experiences, teachers may underestimate the cognitive demands placed on them (Harper & de Jong, 2004). Perspective-taking allows educators to recognize these demands and make necessary instructional adjustments, such as slowing their speech, providing more visuals, or incorporating students' home languages into learning activities (Buxton & Caswell, 2020).

Research shows immersive learning experiences greatly enhance teachers' perspective-taking (Wright-Maley & Green, 2015). When teachers personally experience language barriers, such as during structured language immersion exercises, they develop a deeper understanding of

MLs' struggles and become more motivated to provide linguistic support (Medina et al., 2015). This aligns with Mezirow's Transformative Learning Theory, which suggests that disorienting dilemmas, such as struggling to learn content in an unfamiliar language, prompt individuals to critically reassess their assumptions and modify their practices accordingly (Mezirow, 1998).

Perspective-Taking as a Component of Transformative Learning

Within Transformative Learning Theory (Mezirow, 2003), perspective-taking plays a key role in helping teachers move from awareness to action. Research has demonstrated that when educators critically reflect on their biases and assumptions, particularly through immersive experiences, they transition from deficit-based views of multilingual learners (MLs) to asset-based perspectives (He et al., 2017). This cognitive shift allows teachers to recognize the linguistic and cultural strengths MLs bring to the classroom, ultimately influencing their instructional decisions. Studies by Washburn (2008) and Warren (2014) indicate that teachers who engage in perspective-taking exercises are more likely to adopt scaffolding techniques, such as bilingual glossaries and sentence frames, which provide MLs with structured language support while engaging with scientific content. Additionally, perspective-taking encourages educators to implement collaborative learning strategies, allowing MLs to work alongside peers in ways that enhance comprehension through discussion and cooperative problem-solving. Teachers also become more attuned to the emotional toll of language learning, prompting them to adjust their instructional pace and create a more inclusive, supportive learning environment. Rather than treating ML support as an add-on, perspective-taking fosters sustained pedagogical transformation by integrating inclusive practices into daily instruction, ensuring that MLs have equitable access to rigorous academic content (Lee et al., 2013).

Science Education Reform and ML Engagement

The transition from the New York State Common Core Standards to the Next Generation Science Standards (NGSS) presents a significant opportunity to enhance MLs' engagement in three-dimensional learning. The NGSS framework emphasizes active participation in scientific practices, including model development, evidence-based argumentation, and data analysis, all of which require intentional language integration (Lee & Buxton, 2013). The NGSS is well-aligned with TESOL (Teaching English to Speakers of Other Languages) standards, which mandate that MLs develop proficiency in disciplinary listening, reading, writing, and speaking within the science classroom (Lee et al., 2013). The alignment between NGSS and English Language Proficiency (ELP) standards ensures that MLs develop scientific literacy and language proficiency simultaneously. NGSS promotes three-dimensional learning, in which students engage in Science and Engineering Practices (SEPs) such as arguing from evidence, constructing explanations, and obtaining, evaluating, and communicating information (Lee, 2018). These practices align with TESOL ELP standards, which emphasize developing the listening, speaking, reading, and writing skills necessary for academic discourse (Grapin & Lee, 2021).

For instance, when NGSS requires students to construct explanations for scientific phenomena, the corresponding ELP standard ensures that MLs receive linguistic support to describe their reasoning using discipline-specific language (Lee, 2018). Educators can implement instructional strategies such as visual supports, sentence frames, collaborative discussions, and multimodal learning to scaffold MLs' comprehension and engagement, helping bridge language gaps while deepening scientific understanding (Grapin & Lee, 2021). This alignment is further reinforced by the TESOL Pre-K–12 English Language Proficiency Standards, particularly TESOL Standard 4, which states that MLs must "communicate information, ideas, and concepts necessary for academic success in the area of science" (TESOL, 2006). This is evident in NGSS performance expectations, which require students to actively participate in scientific discourse through listening, speaking, reading, and writing. For example, NGSS 3-PS2-3 asks students to determine the cause-and-effect relationship of electric or magnetic interactions between two objects not in contact. To meet this expectation, MLs must engage in oral and written scientific inquiries, ask questions, and use appropriate scientific terminology. Teachers can support MLs by providing sentence starters such as "What happens when…?" to help students articulate observations while reinforcing scientific language structures (Lee et al., 2013).

Similarly, NGSS 5-LS2-1 requires students to develop a model describing the movement of matter among plants, animals, decomposers, and the environment. This aligns with TESOL Standard 4, which emphasizes describing processes and relationships using academic language. In this case, MLs can create labeled diagrams of the nutrient cycle, incorporating vocabulary such as "decomposition," "nutrient absorption," and "energy flow" to explain the process (Lee et al., 2013). However, the successful implementation of these standards depends on teachers' ability to integrate language and content instruction effectively through sustained professional development. Teacher professional development interventions that integrate language and science instruction have also been shown to enhance educators' ability to support MLs effectively (Lee et al., 2008).

Instructional Strategies for Integrating Language and Science

Samson and Collins (2012) underscore the importance of scaffolded instruction, which provides structured support that enables MLs to access complex science content. Visual aids, word walls, nonverbal cues, sentence starters, and hands-on learning experiences effectively reinforce scientific vocabulary and conceptual understanding (Samson & Collins, 2012). When MLs actively engage in scientific processes—such as designing investigations, analyzing data, and constructing arguments, they develop new language structures and disciplinary literacy skills in authentic contexts (Atobatele et al., 2024).

Teachers play a pivotal role in facilitating the dual development of language and content knowledge by implementing evidence-based instructional approaches that support MLs. Collaborative group work fosters peer-supported learning and encourages the co-construction of scientific knowledge, enabling students to develop both their language proficiency and disciplinary understanding (Lee, 2004). Sheltered Instruction Observation Protocol (SIOP) strategies integrate language objectives into science lessons, providing explicit vocabulary instruction and concept development to help MLs engage more effectively with academic content (Echevarria et al., 2011). Culturally responsive teaching connects science concepts to students' lived experiences and linguistic backgrounds, increasing engagement and deepening comprehension by making learning more personally relevant (Hernandez & Shroyer, 2017). Inquiry-based learning allows MLs to construct scientific meaning through hands-on exploration and problem-solving while receiving targeted language scaffolds that support their understanding of disciplinary discourse (Lee et al., 2008).

The integration of language and content in science education is critical to MLs' academic success. Engaging in scientific processes such as planning, conducting experiments, and analyzing data exposes students to new language structures and disciplinary expressions, reinforcing scientific literacy and language development. Teachers play a fundamental role in structuring these opportunities, ensuring that MLs receive the necessary support to participate meaningfully in scientific discussions and investigations. Collaborative group work encourages peer interaction and shared learning, helping students build confidence in communicating scientific ideas effectively (Lee, 2004). Additionally, culturally responsive teaching, guided inquiry, and sheltered English instruction have been shown to enhance both science and literacy achievement, narrowing achievement gaps among MLs (Lee et al., 2008). Embedding instruction within meaningful, interactive activities incorporating students' linguistic and cultural backgrounds optimizes learning outcomes, making science education more accessible and engaging (Echevarria et al., 2011).

Despite the emphasis on scientific inquiry in teacher education programs, explicit education or professional development in academic language scaffolding, culturally responsive teaching, and discourse-rich science instruction remains limited (Lee et al., 2022). As a result, many educators struggle to implement evidence-based strategies that effectively support MLs' engagement in science learning. Although a growing body of research highlights the benefits of integrating language and content instruction, few studies examine how professional development (PD) programs can effectively prepare science teachers to implement these strategies (Weinburgh et al., 2019). This gap underscores the urgent need for sustained, ML-focused professional development models that equip educators with the skills to successfully integrate science and language instruction, ensuring that MLs have equitable access to rigorous STEM education.

Professional Development

Professional development (PD) is essential for enhancing teachers' pedagogical knowledge, instructional strategies, and ability to meet the diverse needs of their students. According to Darling-Hammond et al. (2002), PD fosters epistemic awareness and pedagogical growth, allowing educators to refine their instructional approaches based on evidence-based practices. Traditionally, PD has been delivered through one-time workshops, which often lack the depth, continuity, and practical application needed for sustained instructional change (Gulamhussein, 2013). Research indicates that only a small percentage of teachers effectively implement strategies learned in isolated PD sessions unless supported by ongoing coaching and mentorship (Gulamhussein, 2013). This highlights the importance of continuous, collaborative professional learning that is aligned with teachers' instructional contexts and directly applicable to their practice.

An effective model for PD includes content-focused training that aligns with subject-specific pedagogies. In these active learning experiences, teachers engage in inquiry-based methods similar to those used with students and coherence with curriculum standards to ensure alignment with science literacy and disciplinary discourse (Desimone, 2009; Lee et al., 2022). Additionally, PD must provide sufficient duration and follow-up support to promote long-term instructional change, along with collaborative learning communities where teachers engage in peer reflection and share best practices (Hargreaves & Fullan, 1998). While general PD enhances instructional effectiveness across disciplines, science educators require specialized training integrating scientific inquiry with language development strategies. Without explicit guidance, teachers may unintentionally prioritize content delivery over linguistic accessibility, limiting multilingual learners' (MLs) engagement with science learning (Seah & Silver, 2018).

Many science educators are underprepared to integrate language support strategies into their instruction despite the increasing number of MLs in classrooms (Rutt et al., 2020). While teacher education programs emphasize science inquiry, they rarely incorporate explicit training in academic language scaffolding, culturally responsive teaching, or discourse-rich science instruction (Lee et al., 2008). Science education PD must address the unique challenges of teaching MLs by incorporating strategies that enhance linguistic and scientific literacy. Lee et al. (2013) emphasize that language development and content learning are mutually reinforcing processes, making it essential for science teachers to integrate academic language instruction into inquiry-based science curricula. PD initiatives should provide educators with effective strategies for facilitating language-rich scientific discussions, supporting students' academic vocabulary development, and scaffolding complex scientific concepts.

In addition to language development, PD for science educators should address the specific challenges that MLs face in science classrooms. Research highlights the importance of discourse-rich instructional strategies, such as scientific argumentation and explanation, enabling MLs to develop conceptual understanding and linguistic proficiency (Buxton & Lee, 2014). Teachers also benefit from professional learning opportunities focused on culturally responsive pedagogy, as understanding students' linguistic backgrounds and lived experiences fosters inclusive science learning environments (Januszyk et al., 2016). Sustained and collaborative PD models have been shown to enhance instructional effectiveness for teachers of MLs. Similarly, professional learning communities (PLCs) that emphasize collaborative professional development, cooperative learning, and integrated language and content instruction can enhance science educators' ability to support multilingual learners through evidence-based instructional strategies (Calderón et al., 2011).

Given the increasing diversity in U.S. classrooms, integrating language-focused strategies within science PD is essential for fostering equitable learning opportunities. Understanding and demonstrating empathy toward diverse cultures significantly influences teachers' ability to connect with multilingual learners (Silva & Kucer, 2016). However, research indicates that teachers of multilingual learners require ongoing professional development to adequately instruct the increasing ML population (Lee et al., 2022). Teachers need opportunities to understand how students with diverse interests, abilities, and experiences make sense of scientific ideas. Educators must know how to support and guide all students (NASEM, 2018).

Effective professional learning opportunities should equip teachers with instructional strategies to meet multilingual learners' social, educational, and affective needs (Weinburgh et al., 2019). When educators receive professional learning on cultural and instructional strategies for teaching multilingual learners, their students' academic achievement increases (Friend et al., 2009). Research has also shown that high-quality PD results in positive changes in teachers' beliefs and practices regarding the integration of science and literacy for MLs (Hart & Lee, 2003). Successful PD programs provide teachers with sufficient time to learn, practice, implement, and reflect upon new strategies, allowing for necessary adjustments in their pedagogical approaches. Rather than one-time workshops, long-term learning opportunities are crucial in fostering meaningful instructional change (Darling-Hammond et al., 2009).

Educators can bridge the gap between science content and language acquisition by embedding language-rich, inquiry-based learning strategies within professional development. Teachers who participate in targeted PD aligned with research-based best practices in science education and ML instruction are better equipped to support students in developing content knowledge and academic language proficiency, ultimately improving MLs' engagement and achievement in STEM disciplines (NASEM, 2018).

Beyond content knowledge, effective instruction for MLs requires teachers to engage in perspective-taking, which allows them to better understand the linguistic and cognitive challenges their students face. To foster perspective-taking, PD should incorporate language immersion simulations where teachers experience the challenges of learning science content in an unfamiliar language (He et al., 2017). This type of training helps educators recognize the emotional and cognitive barriers MLs encounter, increasing their commitment to providing meaningful language support. Case studies and digital storytelling, where MLs share firsthand accounts of their academic journeys, further reinforce the importance of culturally responsive and linguistically inclusive teaching strategies (Rodriguez et al., 2010). Reflective writing exercises encourage teachers to analyze how their perspectives on ML instruction evolve over time, deepening their understanding of the instructional adjustments needed to create more inclusive science classrooms (Romero et al., 2022). Integrating these perspective-taking opportunities into teacher training fosters a sustained commitment to equity-driven instruction, ultimately leading to better academic outcomes for MLs (García & Kleifgen, 2018).

Despite the increased emphasis on equitable STEM education, many PD programs fail to address the unique instructional needs of MLs in science classrooms (Rutt et al., 2020). Science teachers are often trained in inquiry-based instruction and disciplinary literacy but receive limited preparation in language scaffolding, multilingual discourse strategies, and culturally responsive teaching that support MLs' conceptual understanding and scientific reasoning (Lee et al., 2022). This disconnect between language and content instruction results in missed opportunities to engage MLs in scientific practices and discourse, as many educators assume that MLs will develop academic English naturally over time rather than through structured, language-rich instruction (Lee et al., 2013).

To close this gap, researchers emphasize the importance of ML-specific PD models that train science educators to integrate science content with language development, ensuring that MLs gain both disciplinary knowledge and academic language proficiency (Lee et al., 2022). Additionally, PD should provide teachers with strategies to leverage MLs' linguistic resources through translanguaging and bilingual scaffolding, which enhance scientific argumentation and discourse engagement (Karlsson et al., 2019). The use of multimodal scaffolding, such as visualizations, hands-on inquiry, and structured discussions, also plays a critical role in bridging linguistic and conceptual learning, particularly for MLs who are still developing their proficiency in academic English (Wilmes & Siry, 2018). Embedding culturally responsive science pedagogy into PD initiatives ensures that teachers recognize and value MLs' backgrounds, experiences, and linguistic repertoires, ultimately fostering a more inclusive and equitable learning environment (Hernandez & Shroyer, 2017). However, despite the substantial research base supporting these strategies, most science-focused PD initiatives lack structured guidance on implementing them effectively in classroom practice (Lee et al., 2013).

Language Immersion Professional Development

Language immersion experiences are defined as activities, regardless of their duration, that enable preservice or in-service teachers to understand the challenges of not having the necessary language skills to succeed in a specific context (Wright-Maley & Green, 2015). These encounters challenge educators' assumptions about language proficiency and learning processes, enhance their awareness of the complexities of culture and identity, and highlight the necessity for a culturally responsive curriculum (Nero, 2009). Research indicates that preservice teachers who participate in study abroad language immersion programs develop more empathetic and asset-based perspectives toward multilingual learners, leading to improved instructional approaches (Tripp et al., 2023). For example, in a study of preservice teachers in a short-term immersion program in Costa Rica, participants reported a greater appreciation for bilingualism and a deeper understanding of the linguistic challenges faced by MLs in U.S. classrooms. These experiences increased their confidence in working with MLs and shifted their beliefs toward more inclusive and student-centered pedagogies (Tripp et al., 2023). Similarly, studies on in-service teachers show that participating in overseas immersion programs enhances their ability to implement multilingual instructional strategies, reinforcing the importance of experiential learning in teacher education (He et al., 2017). Language immersion experiences allow teachers to develop effective strategies for serving diverse student populations. By immersing themselves in what they teach, educators can better understand their students' challenges and become more informed decision-makers (Easton, 2008).

While professional development equips educators with instructional strategies, language immersion experiences provide them with an embodied understanding and a firsthand, experiential awareness of what it means to learn in an unfamiliar linguistic environment. Such experiences are particularly valuable for science teachers working with multilingual learners, as they allow educators to experience firsthand the cognitive and emotional challenges associated with processing complex academic content in a second language. For science educators, experiencing a language immersion setting allows them to recognize the additional cognitive load MLs face when attempting to process scientific vocabulary, abstract concepts, and inquiry-based learning in an unfamiliar language. This realization often leads teachers to modify their instructional approaches, incorporating greater scaffolding, multimodal supports, and student-centered discourse techniques to make science more accessible.

Medina et al. (2015) state that some teacher preparation programs allow educators to teach or study in foreign countries to enhance their cultural awareness and empathy toward immigrant English learner students. Teachers who experience immersion in their students' language and culture develop greater open-mindedness, awareness, and sensitivity, which enables them to address MLs' linguistic and educational needs. When teachers place themselves in the perspective of an ML, they become more aware of students' struggles, frustrations, and emotions (Guerrettaz et al., 2020). In science classrooms, this awareness often translates into an increased emphasis on academic language scaffolding, multiple representations to explain scientific concepts and a more student-centered approach to content delivery. When teachers do not empathize with their students' linguistic challenges, they may struggle to develop appropriate instructional strategies or misinterpret MLs' learning difficulties. Washburn (2008) suggests that all teachers should be required to study a foreign language, as experiencing the challenges of learning another language firsthand can help educators relate to the frustrations and perplexities experienced by MLs. Research indicates that teachers who undergo language immersion experiences are more likely to implement scaffolded instruction, increase their use of non-verbal supports such as visuals and gestures, and adjust their pacing to accommodate MLs' processing time (Medina et al., 2015). These experiences reinforce the importance of creating a classroom environment where MLs feel safe to take linguistic risks and engage in scientific discourse.

Although immersion experiences provide valuable insights, some researchers argue that brief exposures to unfamiliar linguistic environments may not be sufficient for long-term pedagogical change. Short-term immersion must be coupled with structured reflection, mentorship, and continued professional learning opportunities to ensure teachers can translate their insights into sustainable classroom practices (Gutiérrez & Hunter, 2012). When integrated into a comprehensive PD framework, language immersion experiences become a powerful tool for fostering empathy, strengthening culturally responsive pedagogy, and improving science instruction for MLs.

Theoretical Frameworks

Transformative Learning Theory

Jack Mezirow's (1994) Transformative Learning Theory explains how adults modify their perspectives through critical reflection on disorienting experiences. He defined learning as a social process of constructing and internalizing a new or revised interpretation of one's experiences to guide future actions. Within this framework, action refers to the decision-making process influenced by an individual's evolving understanding of the world. This concept of learning emphasizes shifts in a person's frame of reference, which consists of the deeply embedded structures of assumptions that shape how experiences are interpreted (Mezirow, 1994). Although individuals are not always consciously aware of these assumptions, they significantly influence how one perceives and interacts with the surrounding environment. Cognitive dissonance arises when individuals encounter new information or experiences that challenge their existing frames of reference. According to Mezirow (1998), meaningful learning occurs when this dissonance prompts critical reflection, leading to a reassessment of previously held assumptions.

Mezirow (2003) outlined ten interrelated phases through which transformation occurs:

1. Experiencing a disorienting dilemma
2. Conducting a self-examination of assumptions
3. Engaging in critical reflection
4. Recognizing dissatisfaction with prior assumptions
5. Exploring alternative perspectives
6. Developing a plan for change
7. Acquiring new knowledge and skills

8. Experimenting with new roles
9. Building competence and confidence in new roles
10. Reintegrating new perspectives into one's life

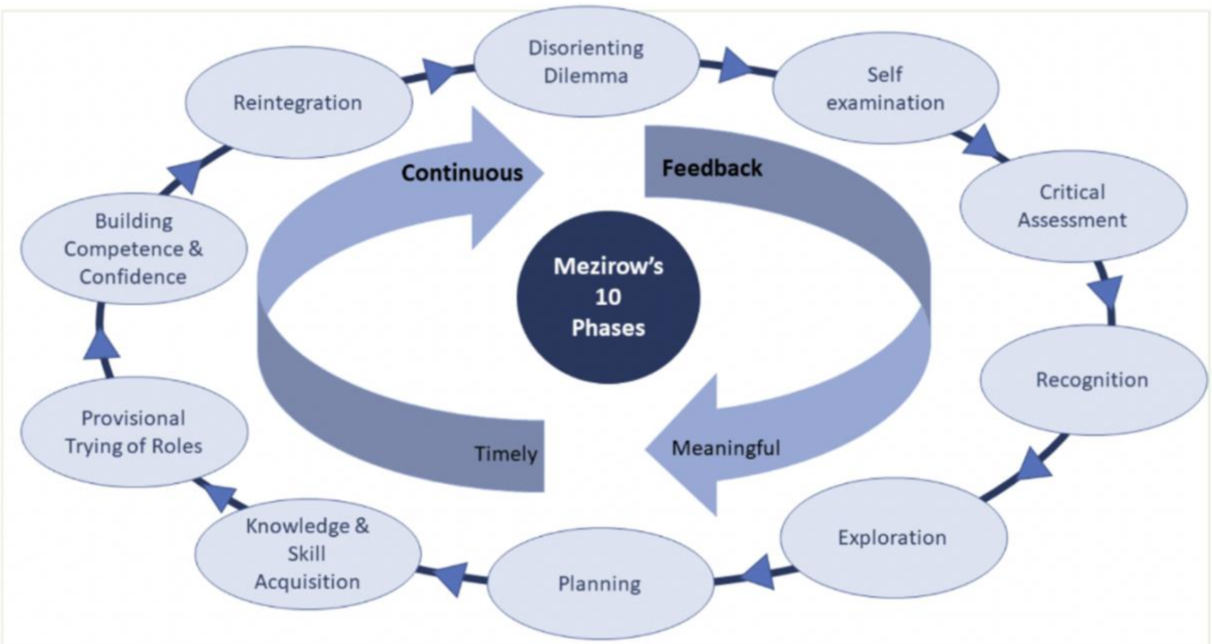

Figure 1 Mezirow's 10 Phases

These phases do not necessarily occur in a rigid sequence; individuals may revisit different stages throughout their transformative learning journey. The initial phase, experiencing a disorienting dilemma, introduces a sense of disequilibrium, which can be triggered by a single profound event or a series of smaller, cumulative experiences (Mezirow, 2003). For example, when individuals engage with an unfamiliar culture that challenges their previously unquestioned assumptions, they may encounter cognitive and emotional discomfort (Taylor, 2001). Mezirow (1994) argued that an individual might encounter a disorienting dilemma when attempting to comprehend the customs of a different culture, especially when those customs contradict the individual's perspective.

Taylor (2001) further emphasized that individuals immersed in a new cultural context may experience cultural disequilibrium, a state in which their existing cognitive frameworks fail to interpret their surroundings adequately. He argued that transformative learning is deeply intertwined with the emotional dimension of knowing, as it requires individuals to develop an empathetic understanding of alternative worldviews. Disorienting dilemmas often evoke strong emotional responses, such as frustration, anxiety, or even humiliation, but these emotions serve as catalysts for deeper reflection and subsequent learning. Rather than hindering the process, emotional discomfort compels individuals to critically reassess their prior assumptions, ultimately fostering personal and intellectual growth.

Transformative Learning Theory is particularly relevant to adult learners, as it underscores the necessity of active engagement with the world, critical analysis of personal experiences, and the implementation of new knowledge into practice (Feller, 2015). Mezirow (1978) defined transformative learning as an active process that involves reflection, participation, and exposure to challenging situations, allowing individuals to develop a more nuanced understanding of themselves and others. In the context of education, experiential learning opportunities, such as a structured language immersion professional development, can serve as powerful catalysts for transformation.

Immersion and Transformation

Study abroad programs, for instance, provide learners with opportunities to engage directly with unfamiliar linguistic and cultural environments, prompting shifts in their perspectives. Bell et al. (2016) found that such experiences facilitate personal growth by encouraging individuals to challenge preconceived notions and embrace alternative ways of thinking. Similarly, Addleman et al. (2014) examined the impact of cultural and language immersion on prospective teachers, concluding that firsthand exposure to diverse cultural contexts enhanced their critical thinking skills and cultural sensitivity. The study revealed that participants who immersed themselves in Austria or Ecuador developed a greater awareness of the sociocultural factors influencing multilingual learners.

He et al. (2017) extended this research by exploring the experiences of in-service teachers who participated in a Chinese language immersion program. The study found that direct engagement with an unfamiliar linguistic environment fostered greater empathy for MLs, leading to a more culturally responsive pedagogical approach. Teachers who had undergone immersion experiences became more attuned to the challenges faced by MLs and subsequently adapted their instructional strategies to include differentiated instruction and inclusive classroom practices. Washburn (2008) further asserted that educators may only fully grasp the struggles of MLs after experiencing the demands of learning a new language and culture firsthand. This empathetic understanding can significantly influence an educator's sense of responsibility, encouraging them to adopt instructional strategies that support linguistic development and cultural integration.

From a professional development perspective, structured language immersion experiences can serve as a valuable form of learning, enabling educators to reflect on their instructional approaches and refine their teaching methodologies. By engaging in critical self-reflection and actively participating in unfamiliar cultural contexts, educators can enhance their ability to support MLs more effectively. Transformative Learning Theory suggests that by stepping into disorienting experiences, individuals develop a deeper awareness of their assumptions and cultivate the adaptability necessary for meaningful pedagogical change.

Building on this theoretical framework, this study employs a qualitative design to explore how science teachers experience language immersion and continuous professional development aimed at fostering empathy, perspective-taking, and more inclusive practices for multilingual learners. The following chapter outlines the methodological approach used to investigate these experiences, including participant selection, data collection procedures, and the analytical framework that guided the interpretation of the findings.

Chapter 3: Methodology

Qualitative Research

As defined by Creswell and Poth (2018), quality inquiry is an approach that seeks to understand human experiences in natural settings, emphasizing meaning-making through rich, descriptive data. This methodological framework is rooted in an interpretivist paradigm, which acknowledges the complexity of social phenomena and prioritizes participants' lived experiences to generate knowledge. Unlike quantitative research, which focuses on numerical data and statistical relationships, qualitative research is exploratory, flexible, and iterative, allowing researchers to adapt their inquiry as themes and patterns emerge (Merriam & Tisdell, 2016). Through methods such as interviews, observations, and narrative analysis, qualitative studies provide in-depth insights into participants' perceptions, emotions, and behaviors, making them particularly valuable for examining the nuanced nature of teacher learning and pedagogical adaptation.

Given this study's focus on language immersion, professional development, and teacher empathy, a qualitative approach is particularly well-suited to capturing how science teachers interpret and internalize their experiences, shaping their instructional practices and support for MLs. This method enables an examination of the deeply personal and contextual factors that influence teachers' ability to foster inclusive science classrooms, uncovering both the challenges they encounter and the strategies they develop to address them. Additionally, qualitative inquiry allows for an exploration of the affective and cognitive dimensions of pedagogical change, elements that are often difficult to quantify but are crucial for understanding how teachers develop empathy, adjust instructional techniques, and navigate the complexities of diverse learning environments (Denzin & Lincoln, 2018). By leveraging the strengths of qualitative research, this study aims to provide a comprehensive understanding of how experiential learning and sustained professional development impact science educators' ability to support MLs effectively.

Phenomenology

As described by Ary et al. (2006), phenomenology provides an appropriate framework for this inquiry, as it seeks to explore and interpret participants' lived experiences. This approach enables a deeper examination of how science teachers make sense of their language immersion experience and how it informs their instructional strategies and attitudes toward MLs. Unlike case study or ethnographic approaches, which focus on bounded systems or cultural contexts, phenomenology is distinct in its emphasis on individual meaning-making and the essence of transformative experiences (van Manen, 1990). This focus aligns with the study's objective of capturing teachers' evolving empathy and instructional practices following immersive and reflective professional learning experiences.

Phenomenology has been widely employed in educational research to explore educators' beliefs, attitudes, and instructional adaptations in response to complex classroom dynamics (Creswell & Poth, 2018). Specifically, in science education, phenomenological studies have provided insight into how teachers conceptualize inquiry-based learning (van Manen, 1990) and how professional development experiences shape pedagogical shifts (Luft & Hewson, 2014). This study aims to capture the essence of teachers' transformative experiences by adopting a phenomenological lens. It will show how immersion and ongoing professional learning cultivate empathy toward MLs. This approach is particularly relevant in science education, where language barriers often intersect with conceptual learning challenges (Lee, 2005).

Research Focus of the Study

Grounded in Transformative Learning Theory, this study investigates how a language immersion activity paired with continuous professional development shapes science teachers' empathy, perspective-taking and instructional practices for multilingual learners (MLs). Through experiential learning, structured reflection, and opportunities for pedagogical changes, this study explores shifts in teachers' perceptions and the changes in their instructional approaches. A phenomenological qualitative approach was chosen to better understand secondary educators' lived experiences when supporting MLs in science classrooms. The research focuses on the following objectives:

1. Examining teachers' beliefs about instructing MLs.
2. Assessing teachers' comfort levels in designing and implementing instruction for MLs.
3. Identifying strategies to improve instructional practices that enhance MLs' learning outcomes in science.

Research indicates that many educators lack an accurate understanding of MLs' language acquisition processes, often resulting in misconceptions that hinder effective instruction (Reeves, 2006). As an instructional leader and advocate for MLs, I aim to facilitate a critical examination of science teachers' perspectives and experiences in working with MLs as an essential step in fostering empathy and instructional effectiveness. The study is designed to positively shift science teachers' perceptions and cultivate empathy through a simulated language immersion experience, which can help educators relate to the challenges of learning a new language and culture. Washburn (2008) suggested that such experiences can significantly influence teaching approaches by promoting self-reflection and pedagogical adaptation.

Ultimately, this study seeks to encourage science educators to reassess and refine their instructional practices by leveraging empathy to strengthen teacher-student relationships and implement effective strategies for second-language acquisition. The findings will contribute to the broader discourse on equitable science education for MLs and inform professional development initiatives to enhance teacher preparedness in linguistically diverse classrooms.

Researcher Positionality and Role

In this study, I acted as a facilitator, observer, active listener, primary data collector, and data evaluator. With 24 years of experience in education, I bring a wealth of practical knowledge gained from working in various urban and suburban K-12 schools. My career began as a permanent middle school substitute teacher, eventually transitioning to a full-time science teacher. Much my teaching experience was dedicated to serving as a bilingual science teacher, primarily supporting Latinx students. As a bilingual educator, I delivered instruction in two languages and served as a cultural and linguistic bridge for my students and their families. These experiences deeply shaped my beliefs about equity in education.

Over the years, I witnessed firsthand how MLs were often marginalized within the education system, particularly in science education. I saw students struggle not because of a lack of ability but because of systemic issues such as the absence of a bilingual science curriculum, lack of language-accessible test administration, and minimal professional development designed for bilingual content teachers. I often translated entire science units and assessments myself to ensure my students had equitable access to the content. Despite these efforts, I noticed a persistent lack of understanding and support from school leadership regarding the needs of MLs.

It was this inequity that ultimately compelled me to move into administration. I felt a moral responsibility to advocate for systemic change that would better support MLs. After fifteen years in the classroom, I advanced into a building-level administrative role, which I have held for the past eight years. In this capacity, I have worked closely with educators across a spectrum of effectiveness, supporting highly effective teachers and those in need of growth. I have continued to center MLs in my work, pushing for more culturally and linguistically responsive instructional practices, inclusive curriculum, and meaningful professional development.

My extensive background in bilingual education and leadership is particularly relevant to this study, as it provides a nuanced understanding of the challenges and opportunities associated with teaching linguistically diverse students. These experiences uniquely position me to interpret the data with both practical insight and academic rigor. At the same time, I remain critically aware of how my experiences as a bilingual educator, advocate, and administrator may shape the way I engage with participants' reflections and interpret the study's findings. Throughout this research, my goal has been to elevate teacher growth, foster empathy and perspective-taking, and contribute to the development of more inclusive science classrooms, particularly for multilingual learners.

Field Setting

The research site for this study consists of teachers from secondary schools within a district where I previously held a school administrator position. This suburban district in New York is characterized by its diverse student population and ongoing de facto segregation. While not legally mandated, this segregation results from socioeconomic, residential, and historical factors significantly influencing the district's demographic composition and educational structures. The district serves approximately 3,000 students, with over 85% qualifying for free or reduced-fee lunch, reflecting the socioeconomic challenges within the community. The secondary schools in the district collectively serve about 1,700 students, with 25% identified as MLs. The secondary schools in the district collectively serve about 1,700 students, of whom 25% are classified as MLs. The secondary instructional staff comprises approximately 210 teachers, with fewer than 10% representing diverse backgrounds. Notably, about 30 of these teachers either live in or grew up in the town. However, those raised in the southern part of the community typically did not attend the zoned public schools, and many teachers with school-age children opt for private education for their own families.

A district-conducted Professional Learning Plan Survey revealed that 42% of secondary teachers expressed a desire for more professional development opportunities focused on supporting MLs. Specifically, they identified a need for relationship-building training, language skills, leveraging students' native languages, differentiation, and scaffolding techniques. The district's and its educators' characteristics provide a meaningful context for examining the challenges and opportunities involved in supporting linguistically and culturally diverse learners within a suburban educational setting.

Participants

Phase I Participants

Participants for this study were recruited through an invitational email sent to approximately 30 science teachers within the school district. These educators were invited to participate in a language immersion professional development (PD) session (described in detail later) designed to align with the study's objectives. A total of 18 teachers took part in Phase I of the study. These 18 participants held various New York State Teaching Certifications, including Science, Childhood Education, Special Education, and Mathematics. Their ages ranged from 24 to 56 years, and they brought teaching experience ranging from 2 to over 20 years. Regarding demographics, the group included 2 Latinx teachers and 16 White teachers, and 2 male and 16 female participants. Table 1 includes Phase I participant demographics (also see Chapter 4).

Table 1
Participant Demographics

Demographic Category	Details
Total Participants	18
Age Range	25-56
Gender Distribution	Male: 2 Female: 16
Years of Teaching Experience	1–4 years: 2 5–9 years: 2 10–14 years: 4 15–20 years: 5 20+ years: 5
Ethnic Background	Hispanic/Latinx: 2 White/Caucasian: 16
Certifications	Science: 7 Early Childhood: 7 Special Education: 1 Other (ELA, Math): 3
Educational Background	Bachelor's Degree: 1_ Master’s degree: 16 PhD/EdD: 1
ENL Professional Development History	Never: 4 A long time ago: 10 A year ago: 2 A few months ago: 2
Multilingual Abilities	Spanish: 2 Italian: 1

Phase II and Phase III Participants

Following the initial language immersion PD, three science teachers were invited to participate in Phase II and Phase III of the study, which involved ongoing professional learning throughout the academic year. These educators, who teach grades 6–9, were informed that their participation would not influence teacher evaluations. Their diverse teaching backgrounds and experiences contributed valuable insights into the long-term impact of the professional development initiative. The three participants who continued through these phases included:

- Mr. Parker: A White male teacher in his late-40s, certified in elementary education, currently teaching science and mathematics. He has over 20 years of teaching experience, bringing extensive instructional knowledge to his practice.
- Mrs. Ramirez: A Hispanic female teacher in her mid-30s, a former English as a New Language (ENL) student with over 10 years of teaching experience. She teaches Living Environment and provides a unique perspective as both an educator and someone who has personally navigated the challenges of language learning.
- Ms. Caldwell: A White female teacher in her early 30s with six years of teaching experience specializing in general science. As an early-career teacher, she offers insights into how newer educators approach multilingual instruction.

These participants played a key role in shaping the study's findings, offering perspectives informed by their varied teaching backgrounds, subject areas, and experiences with multilingual learners. Their continued engagement throughout Phase II and Phase III allowed for a deeper exploration of how immersive professional learning influences long-term instructional practices and attitudes toward multilingual students.

Data Collection

Multiple forms of data were collected throughout this study to inform the analysis process (Creswell & Gutterman, 2019). The data sources included surveys, questionnaires, written reflection responses, article reflection responses, video reflection responses, and lesson plan editing activities. This comprehensive approach ensured that the data captured teachers' perspectives on the daily experiences of MLs and how teachers can address MLs' needs to improve learning outcomes in science content areas. According to Creswell and Gutterman (2019), data for phenomenological studies can be collected from individuals who have experienced a common phenomenon and then develop a common meaning of these shared phenomena. The following data sources were utilized:

Demographic Survey

Participants completed a demographic survey (Appendix A) at the beginning of the study, providing information about their educational backgrounds, teaching experiences, and familiarity with working with MLs. This data established a baseline understanding of the participants' professional contexts and informed the analysis of their subsequent reflections and activities.

Empathy Survey

Participants completed an empathy survey (Appendix B) at the beginning of the study, adapted from Warren (2013) and Davis (1980), to explore their perspective toward empathy and its role in teaching multilingual learners. The survey gathered initial insight into how participants viewed empathy about their professional responsibilities and interactions with students. This data provided a baseline understanding of participants' dispositions toward empathy and informed the analysis of their reflections and responses throughout the professional development experience.

Language Immersion Reflection Responses

Participants completed reflection surveys after attending one professional development language immersion session designed to simulate the experiences of MLs in classrooms without language support and with language support. These reflections captured participants' emotional responses, instructional insights, and strategies for improving support for MLs. Teachers shared their feelings of frustration, anxiety, and eventual relief when provided with linguistic aids, such as glossaries and visual supports, offering rich qualitative data on their learning process and perspectives on MLs' challenges.

Article Reflection Responses

Teachers engaged in an article-based professional learning activity, reflecting on strategies for supporting MLs and deepening their understanding of the challenges faced by these students. Their responses revealed key takeaways, such as the importance of culturally responsive teaching, the integration of native languages in instruction, and the necessity of strong foundational literacy for academic success. Participants also identified areas for improvement in their practices and shared innovative instructional strategies they found effective.

Video Reflections on ML Experiences

Teachers viewed a video highlighting the personal and academic journeys of former MLs and reflected on the challenges these students faced, such as adapting to a new language and culture while mastering academic content. The reflections underscored the importance of building supportive teacher-student relationships and implementing strategies like peer assistance, relevance-driven instruction, and personalized support.

Lesson Plan Editing Responses

Participants reviewed and edited a science lesson plan to incorporate ML-friendly strategies, such as bilingual glossaries, visual aids, and collaborative peer activities. These lesson plan adaptations reflected their growing understanding of the need to scaffold academic content and provide linguistic support, enabling MLs to engage more fully in classroom learning.

This combination of reflective surveys, article-based learning, video reflections, and lesson plan editing provided a comprehensive dataset for analyzing how professional development influenced teachers' attitudes, empathy, and instructional practices for supporting MLs. These data sources were instrumental in examining the impact of professional development on teacher learning and classroom implementation.

Procedure

This study was conducted in three phases: Phase 1, the Perspective and Preparation for Teaching MLs survey; Phase 2, the Language Immersion Professional Development (LIPD); and Phase 3, Empathy Building through Continuous Professional Development. Recruitment began in late August.

Phase I

During the last week in August, I sent all potential participants, approximately 30 science teachers, a recruitment email (Appendix C) with a brief introduction, an overview of the study, and an invitation to participate in the Language Immersion PD (LIPD). The LIPD was conducted in late September. A week before the PD, all science teachers received a reminder email with the details of the LIPD and a request to complete The Perspective and Preparation for Teaching MLs Survey (Appendix D). This survey, adapted from Lucas et al. (2008), was administered via a Google Form and was designed to assess participants' self-reported expertise and comfort in designing and implementing instructional material for MLs. At the beginning of the LIPD, participants privately compile their scores individually and compare them to general descriptions of the scores provided in Table 2.

Table 2
Preparation for Teaching MLs Score Categories (Minimum Score 13 points)

Points	Description
13–26 points	You are aware of the challenges you face when teaching MLs but need a great deal more information on language, culture, prior knowledge, and modification of instruction for MLs. You also don't have an in-depth understanding of the interplay between language, culture, instruction, and learning.
27–52 points	You are aware of the challenges you face when teaching MLs and have a beginning understanding of language, culture, prior knowledge, and modification of instruction for MLs. You have an understanding of the interplay between language, culture, instruction, and learning.
53-78 points	You have an in-depth understanding of language, culture, prior knowledge, and modification of instruction for MLs. You have a deep understanding of the interplay between language, culture, instruction, and learning. There may still be some topics on this survey that you would like to develop further.

After seeing what category their scores fall into, participants were guided through a structured reflection exercise via a Google Form (Appendix E) about their reactions to the survey. The reflection prompts, adapted from Lucas et al. (2008), included the following questions:

1. How did you feel after taking the survey regarding your preparation to teach ELs?
2. Did your responses to specific questions surprise you? Which ones? Why?
3. Do you think your final score on the Preparation to Teach ELs/MLs survey aligns with the description of the category you fall into? Why or why not?
4. Which areas are the strongest for you?
5. Which areas would you like to develop further?

Phase II

After completing the Perspective and Preparation for Teaching MLs survey, 18 participants engaged in the Language Immersion PD. This Phase consisted of two science lessons presented entirely in Polish. The lessons were delivered by the science department chairperson, a certified science teacher fluent in Polish, who also holds a quasi-administrative role within the middle school. Her role in facilitating the LIPD was particularly valuable, as she was able to approach the lesson with both pedagogical expertise and leadership insight. The first lesson was teacher-led, with no visuals or language support, and lasted about 20-25 minutes. The instructor utilized the Gradual Release of Responsibility Framework, *I Do, We Do, You Do* approach, to guide the lesson. Participants reflected on their experience after this lesson by completing a Google Form with guiding questions (Appendix F) for Experience 1: LIPD Polish Lesson.

After completing their reflections, participants engaged in the same lesson, which was conducted again in Polish but with appropriate language support, such as visuals and other scaffolding techniques. After the second lesson, participants completed another reflection using a separate Google Form with guiding questions to evaluate the impact of the language support on their comprehension and learning experience.

Throughout the LIPD, I played a dual role as a facilitator and observer. As facilitator, I set the stage for the LIPD by providing an overview of the objectives and expectations, ensuring participants understood the purpose and structure of the activity. I also guided participants through reflective practices, encouraged active engagement, and provided clarification when needed. During the lessons, I observed participants' behaviors, noting their reactions, levels of engagement, and coping strategies.

Upon completing both language immersion experiences, participants engaged in a structured debrief. Initially, they discussed their experiences in pairs while I circulated the room to capture key observations, prompt deeper reflection, and address emerging themes. Following the pair discussions, participants shared their experiences through reflective. They contributed to a facilitated group discussion where I encouraged participants to connect their experiences to the challenges faced by MLs and consider instructional strategies to address these challenges. Discussions from the LIPD sessions were collected through digital audio recordings and subsequently transcribed for analysis. All data, including reflections, pair discussions, and group discussions, provided a rich foundation for understanding participants' perspectives on the challenges MLs face and the role of instructional strategies in addressing these challenges.

Phase III

Llosa et al. (2016) highlight the importance of providing targeted professional development to teachers who work with multilingual learners and the potential impact of such programs on teacher practice and student learning outcomes. Building on the insights gained during the language immersion experiences, participants were invited to continue in Phase III through an invitational email sent to all initial participants (Appendix G). This phase focused on engaging participants in targeted activities designed to deepen their empathy for MLs and enhance their instructional practices.

Article Reflection. For the first activity in this phase, the participants independently read an article by Ziegenfuss et al. (2014), "How Can We Help Students Who Are English Language Learners Succeed?" Participants then reflected on the article, focusing on its relevance to their teaching practices and understanding of MLs as individual learners. The use of article reflections as a data source in qualitative research is supported in the literature. Gläser-Zikuda et al. (2024) explore the role of reflective writing in teacher education, emphasizing how it can provide deeper insights into teachers' learning processes. Their study highlights that analyzing reflective writing can offer valuable qualitative data, contributing to a better understanding of teacher development and educational research. This activity encouraged participants to consider the unique cultural, linguistic, and personal factors that shape MLs' educational experiences and identify actionable strategies to support these learners effectively. After completing their independent guided reflection (Appendix H), the participants and I met to discuss their insights and questions about the article. This facilitated discussion provided an opportunity to connect the article's key ideas to participants' personal experiences and instructional practices. I guided the conversation to highlight themes such as culturally responsive teaching, supporting MLs' literacy development, and leveraging students' strengths in the classroom.

Video-Elicited Reflections. Video-elicited reflection is a qualitative research method that utilizes video recordings as stimuli to provoke participants' reflections, thereby generating rich, contextualized data about their experiences and perceptions. This method has gained traction in various fields, particularly in education, where it has been employed to enhance understanding of teaching practices and learning experiences (Gibbons & Farley, 2019). Stoetzel et al. (2022) explore the use of video-based reflection in instructional coach development, emphasizing its role in fostering critical self-reflection and challenging entrenched misconceptions among educators. Their study demonstrates that structured video analysis enhances individual professional growth and facilitates collaborative learning as participants engage in discussions that refine their instructional strategies. This aligns with the principles of phenomenological research, which seeks to uncover the essence of lived experiences through participants' reflections (Ary et al., 2006),). Similarly, Powell (2005) discusses the integration of video elicitation in qualitative methods, emphasizing its role in fostering critical analysis and self-awareness among participants. Her findings highlight the potential of video-elicited reflections in educational contexts, as this approach enables educators to examine their practices and beliefs in a structured manner.

In this phase of the study, participants viewed a pre-recorded video featuring former multilingual learners discussing their high school experiences and motivations for pursuing science fields. The independent guided reflection (Appendix H) following the video viewing is critical component of phenomenological inquiry, inviting participants to articulate their thoughts and feelings, thereby enriching the data collected. By integrating video-elicited reflection, this study builds on prior research demonstrating that video analysis can serve as a powerful tool for deepening educators' awareness, refining instructional strategies, and fostering a more inclusive approach to ML education (Stoetzel et al., 2022).

Lesson Plan Editing. Lesson plan editing serves as a critical tool for enhancing instructional strategies, fostering teacher reflection, and improving student outcomes. Research suggests that modifying lesson plans through structured, collaborative, and reflective practices strengthens teachers' ability to adapt their instruction to meet diverse student needs (Darling-Hammond et al., 2017; Fujii, 2016). Engaging in this process not only refines pedagogical approaches but also promotes professional development by encouraging educators to critically evaluate and adjust their teaching methods.

In the final activity, participants engaged in a hands-on review and editing of a lesson plan, specifically focusing on addressing the needs of MLs. This process involved identifying areas that required adaptation and making targeted modifications to ensure that MLs could fully access content and achieve both linguistic and academic success. Participants adjusted key components of the lesson, such as aligning language objectives with content goals, incorporating scaffolding strategies like visual aids and sentence stems, and modifying assessments to accommodate varying levels of language proficiency. Research supports the effectiveness of this approach, as Amalia et al. (2020) found that engaging in reflective lesson planning enables educators to systematically analyze their instructional decisions and enhance teaching performance.

Collaborative lesson planning has been widely recognized as a powerful means of professional growth. Gutierez (2020) found that engaging in collaborative lesson planning (CLP) serves as a positive “dissonance” to individual planning practices, fostering continuous learning and refinement of teaching strategies. Similarly, Fujii (2016) emphasized that lesson planning within the Lesson Study framework allows teachers to anticipate student responses, structure lesson flow effectively, and adapt instructional tasks for improved engagement. These findings highlight the importance of collaborative revision and reflection in shaping effective teaching practices.

Following the lesson plan editing process, participants documented their specific modifications and provided rationales grounded in instructional best practices. This reflective component is essential, as it allows educators to articulate their decision-making processes and connect their edits to principles of linguistically responsive instruction. Amalia et al. (2020) emphasize that reflective practice in lesson planning helps educators refine their instructional approaches by critically examining how lesson components align with student needs.

By engaging in lesson plan editing and reflection (Appendix J), teachers refine their instructional strategies and strengthen their ability to create equitable learning environments. These findings underscore the importance of integrating structured, collaborative, and reflective lesson planning into professional development initiatives to enhance teaching effectiveness and student success.

Phase Integration

Each Phase of the study is designed to build upon the insights and outcomes of the preceding Phase, ensuring a progression in data collection and analysis. In Phase I, the survey and reflection exercises provide baseline data on participants' self-assessed preparedness and perceptions regarding teaching MLs. This data helps identify key themes and areas of focus, which directly inform the structure and objectives of Phase II. During Phase II, the immersive language experiences and associated reflections allow participants to deepen their understanding of the challenges faced by MLs, offering rich qualitative data on their emotional and cognitive responses to language barriers. This Phase reinforces themes identified in Phase I and highlights specific areas for professional growth, which set the stage for Phase III. Building on the empathy and insights developed in Phase II and III activities, article reflections, video-elicited reflections, and lesson plan editing focus on applying theoretical understanding to practical contexts. These targeted activities allow participants to refine their instructional strategies and further explore the actionable steps they can take to support MLs effectively. By progressively deepening participants' engagement and reflection at each Phase, the study ensures that data collection is iterative and responsive, enabling a comprehensive exploration of the research questions.

Table 3 summarizes the three phases of the study, including the corresponding data sources and the estimated duration of each phase. In addition to the formal activities and data collection outlined within each phase, participants were also offered supplemental supports designed to reinforce learning and foster collaboration beyond individual implementation.

Table 3
Summary of Phases

Research Phase and Description	Data Sources and Instruments	Timeline/ Participant Time Demand
Phase I: Participants complete The Perspective and Preparation for Teaching MLs survey	1. Survey 2. Written Reflections	September 30 minutes
Phase II Participants experience Language Immersion PD with and without Language Supports	1. Written Reflections 2. Group Discussions 3. Researcher Field Notes	October 2 hours
Phase III Participants undergo Targeted Continuous PD facilitated by the researcher	1. Individual Meetings 2. Researcher Notes 3. Article Reflection 4. Video Reflection 5. Lesson Plan Modifications 6. Exit Interview	November-June 15-20 hours 9 months

Extended Professional Learning Opportunities

During the follow-up conversations that occurred after each instructional task, participants received targeted recommendations designed to extend their learning and deepen the integration of language supports within science instruction. Specifically, participants were encouraged to conduct intervisitations with ENL and bilingual teachers in their respective buildings. These visits were intended to help science teachers observe real-time language support strategies in varied instructional contexts. Participants were also advised to collaborate with ENL teachers during lesson planning to intentionally embed language objectives alongside science content goals.

As part of the study's design to promote sustained reflection and professional collaboration, participants were encouraged to engage in the district's embedded Professional Learning Community (PLC) sessions, which occurred every other day for 30-minute intervals. These PLCs offered a structured space for participants to share strategies, debrief intervisitation experiences, and engage in co-planning with ENL colleagues. These supports were intentionally embedded to enrich teachers' professional growth by fostering ongoing collaboration, reflection, and the integration of language scaffolds within science instruction. Through these experiences, participants engaged in continuous learning that strengthened their instructional practice and deepened their empathy for the needs of multilingual learners.

Data Analysis

This study examined the impact of a language immersion experience, paired with continuous professional development, on science instructors' empathy for multilingual learners (MLs) and the continuing development of their approaches to teaching. This study applied Mezirow's (1991) Transformational Learning Theory to investigate the shifts in educators' perceptions through experiential learning, structured reflection, and pedagogical changes. This study employs a phenomenological qualitative design, gathering data through written reflections and semi-structured interviews with science teachers from a Long Island school district. The goal is to explore their perceptions of multilingual learners and how building empathy can transform science teaching practices to better support these students. Data collection includes semi-structured interviews and written reflections, ensuring a rich, descriptive account of teachers' experiences. As Creswell (2014) noted, structured approaches are essential in phenomenological research to systematically capture and analyze participants' lived experiences.

Table 4 summarizes the data collection process, illustrating the alignment between each research phase, its guiding research question, and the corresponding data sources utilized throughout the study.

Table 4
Summary of Data Collection Process

Phase	Research Questions	Data Collection
1	In what ways can a language immersion experience foster empathy and perspective-taking to initiate the transformation of science teachers' dispositions toward MLs?	Surveys, reflections, group discussions
2	How does a language immersion experience followed by ongoing focused professional development encourage science teachers to develop empathy and perspective-taking as they reflect on MLs' needs and begin transforming their teaching practices?	Surveys, reflections, group discussions, interviews, unit lesson plans, classroom observations
3	How does a language immersion experience followed by continuous professional development cultivate empathy and perspective-taking that support the transformation of science teachers' practices to create more inclusive learning environments and better support ML learners?	Reflections, lesson plans, observations of teacher-student interactions

Coding Process

Data analysis followed a systematic, multi-phase process involving both manual coding and NVivo 14 software-assisted thematic analysis. The process began with Phase I survey and reflection transcripts, where participant responses were organized into clusters based on key questions. These clusters served as the foundation for preliminary themes, which were further refined through multiple rounds of coding and analysis. Thematic analysis, as described by Braun and Clarke (2006), was conducted through multiple readings of the data to ensure comprehensive coverage, focusing on how a language immersion experience, combined with ongoing professional development, influenced pedagogical transformation.

Keyword Identification and NVivo-Assisted Analysis

A key component of the data analysis was identifying frequently occurring words and phrases in participant responses. I conducted close readings of transcripts, searching for recurring keywords and conceptual patterns aligned with the study's research questions. To enhance rigor and minimize researcher bias, NVivo's word frequency queries highlighted significant terms frequently appearing in participants' discussions of their experiences (Woolf & Silver, 2018). Keywords and phrases such as "struggle," "understanding," "confidence," "barrier," "connection," and "adjusting instruction" emerged as central to participants' reflections, highlighting their evolving awareness of MLs' challenges and their instructional shifts. The term "struggle" was frequently used to describe both teachers' difficulties during immersion and MLs' experiences in science classrooms, while "understanding" reflected participants' deepening awareness of MLs' needs and effective instructional strategies. The word "confidence" appeared in discussions about teachers gaining confidence in implementing inclusive strategies and MLs feeling more assured when provided with appropriate language support. References to "barriers" emphasized the linguistic, instructional, and systemic challenges MLs and teachers face. The term "connection" surfaced in relation to building stronger relationships with MLs and integrating culturally responsive teaching strategies. Finally, "adjusting instruction" captured teachers' deliberate pedagogical changes, such as incorporating scaffolding, translanguaging, and inquiry-based learning to foster a more inclusive science classroom.

Following automated keyword identification, these words were analyzed within the context of participants' reflections to ensure relevance and accuracy (Saldaña, 2019). For example, the word "struggle" was often mentioned, but its meaning varied; some teachers used it to describe their experience during the immersion activity, while others referred to the challenges MLs face in science classrooms. This step ensured that keywords were not analyzed in isolation but rather interpreted within the broader themes of the study.

Deductive and Inductive Coding Approaches

The coding process progressed through deductive and inductive approaches (Saldaña, 2019). Initially, deductive coding was applied to classify data into pre-identified categories related to language immersion, empathy development, and instructional shifts (Creswell & Poth, 2018). Subsequently, inductive coding was used to capture unexpected themes that emerged organically from participants' narratives. NVivo's query and visualization tools facilitated further refinement by exploring patterns and relationships between codes. Additionally, word frequency analysis helped identify key terms that informed further thematic categorization.

Through NVivo-assisted analysis and manual coding, key themes emerged, including:

1. *Cognitive and Emotional Impact of Language Immersion* – Teachers experienced frustration, anxiety, and cognitive overload, mirroring MLs' struggles, reinforcing the need for scaffolding and linguistic support.
2. *From Awareness to Action: The Role of Reflection* – Empathy alone did not lead to change; structured reflection and PD were essential in helping teachers rethink and adjust their instructional strategies.
3. *Shifting Perspectives on MLs' Potential* – Initially, some teachers viewed MLs' language barriers as deficits but later recognized their linguistic assets, supporting home language use in learning.
4. *Scaffolding and Differentiation in Science Instruction* – Teachers adopted visuals, bilingual glossaries, and slower pacing to reduce MLs' cognitive load and support comprehension.
5. *Inquiry-Based Learning as a Language-Supportive Strategy* – Moving beyond rote memorization, teachers incorporated hands-on, inquiry-driven activities, fostering both

science learning and language development.

6. *Translanguaging and Multilingual Support* – Teachers shifted from resisting home language use to embracing translanguaging strategies, such as dual-language word banks and peer-based language support.
7. *Barriers to Implementation* – Limited time, lack of administrative support, and standardized testing pressures created challenges in sustaining ML-inclusive strategies.
8. *Commitment to Equity and Advocacy* – Teachers expressed a long-term commitment to improving ML instruction and advocated for systemic policy changes to support inclusive science education.

By integrating manual thematic analysis and NVivo-assisted keyword analysis, this study ensures methodological rigor while allowing for a nuanced interpretation of participants' experiences. The final themes illustrate how science teachers' engagement in a language immersion experience and ongoing professional development can shape their empathy toward MLs and transform their instructional practices to foster more inclusive and equitable science learning environments. This analytical process aligns with Creswell's (2014) recommendations for theme identification and interpretation in qualitative research, reinforcing the credibility and trustworthiness of the study's findings (Lincoln & Guba, 1985).

Elements of Rigor

To ensure the trustworthiness of this study, rigorous qualitative research strategies are implemented, aligning with the criteria established by Lincoln and Guba (1985) and further refined by Creswell and Poth (2018). Trustworthiness in qualitative research encompasses credibility, transferability, dependability, and confirmability, which parallels validity and reliability in quantitative research. These elements are reinforced through triangulation, member checking, thick description, and peer review to enhance methodological integrity.

Credibility. Credibility, or confidence in the accuracy of the data, is established through methodological triangulation by cross-verifying evidence from multiple data sources, including semi-structured interviews, written reflections, and researcher notes. Triangulation strengthens the validity of themes by ensuring that findings are not based on a single perspective but rather emerge from consistent patterns across multiple data points (Creswell & Poth, 2018). Additionally, member checking is employed, where participants review interview summaries and preliminary findings to confirm the accuracy of their responses and interpretations (Creswell & Poth, 2018). This process reduces researcher bias and ensures that participant voices are accurately represented.

Transferability. To address transferability, or the ability of findings to be applied to similar contexts, the study provides rich, thick descriptions (Lincoln & Guba, 1985). Thick description involves detailed contextualization of participants' experiences, allowing readers to determine whether the findings are relevant to their settings (Nowell et al., 2017). The study facilitates broader applicability beyond the immediate research site by presenting direct quotes, contextual background, and nuanced interpretations.

Dependability. Dependability, which parallels reliability in quantitative research, was ensured through a structured and systematic approach to data collection and analysis. Written reflections, survey responses, and researcher notes were carefully documented, organized, and coded using NVivo software, ensuring consistency in theme identification and interpretation. An audit trail was maintained, detailing coding decisions, theme development, and methodological choices, allowing for transparency in the research process. Additionally, peer debriefing was conducted, where an external reviewer (e.g., a faculty advisor or qualitative research expert) examined the coding structure and thematic consistency to enhance reliability and confirm coherence in data interpretation (Nowell et al., 2017).

Confirmability. Confirmability is established by maintaining transparency in the data analysis process and minimizing researcher bias (Guba & Lincoln, 1994). Clear documentation of coding decisions, thematic development, and data interpretations ensures that findings are grounded in participants' narratives rather than the researcher's preconceived assumptions. This study upholds rigorous qualitative research standards by incorporating triangulation, member checking, thick description, and reflexive analysis. These strategies enhance the credibility, transferability, dependability, and confirmability of the findings, ensuring that the research process and conclusions remain methodologically sound, ethically responsible, and academically robust.

Chapter 4: Findings

Examining Teacher Growth Through Multiple Data Sources

The study draws on multiple data sources, including survey responses, post-survey reflections, article reflections, video reflections, lesson plan revisions, and exit interviews, to examine how language immersion and professional development influenced teachers' empathy, reflective practices, and instructional strategies. These qualitative insights reveal how participants deepened their understanding of multilingual learners' (MLs) challenges, critically evaluated their teaching methods and implemented more inclusive instructional approaches.

Building on these data sources, this chapter analyzes how participants engaged with language immersion and professional development initiatives. It explores their evolving empathy, critical reflection on instructional practices, and implementation of inclusive teaching strategies, situating these findings within the context of existing research to highlight their broader significance. This chapter presents the findings of this study, exploring how language immersion experiences and ongoing professional development influence science teachers' empathy, awareness, and teaching practices when working with multilingual learners (MLs). This chapter addresses the study's three guiding questions, providing a comprehensive examination of how these interventions foster teacher growth and contribute to more inclusive classrooms:

1. In what ways can a language immersion experience foster empathy and perspective-taking to initiate the transformation of science teachers' dispositions toward MLs?
2. How does a language immersion experience followed by ongoing focused professional development encourage science teachers to develop empathy and perspective-taking as they reflect on MLs' needs and begin transforming their teaching practices?
3. How does a language immersion experience followed by continuous professional

development cultivate empathy and perspective-taking that support the transformation of science teachers' practices to create more inclusive learning environments and better support ML learners?

This chapter draws on multiple data sources, including the participants' reflections on immersion experiences, professional development activities, such as video and article reflections, and lesson plan adaptations to address these research questions. The findings reveal the gradual but meaningful transformative process teachers underwent as they critically reflected on their immersion experiences and engaged with ongoing professional development.

The Language Immersion Experience

The language immersion served as a profound disorienting dilemma for teachers, exposing them to MLs' challenges and fostering empathy through direct, personal experiences. The eighteen participants who took part in the first Polish-language science lesson without any language support described their experiences as overwhelmingly anxiety-inducing, frustrating, and disorienting, mirroring the struggles that MLs face daily when attempting to learn content in an unfamiliar language. Below are more details about the 18 participants (See Table 1, p. 44).

Phase I Participants complete The Perspective and Preparation for Teaching MLs survey
Phase II Participants experience Language Immersion PD with and without Language Supports
Phase III Participants undergo Targeted Continuous PD facilitated by the researcher

Participant Demographics and Professional Backgrounds

This section overviews of the 18 study participants, highlighting key demographic factors such as age, gender, teaching experience, and certifications (See Table 1, p. 44). These characteristics offer insights into their professional backgrounds, cultural diversity, and readiness for professional development in the context of multilingual learners (MLs).

Age Range

The participants ranged in age from 25 to 56 years, representing a diverse age group at different career stages. While younger participants may have had more recent exposure to evolving pedagogical approaches, older participants may bring extensive classroom experience. In science education, veteran teachers may be more accustomed to traditional, content-heavy instruction, whereas newer educators might be more familiar with language-integrated strategies that support multilingual learners (MLs).

Years of Teaching Experience

Most participants (N=10) have 15+ years of experience, reflecting a seasoned cohort of educators. However, in science instruction, longer teaching experience does not always correlate with a readiness to adapt to ML-friendly practices. Veteran science teachers may need targeted interventions that help them shift from content-driven instruction to language-integrated strategies. Meanwhile, early-career science teachers might be more adaptable but could lack practical experience in implementing empathy-based approaches for MLs.

Gender and Representation in Science Education

The majority of female representation aligns with national trends in education. In science classrooms, however, gender representation is often skewed toward male educators, especially in secondary STEM fields (National Science Teaching Association, 2020). The presence of more female participants may influence empathy-related discussions, as research suggests that female educators often report higher levels of empathic engagement with students (Warren, 2018).

Cultural and Linguistic Diversity: Ethnic Background

The predominance of White/Caucasian participants (N=16) underscores a potential disconnect in understanding the diverse backgrounds and linguistic needs of multilingual learners (MLs). This is particularly relevant in science education, where students' cultural perspectives shape how they engage with scientific inquiry (Mensah, 2011). However, the inclusion of Hispanic/Latinx participants (N=2) enriched the study by providing firsthand insights into multilingual and multicultural experiences. These perspectives contributed to a deeper exploration of culturally and linguistically responsive teaching practices in science education.

Professional Expertise and Educational Attainment: Certifications

The mix of science and early childhood educators presents a unique intersection of teaching philosophies. Early childhood teachers often integrate social-emotional learning and language development, whereas science educators may need explicit training in embedding empathy into content-heavy instruction.

Educational Background

The presence of advanced degrees suggests a highly educated group of educators. While this may indicate strong reflective practices, it could also mean that some participants have deeply ingrained instructional habits that may require targeted professional development to adapt to ML-inclusive teaching.

Training and Multilingual Proficiency: ENL Professional Development History

Timing of Last ENL PD: *Never, a long time ago, a year ago, a few months ago*

The inconsistent history of ENL training suggests that many participants may lack current best practices for teaching MLs in science classrooms.

Multilingual Abilities

The small group of multilingual participants may already demonstrate greater empathy toward MLs and could be instrumental in helping their monolingual peers understand language acquisition challenges. Science teachers who are monolingual may need immersive experiences and simulations to develop deeper empathy for MLs.

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Phase I

Empathy and Science Teachers' Perspectives on Multilingual Learners Survey

The Perspective and Preparation for Teaching MLs Survey adapted from Lucas et al. (2008) provides critical insights into science teachers' definitions, perceptions, and self-assessments of empathy, particularly concerning their interactions with multilingual learners (MLs). Understanding participants' views on empathy as a disposition, a learned skill, and an instructional tool is essential for evaluating the impact of language immersion experiences on shifting attitudes and teaching practices.

Defining Empathy: Participants' Personal Conceptualizations

Participants' definitions of empathy reflect a strong awareness of its role in human connection and understanding. Many responses emphasized the importance of perspective-taking and emotional sensitivity, with participants describing empathy as "the ability to relate to others even if you haven't had the same experiences," "putting yourself in someone else's shoes to understand how they might feel," and "the ability to understand and share the feelings of another." A significant theme across responses was the idea that empathy involves both emotional recognition and cognitive perspective-taking, aligning with Davis' (1983) multidimensional model of empathy. This model distinguishes between affective empathy, or feeling what another person feels, and cognitive empathy, which involves understanding another person's experience without necessarily sharing the same emotions.

For science teachers working with MLs, this distinction is important. While affective empathy can drive compassion and relationship-building, cognitive empathy is crucial for adapting instructional practices to meet the linguistic and academic needs of MLs. This dataset explores participants' definitions of empathy, their understanding of empathy's origins, and how they perceive its role in interpersonal and professional contexts. The data reflects varying levels of awareness and beliefs about empathy, which connect directly to Mezirow's Transformational Learning Theory, particularly its components of critical reflection, perspective transformation, and action (Mezirow, 1994).

How Participants Conceptualize Empathy in Their Teaching Practice

Participants overwhelmingly supported the idea that empathy is learned rather than innate when asked to categorize their beliefs about empathy. Most participants (12 out of 18, or 67%) stated that empathy is a learned behavior, while 6 participants (33%) believed empathy is cultivated over time but has an innate component. This suggests that teachers recognize the potential for professional development experiences, such as language immersion, to enhance empathy toward MLs. This supports Warren's (2018) research, which posits that empathy-building experiences in professional development can shift teachers' perspectives and instructional practices. Additionally, nearly all participants (17 out of 18, or 94%) viewed empathy as a critical component of teaching, agreeing that it is of great importance in their work as classroom teachers. Only one participant (6%) acknowledged empathy as important but not a priority. These responses underscore that while teachers recognize the value of empathy, the challenge lies in translating it into actionable classroom strategies.

Science Teachers' Self-Assessments of Empathy

Participants' self-ratings on empathy-related behaviors suggest a high level of self-reported empathy. All 18 participants (100%) agreed or strongly agreed that empathy is necessary for teachers of multilingual learners. Additionally, 17 participants (94%) reported frequently experiencing tender, concerned feelings for people less fortunate than themselves. Participants also demonstrated strong emotional responsiveness to social injustices, with 15 participants (83%) stating that they feel protective when they see someone being taken advantage of and 16 participants (89%) reporting that they try to understand friends' perspectives by imagining their experiences. However, some participants expressed difficulty in fully adopting another person's perspective. Six participants (33%) indicated that they sometimes struggle to see things from another person's point of view, while seven participants (39%) acknowledged that they occasionally find it difficult to feel deep sympathy for people experiencing hardships. These findings suggest that while most participants self-identify as empathetic, some may struggle with perspective-taking in unfamiliar contexts, which could impact how they interpret multilingual learners' (MLs) classroom experiences.

Empathy and Perspective-Taking in Teaching MLs

Participants were asked to evaluate their ability to consider multiple perspectives and engage in fair decision-making. Sixteen participants (89%) reported that they try to consider all sides of a disagreement before making a decision, and 14 participants (78%) stated that they believe there are two sides to every question and strive to examine both. These responses suggest that most participants see themselves as open-minded educators. However, responses varied when asked whether they listen to opposing viewpoints even when they feel confident about their position. Only one participant (6%) admitted disregarding others' arguments when confident in their beliefs, while 14 participants (78%) stated that they still listen to opposing perspectives. This willingness to consider multiple viewpoints is a promising indicator for science education, where critical thinking and inquiry-based learning are essential. Nonetheless, some participants may still struggle with adapting their perspectives when faced with unfamiliar cultural and linguistic challenges, highlighting the need for experiential learning activities such as language immersion to enhance their ability to support multilingual learners (MLs).

Phase I Post Survey Reflection

Empathy is a foundational element of effective teaching, particularly when working with multilingual learners (MLs). Research has shown that teacher empathy positively impacts student engagement, motivation, and academic success (Warren, 2018). This section analyzes educators' self-reported empathy levels, cognitive and emotional processes during the assessment, and reflections on how empathy influences their teaching practices. The findings provide insight into how teachers conceptualize, experience, and apply empathy in their professional roles and the challenges they encounter in its implementation.

Perceptions of Empathy Scores

Survey responses indicate that most participants were not surprised by their empathy scores, as they already considered themselves highly empathetic individuals. Many expressed confidence in their ability to understand and respond to students' emotional and academic needs, which aligns with prior research that suggests educators perceive empathy as essential to building supportive learning environments (Warren, 2018). Several participants referenced personal backgrounds as shaping their empathetic dispositions, particularly those who had familial experiences with caregiving responsibilities. However, a few respondents expressed mild surprise at their scores, particularly those who had anticipated higher or lower levels of empathy. For example, one participant noted that while they generally exhibit empathy, their high expectations for students sometimes lead to moments where they lack patience or fail to fully appreciate students' challenges. This suggests that while educators may see themselves as empathetic, situational factors influence its application, highlighting the need for continuous self-reflection. This aligns with findings from Kitchenham (2008), who asserts that transformational learning occurs when individuals critically evaluate their assumptions and revise their perspectives based on new experiences.

Reevaluating Empathy and Its Role in Teaching

Most participants' views on empathy remained unchanged after taking the assessment. They maintained that empathy is a critical component of effective teaching and that their initial self-perception aligned with their results. However, a few respondents reported a shift in perspective, recognizing the need to deepen their empathy, particularly toward students facing external challenges beyond language barriers. One participant reflected, "I frequently consider how language acquisition impacts learning, but I now realize I also need to be mindful of students' home environments and emotional states." This shift aligns with Mezirow's (1998) Transformative Learning Theory, which emphasizes that perspective change occurs when individuals critically reflect on prior assumptions and expand their understanding through new experiences.

Empathy's Role in Building Relationships with Multilingual Learners

Respondents unanimously agreed that empathy is fundamental in establishing meaningful relationships with MLs. Many described how demonstrating empathy fosters trust, increases student engagement, and encourages participation. One common strategy cited was incorporating students' native languages into classroom interactions, such as asking students how to say certain words in their language or utilizing translation tools. Some educators shared classroom experiences in which students initially hesitated to express themselves but became more comfortable when their linguistic and cultural backgrounds were acknowledged and respected. These strategies are well-supported in existing literature. Research suggests that teachers who validate and incorporate students' linguistic backgrounds create a more inclusive and culturally responsive classroom environment (Gay, 2018). Several educators recalled experiences where students, initially hesitant to express themselves, became more comfortable when their cultural and linguistic backgrounds were acknowledged. One participant emphasized that "learning cannot take place if students feel threatened by how the teacher teaches." This underscores the relational nature of empathy and its role in reducing anxiety and fostering a sense of belonging in MLs (Zhang, 2022).

Empathy's Impact on Teaching Practices and Challenges in Implementation

Survey responses suggest that empathy directly informs instructional decision-making, particularly in modifying teaching practices to be more inclusive. Many participants reported making deliberate efforts to differentiate instruction, scaffold learning activities, and provide multilingual resources to support MLs. Several noted that empathy helped them remain patient and attuned to students' needs, ensuring that lessons were accessible while maintaining academic rigor. However, despite recognizing the importance of empathy in teaching, respondents highlighted key challenges in its implementation. The most frequently cited obstacle was time constraints, particularly the difficulty of translating materials, finding appropriate resources, and balancing differentiated instruction with other pedagogical responsibilities.

Additionally, some participants noted that working with MLs from diverse linguistic backgrounds presented additional complexities, as strategies that were effective for one group might not be equally applicable to another. These findings suggest that while educators recognize the importance of empathy, they struggle with the logistical demands of translating it into daily practice. This is consistent with the literature, highlighting that many teachers acknowledge the importance of empathy but often feel unprepared to apply it effectively in multilingual classrooms due to systemic constraints (Durgunoğlu & Hughes, 2010).

Connecting Phase I Data to Mezirow's Transformational Learning Theory

This dataset provides insight into how participants define, perceive, and apply empathy, aligning with Mezirow's Transformational Learning Theory, particularly in critical reflection, perspective transformation, and action-oriented learning (Christie et al., 2015). Through the lens of Mezirow's Transformational Learning Theory, the data suggests that teachers move through distinct phases of perspective transformation, progressing from cognitive understanding to emotional engagement and, ultimately, to action-oriented change. While some educators have fully integrated empathy into their instructional practices, others are still in earlier stages of transformation, suggesting a continued need for reflection and professional learning opportunities (Kitchenham, 2008). These findings reinforce that empathy is not static; it is a continuous process of growth, adaptation, and intentional practice in creating inclusive and supportive learning environments for MLs.

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Phase II

Findings from the Language Immersion Professional Development (LIPD)

During the Language Immersion Professional Development (LIPD) session, teachers experienced firsthand the challenges that English Language Learners (ELLs) face in classrooms where they receive little to no language support. Their reactions mirrored the struggles of ELLs, highlighting feelings of confusion, frustration, and disengagement. Participants engaged in a language immersion workshop where two science lessons were delivered entirely in Polish, without any language supports and scaffolds and with proper supports to aid comprehension. Observations and reflections during this experience underscored the cognitive and emotional challenges educators encountered in a linguistically unfamiliar environment. These responses highlighted their growing empathy for multilingual learners (MLs) while showcasing the diverse strategies they employed to navigate the lesson. The data collected provides insight into how language barriers impact engagement, comprehension, and confidence, reinforcing the importance of structured support for MLs in the classroom.

LIPD without Linguistic Support

Many teachers expressed feeling lost and overwhelmed. One participant stated, "I felt lost, totally confused," while another admitted, "I felt dumb. I completely shut down." Others described similar reactions, such as, "I zoned out" and "I wanted to put my head down." The lack of clarity in instructional expectations was a key frustration, as one teacher noted, "I knew what everything was in the picture, but I couldn't understand what she wanted me to do." One of the most striking realizations came from a teacher who directly connected their experience with their ML students, stating, "I wanted to ask to go to the bathroom because I didn't understand. Now I know why many of my ELLs ask to go to the bathroom every day during my class period."

This moment of reflection underscores the importance of scaffolding instruction, providing linguistic supports, and creating inclusive learning environments that foster comprehension rather than isolation. Many participants shared feelings of being lost, disengaged, and cognitively shutting down, common responses for MLs who lack adequate linguistic support in academic settings. This experience underscores the critical need for professional development that helps science teachers cultivate empathy for multilingual learners while equipping them with effective instructional strategies. By immersing themselves in the challenges MLs face, teachers can better appreciate the importance of scaffolding instruction, integrating language supports, and utilizing hands-on, inquiry-based approaches to make science learning more accessible, engaging, and meaningful for all students.

Participants highlighted several barriers to comprehension, including lack of visual support, rapid speech, and the absence of bilingual scaffolding. Many teachers exhibited signs of confusion, frustration, and disengagement during the first Polish-language lesson. Observations revealed that several participants nodded their heads in agreement without fully understanding the instructions, with some resorting to vague affirmations such as "sure, yes" or repeating unfamiliar words, like "Słońce" and "Skała," in an attempt to make sense of the lesson. Others explicitly questioned the task, with one teacher asking, "What is she asking us to do?" while another speculated, "I think we have to make a list of things in nature?" Their struggle to grasp the lesson's objectives highlights the challenges MLs face when content is delivered without linguistic support.

The emotional effect of this experience played a key role in shifting teachers' perspectives, directly addressing the first research question. Many participants reflected on how they had previously misunderstood their ML students' struggles, often mistaking silence or disengagement for a lack of motivation rather than an indication of linguistic barriers. The facilitator noted recurring themes in the teachers' reflections, summarizing their feelings: "I shut down, I zoned out, I was confused, I was frustrated, this was stressful, I did not know what she was saying." This moment of realization prompted one teacher to reflect on a specific student, stating, "I was thinking about Marvin, poor Marvin, and no wonder why he doesn't want to come to school. We have an attendance issue with our ELLs, and it's probably because they feel lost." This newfound empathy laid the foundation for teachers to rethink their instructional approaches and seek ways to provide more meaningful language support. One participant acknowledged, "We both felt that the teacher expected that we understood," mirroring the common classroom dynamic where MLs are expected to follow along without explicit scaffolding.

By experiencing these challenges firsthand, teachers developed a deeper awareness of the need for scaffolding strategies such as slower speech, visual supports, and bilingual resources. When asked whether slower speech would have helped, one participant admitted, "I was trying to figure out the vocabulary, but I couldn't keep up. She was speaking too fast." Another emphasized the lack of instructional clarity, saying, "I see water, so maybe it's about nature." Despite their best efforts to rely on prior knowledge, group collaboration, and digital tools, most participants remained confused and overwhelmed.

Cognitive and Emotional Responses to the Immersion Experience

Participants exhibited a range of emotional and cognitive responses during the science lesson, illustrating the varied ways MLs engage with content in unfamiliar linguistic settings. The dominant emotions expressed included frustration, anxiety, stress, confusion, and embarrassment, reflecting the psychological toll of language barriers on engagement and learning. One participant shared, "It was frustrating! I had no idea what she was saying in the first lesson." Another echoed this sentiment: "It was stressful and overwhelming." One participant, overwhelmed by the experience, admitted, "I just stopped listening. It was difficult to understand what I was being asked to do." Another reflected, "I felt confused during the course of the first lesson and frustrated because I heard the teacher but could not comprehend the information."

A Spanish-speaking participant who had previously been an English as a New Language (ENL) student noted that, despite her background, she approached the lesson differently as an adult. Rather than disengaging, she actively attempted to make connections using prior linguistic knowledge to determine the lesson's objectives. However, she acknowledged that the task remained difficult without proper scaffolds, reinforcing the necessity of structured linguistic support in classroom instruction. Conversely, another participant experienced cognitive overload and withdrew entirely, effectively "zoning out." This disengagement aligns with Sweller's (1988) cognitive load theory, which posits that excessive extraneous cognitive load, such as processing unfamiliar linguistic input, can overwhelm working memory and impede learning. Without comprehensible input or adequate instructional support, MLs may feel similarly overwhelmed, limiting their opportunities for meaningful learning. A third participant attempted to use Google Translate as a compensatory strategy but quickly found it ineffective due to the rapid pace of instruction. His struggle underscores the limitations of relying solely on translation tools when the instructional tempo and cognitive demands exceed processing capabilities. This experience parallels the challenges many MLs face when expected to keep up with fast-paced lessons without real-time linguistic support.

As teachers engaged in the first Polish-language science lesson, their body language and spontaneous reactions revealed moments of discomfort and heightened self-awareness. While attempting to follow the lesson, one teacher let out a nervous chuckle. When asked why, she admitted, "I'm nervous I'm going to be called on, and I won't be able to answer—I guess it's a nervous chuckle." This brief exchange reflected the anxiety and vulnerability that many MLs experience daily when expected to process, comprehend, and respond in an unfamiliar language. Another teacher, throughout the lesson, repeatedly shook her head in frustration. When asked why, she sighed and admitted, “I have no idea what she is saying.” This response mirrored the overwhelming cognitive load MLs endure when they lack linguistic access to content, reinforcing the need for scaffolded instruction, visual aids, and intentional support strategies in the science classroom. Perhaps the most impactful moment occurred after the PD ended; a participant paused to reflect on her experience. She stated, "Wow, now I know how the ENL kids feel. I need to do better." This realization encapsulates the purpose of the immersion experience—to cultivate a shift in perspective that leads to meaningful pedagogical change.

Coping Strategies

Despite the lesson's challenges, participants employed various compensatory strategies to try to understand the content, reflecting how MLs often adapt in real classroom settings.

Use of Technology for Translation

Several teachers attempted to use Google Translate to decode individual words or phrases. However, this strategy was often ineffective due to the fast pace of instruction, a limitation frequently experienced by MLs. “I tried using Google Translate, but the teacher was going too fast for me to keep up.” “I wanted to use technology, Google Translate.”

Visual Cues and Context Clues

Many participants relied heavily on visuals, gestures, and environmental cues, mirroring the strategies their ML students likely use in the classroom. One participant shared, “I used the pictures on the board and tried to use my background knowledge to understand the task.” Another explained, “I looked at what other people in the room were doing to see what I was supposed to do.” These strategies reflect how MLs navigate unfamiliar language environments by drawing on available non-verbal cues to process meaning and complete tasks. Just as the participants found themselves relying on images, gestures, and peer modeling to comprehend instructions, their MLs employ similar techniques when engaging with new science content in an academic setting. This experience provided teachers with firsthand insight into the challenges MLs face and the importance of integrating visual and contextual supports to enhance student learning.

Linguistic Pattern Recognition and Cognates

Some participants also attempted to decode Polish words by recognizing familiar patterns, such as prefixes, phonetics, or cognates. One teacher noted, “The prefix of ‘nie’—knowing this meant ‘not’—helped me understand the meaning of some words,” while another said, “I used cognates. For example, the word ‘characteristic’ was very similar in Polish.” These strategies align with research on cognate awareness (Nagy et al., 1993) and highlight the value of explicit instruction in cognates for MLs in content areas.

LIPD with Linguistic Support

The second part of the language immersion experience introduced structured linguistic supports, allowing participants to experience firsthand how instructional accommodations impact multilingual learners’ (MLs) comprehension, confidence, and overall engagement in science education. Compared to Lesson 1, where participants struggled with frustration, anxiety, and cognitive overload, Lesson 2 incorporated scaffolds such as bilingual glossaries, translated materials, visuals, and slowed-down speech, significantly improving participants' experiences. Participants reported feeling more supported and less stressed in Lesson 2, with one noting, "I felt more confident in taking risks to understand the lesson." Others echoed this sentiment, explaining that the presence of visual aids, repetition, and translated materials helped clarify the lesson's objectives and instructions. These findings align with research indicating that linguistic supports are essential for reducing cognitive overload and increasing engagement in MLs (Zhang, 2022). Moreover, participants were more engaged and collaborative, often working in pairs and using resources such as bilingual dictionaries to complete their tasks. The lesson structure encouraged participation, reinforcing the idea that linguistic support enhances comprehension and promotes active learning and engagement (Llosa et al., 2016).

The Role of Instructional Scaffolds in Science Learning

Participants emphasized the effectiveness of bilingual glossaries, translated vocabulary lists, and visual aids in determining lesson objectives. Many teachers found that presenting objectives in both Polish and English provided immediate clarity, while others relied on visuals and prior knowledge to establish the lesson's focus. This aligns with research suggesting that multimodal instruction, which integrates text, visuals, and translation, enhances content comprehension for multilingual learners (Jaray-Benn, 2019). Key supports identified by participants included bilingual glossaries with direct translations of science terminology, visual aids such as diagrams and T-charts for organizing concepts, slower-paced instruction with repeated key terms to ease language processing, and peer collaboration to facilitate shared understanding. These strategies reflect research on scaffolded instruction, which emphasizes that linguistic support fosters student autonomy and content mastery (Lee et al., 2022).

Shifts in Teacher Perceptions and Confidence

Compared to Lesson 1, where participants experienced overwhelming frustration, Lesson 2 fostered a noticeable increase in confidence and willingness to participate. Many educators felt more relaxed and engaged, with one stating, "I felt less confused and stressed." Others highlighted that translations and visual cues reduced the fear of making mistakes, which aligns with research indicating that linguistic scaffolds help mitigate language-related anxiety in MLs (Llosa et al., 2016). Several participants also noted that the facilitator's approach, speaking more slowly, repeating key phrases, and offering bilingual translations, made the lesson significantly more accessible. This mirrors best practices in ML instruction, which advocate for clear, structured input that gradually builds student comprehension (Lee et al., 2022).

Empathy and Professional Growth Through Reflection

Participants' reflections in Lesson 2 revealed a deeper awareness of how linguistic supports influence MLs' learning experiences. Many teachers recognized the challenges MLs face when linguistic support is absent, but more importantly, they began critically considering how they could integrate similar scaffolds into their classrooms. This process aligns with Mezirow's (1991) Transformative Learning Theory, which posits that educators undergo significant perspective shifts when confronted with disorienting experiences that challenge their assumptions. As teachers engaged in reflection, they developed greater empathy for MLs and reconsidered their instructional practices, recognizing the importance of proactive linguistic support in fostering equitable learning environments. Observations during the lesson reinforced these insights as teachers engaged more actively, collaborated with peers, and made use of translation tools. Their increased engagement demonstrated the power of linguistic scaffolds in fostering meaningful learning experiences, further supporting the need for experiential professional development for science educators (Ajani, 2023).

The introduction of linguistic support in Lesson 2 significantly transformed participants' experiences, engagement levels, and overall confidence in navigating content in a second language. These findings underscore the importance of bilingual glossaries, visuals, and scaffolded instruction in reducing stress and improving comprehension for MLs. Furthermore, the integration of reflective practices within the professional development experience allowed teachers to internalize the challenges MLs face, reinforcing the need for structured linguistic accommodations in science instruction.

These reflections reinforced the necessity of professional development that equipped teachers with strategies to support MLs, ensuring that language served as a bridge to deeper engagement and understanding rather than a barrier to learning. This experience underscored the critical need for professional development that helped science teachers cultivate empathy for multilingual learners while equipping them with effective instructional strategies. By immersing themselves in the challenges ELLs face, teachers developed a deeper appreciation for the importance of scaffolding instruction, integrating language supports, and utilizing hands-on, inquiry-based approaches. These strategies helped make science learning more accessible, engaging, and meaningful for all students.

The Role of Professional Development in Transforming Teaching Practices

While the language immersion experience heightened teachers' awareness of the cognitive and emotional challenges multilingual learners (MLs) face, ongoing professional development (PD) was essential in transforming that awareness into sustained instructional change. The PD extended seven months, incorporating check-in sessions after each Phase II task.

These sessions focused on structured reflection, lesson plan adaptations, and discussions on research-based ML instruction. Through this process, teachers had multiple opportunities to revisit their immersion experience, analyze student learning challenges, and implement targeted instructional strategies in their classrooms.

The findings suggest that, while impactful, immersion alone was insufficient to drive long-term pedagogical shifts. Instead, structured reflection, collaborative discussions, and targeted instructional strategies played a critical role in helping teachers bridge the gap between empathy and action. Instead, structured reflection, collaborative discussions, and targeted instructional strategies played a critical role in helping teachers bridge the gap between empathy and action. The second Polish-language science lesson, which incorporated bilingual glossaries, labeled visuals, slower speech, and repeated key terms, starkly contrasted teachers' initial experience of learning without linguistic support. Participants described a noticeable difference in their comprehension and engagement, emphasizing how these scaffolds alleviated their anxiety. One teacher reflected, “Having the keywords in both languages made all the difference, I could actually follow along.” Another participant observed, “The visuals helped a lot. I didn’t feel as lost, and I wasn’t just guessing.” This shift reinforced the importance of explicit scaffolding in content instruction.

Many teachers recognized the effectiveness of these supports and began reflecting on how to integrate similar strategies into their classrooms. A participant shared, “I never thought about using word banks before, but now I see how much it helps.” Through these sustained PD sessions, teachers engaged in structured reflection, lesson plan adaptations, and discussions on research-based ML instruction. As a result, key instructional shifts emerged, including increased use of visuals and multimodal instruction, intentional incorporation of bilingual glossaries and translations to support academic and vocabulary acquisition, and adjustments to pacing and repetition to account for MLs' cognitive load. These findings highlight that immersion alone is not enough; while it served as a disorienting dilemma that cultivated empathy, aligning with Mezirow's (1991) Transformational Learning Theory, it was the structured reflection and pedagogical training that enabled teachers to translate their empathy into concrete instructional change. Mrs. Ramirez candidly stated:

> I used to assume my ELLs would eventually get it. Now I know they need a lot of support, and it's my responsibility to provide it for them. This takes a lot of planning and preparation on my part, but they deserve every opportunity to be successful in my science class.

Creating More Inclusive Learning Environments

The third research question examines how language immersion and professional development work together to create more inclusive science classrooms. As teachers continued to reflect on their experiences and engage in ongoing PD, they moved beyond isolated scaffolding strategies and began reconsidering their broader approach to instruction, assessment, and student engagement. This transformation resulted in three key instructional shifts. First, teachers began incorporating culturally responsive teaching practices, integrating students' linguistic and cultural backgrounds into science instruction rather than viewing them as barriers. Mr. Parker shared, "I used to think that speaking to them only in English would help them understand the content, but now I realize that incorporating words in their language can support their comprehension and engagement." Second, they adopted more structured peer collaboration strategies, recognizing that MLs benefit from working with supportive classmates and engaging in both their home language and English to enhance comprehension. Ms. Caldwell noted, "I pair my ELLs with bilingual peers. It makes a difference in their participation." Third, teachers revised their assessment practices, shifting away from language-heavy tests toward more inclusive, multimodal approaches that allowed MLs to demonstrate scientific knowledge through visual models, oral explanations, and scaffolded writing prompts. Ms. Caldwell shared, "I realized my tests were really testing English, not science. Now I let students explain their answers verbally or use diagrams." These instructional changes reflect a more profound commitment to creating learning environments where MLs can engage equitably with science content.

Connecting Phase II Findings to Transformational Learning Theory

These findings illustrate how immersive experiences and structured reflection can drive meaningful change in educators' perspectives and instructional practices. Mezirow's (1991) Transformational Learning Theory suggests that deep learning occurs when individuals critically examine their assumptions, shift perspectives, and apply new understandings to practice. In this study, the immersion experience functioned as a catalyst, creating a disorienting dilemma that forced teachers to confront the realities of MLs' struggles. However, a more profound transformation occurred through structured reflection and ongoing PD as teachers critically evaluated their instructional methods. As Ms. Caldwell noted, "Before, I never thought about how lost my students felt. Now, I catch myself thinking, what supports would I need if I were them?"

Ultimately, this study underscores the importance of a comprehensive, sustained approach to professional learning. Teachers not only gained a deeper awareness of MLs' challenges but also developed the instructional expertise necessary to create more inclusive and equitable science classrooms. By combining experiential learning, critical reflection, and pedagogical training, this study demonstrates that transformative learning is possible when teachers are given the tools, time, and support to reflect on their practice and make meaningful changes. Through this process, educators became more empathetic, reflective, and committed to fostering inclusive science instruction for multilingual learners. As a LIPD participant shared, “All teachers in this district should be required to take part of these PDs. We all have ELLs in our classrooms and after this experience, it has made me rethink how I teach every day.”

Phase I Participants complete The Perspective and Preparation for Teaching MLs survey
Phase II Participants experience Language Immersion PD with and without Language Supports
Phase III Participants undergo Targeted Continuous PD facilitated by the researcher

Phase III

Article Reflections

Participants engaged in an article-based reflection exercise focusing on evidence-based strategies for supporting multilingual learners (MLs) in academic settings. The article emphasized scaffolding, cultural awareness, and fostering inclusive learning communities, prompting participants to critically analyze their instructional practices and reflect on MLs' challenges. Their responses illustrate the transformative learning process as they reconsidered assumptions, teaching methods, and strategies for effectively engaging MLs. Research supports the use of structured reflection as a powerful tool for teacher learning and professional growth (Farrell & Macapinlac, 2021). In phenomenological studies, written reflections provide insight into teachers' evolving perspectives and instructional shifts (Kuiper, 2017). By analyzing participants' reflections, this study captures how educators integrate theoretical knowledge into practice and develop a deeper awareness of MLs' needs.

Key Takeaways

Participants identified several key ideas that resonated with them, particularly regarding integrating students' native languages, deepening awareness of MLs' challenges, teacher readiness and professional development, effective strategies for supporting MLs, identifying areas for growth in ML instruction, and the importance of culturally responsive teaching.

Valuing Students' Native Languages

One major theme that emerged was valuing students' native languages. Participants recognized that creating space for students' native languages positively impacts their academic development. Research indicates that validating students' home languages and cultures benefits their social-emotional well-being, instills confidence, and nurtures risk-taking in learning environments (Echevarria et al., 2011). Additionally, embracing students' native languages supports bilingualism, preserves cultural identity, and strengthens overall academic literacy. Participants emphasized the importance of actively integrating students' native languages into classroom activities to foster a more inclusive and effective learning environment.

Culturally Responsive Teaching

Participants also highlighted the need for culturally responsive teaching by incorporating students' backgrounds, life experiences, and linguistic strengths into the curriculum. This aligns with culturally responsive teaching frameworks, which emphasize that validating students' cultural identities fosters higher engagement and academic success (Gay, 2018; Nieto, 2013).

Deepening Awareness of MLs' Challenges

Additionally, the article prompted participants to critically examine systemic challenges MLs face, including reading comprehension difficulties, language acquisition barriers, and the social-emotional impact of learning a new language. Recognizing these challenges reinforced the need for teacher readiness and professional development.

Teacher Readiness and Professional Development

Many participants acknowledged that they lacked sufficient training in language acquisition and bilingual education, a concern well-documented in research. de Jong and Harper (2005) note that mainstream teachers often receive little preparation for working with MLs. Darling-Hammond et al. (2002) highlight that teacher preparation programs vary widely in their effectiveness in preparing educators for diverse classrooms. Ms. Caldwell stated, "I have so much to learn and to grow as a teacher to help MLs learn science better," reflecting a common concern among science educators. Research further supports that many teachers feel underprepared to teach MLs due to limited coursework on bilingual education (Durgunoğlu & Hughes, 2010).

Effective Strategies for Supporting MLs

As part of their reflections, participants identified effective strategies for supporting MLs. One commonly mentioned strategy was incorporating culturally relevant content. For example, Mrs. Ramirez noted that decorating classrooms with historical figures from diverse backgrounds and using math problems related to students' countries of origin can make MLs feel valued and included. This aligns with culturally sustaining pedagogy, which suggests that representation in the curriculum strengthens students' sense of belonging and engagement (Paris & Alim, 2017). Another key strategy identified was the use of scaffolded assessments, including group tests, projects, and lab-based learning, to allow MLs to demonstrate knowledge beyond traditional written exams. Research confirms that alternative assessments improve MLs' ability to showcase their learning while reducing language-related barriers (Gottlieb, 2021).

Additionally, bilingual and multimodal instruction was highlighted as essential for ML success. Mrs. Ramirez emphasized the importance of providing content-specific texts in both

English and students' native languages to support comprehension and literacy development. Studies show that bilingual instructional approaches enhance MLs' academic achievement by allowing them to draw on their home language as a resource (Echevarria et al., 2011).

Co-Teaching and Collaboration Challenges

When reflecting on areas for growth in ML instruction, participants discussed challenges such as co-teaching and collaboration. Mr. Parker noted that effective co-teaching requires both content teachers and language support teachers to understand and communicate content and language development strategies, a challenge noted by Honigsfeld and Dove (2019).

Structural Barriers in Secondary Education

Ms. Caldwell, who teaches at the high school level, questioned whether stretching regents-level courses over two years would provide better outcomes for MLs. Research suggests that providing extended instructional time allows MLs to acquire academic English while keeping up with content learning (Goldenberg, 2008). These reflections indicate that while teachers are eager to improve ML instruction, structural barriers within secondary education must be addressed to support MLs effectively.

Unanswered Questions and Areas for Further Inquiry

The article also raised several unanswered questions that participants felt required further inquiry. One major concern was institutional support for MLs. Mr. Parker asked, "Why is a district with a large ENL population not doing more to educate teachers on effective instructional strategies?" This frustration aligns with research showing that many districts fail to provide adequate professional development for ML instruction (Walker et al., 2004). Ms. Caldwell questioned the lack of quantitative data in the article regarding how high-quality instruction impacts MLs' academic performance, reflecting that broader research calls for more empirical studies on the effectiveness of ML teaching strategies (Samson & Collins, 2012). Lastly, Ms. Caldwell, who teaches high school science, inquired whether MLs should be taught in both English and their home language to better prepare them for standardized exams. This inquiry reflects ongoing debates in bilingual education, where translanguaging has been shown to support MLs' academic success (García & Kleifgen, 2018).

Through this reflective exercise, participants deepened their understanding of ML instruction, recognized the gaps in their professional development, and explored effective strategies for supporting MLs. Their reflections illustrate the transformative potential of structured reflection in reshaping instructional practices and fostering culturally and linguistically inclusive classrooms.

Video Reflections

Video-elicited reflection is a qualitative research method that utilizes video recordings as stimuli to provoke participants' reflections, thereby generating rich, contextualized data about their experiences and perceptions. This approach has been shown to enhance teachers' reflective practices in educational settings. For instance, a study by González (2017) examined how video-elicited reflection mediated teacher candidates' understanding of pedagogy, highlighting its effectiveness in teacher preparation programs. Participants watched and reflected on a video interview with former multilingual learners (MLs) who shared their educational journeys, the challenges they encountered in science classrooms, and their eventual pursuit of careers in STEM fields. These reflections served as a transformative learning experience, prompting teachers to critically analyze the emotional, linguistic, and academic barriers that MLs encounter. The reflections demonstrated a shift in participants' perspectives, reinforcing their commitment to fostering inclusive, culturally responsive, and linguistically supportive science learning environments.

The Role of Video Reflections in Transformative Learning

Mezirow's (1991) Transformative Learning Theory suggests that disorienting dilemmas, moments when individuals confront perspectives that challenge their existing beliefs, can lead to deep reflection and change. Watching former MLs describe their struggles in science classrooms served as an additional disorienting experience, compelling participants to critically evaluate their own instructional practices.

Participant reflections highlight how the video deepened their awareness of MLs' emotional and cognitive struggles. Mrs. Ramirez noted, "This video reminded me that many ENL students come to our district without having mastered their own language, let alone understanding anything in English, especially science terminology." This recognition aligns with research indicating that many MLs face the dual challenge of acquiring English proficiency while simultaneously building academic literacy in content areas such as science (Echevarria et al., 2011). Ms. Caldwell reflected on how MLs often enter a "fight or flight" state of learning, constantly navigating a sense of survival in classrooms where instruction is delivered in an unfamiliar language. Such emotional and cognitive overload can significantly impact academic engagement and confidence, reinforcing the need for empathetic and structured instructional support (Zhang, 2022).

The Influence of Science Teachers on MLs' Academic and Career Pathways

A central theme that emerged from the reflections was the profound impact that science teachers had on the former MLs' academic journeys and career choices. Participants noted that the former MLs credited their science teachers for creating a welcoming classroom environment, providing individualized support, and fostering a love for science. This aligns with research suggesting that positive student-teacher relationships play a critical role in shaping MLs' academic self-concept and motivation to pursue STEM fields (Lee et al., 2013).

Mr. Parker observed, "Without a doubt, the young ladies being interviewed would not have chosen their current careers if they had not had a teacher who made them love science and who cared about them." Mrs. Ramirez reflected on the emotional connections MLs formed with their teachers, emphasizing that "many times, it is not precisely what the teacher said, but how it is said" that makes a difference in student engagement. This reinforces the importance of culturally responsive teaching, which prioritizes relational teaching, student empowerment, and linguistic inclusivity (Ladson-Billings, 2009).

Lesson Plan Edits

The participants revised an existing science lesson plan to incorporate strategies that address the linguistic and academic needs of multilingual learners (MLs). The changes they made, such as adding bilingual glossaries, visual aids, collaborative activities, and inquiry-based instruction, demonstrated how their reflective insights translated into actionable teaching practices. These revisions illustrate teachers' growing commitment to inclusivity and their understanding of how to scaffold science content for MLs.

The process of revising lesson plans can be understood through the lens of Transformative Learning Theory, which posits that critical reflection on prior assumptions and new experiences can lead to profound shifts in beliefs and instructional practices (Mezirow, 1991). In this part of the study, the act of modifying lesson plans encouraged teachers to critically evaluate their existing approaches, recognize the barriers MLs face in science education, and implement research-based strategies to create a more equitable learning environment. Koubek and Wasta (2023) found that preservice teachers engaged in action research developed a deeper awareness of equitable teaching practices, demonstrating the power of reflection in shaping inclusive instruction. Similarly, the modifications made by participants in this study exemplify the transformational process of moving from awareness to action as teachers incorporated research-supported strategies to enhance accessibility and engagement for MLs.

The lesson plan revisions align with research on culturally responsive teaching, differentiated instruction, and effective science pedagogy for MLs. The Sheltered Instruction Observation Protocol (SIOP) model provides a framework for integrating language development with content instruction, demonstrating that structured language support improves science achievement for MLs (Echevarria et al., 2006). Additionally, inquiry-based learning, where students actively explore scientific concepts through hands-on activities, has increased engagement and deepened conceptual understanding for MLs by providing contextual learning experiences that support both language acquisition and scientific literacy (Jiang & McComas, 2015). These research-backed strategies provided a foundation for teachers' lesson revisions, fostering instructional approaches that integrate both content mastery and linguistic development.

Participant responses reinforced these findings. Mr. Parker incorporated a bilingual glossary with English-to-Spanish translations and labeled images to help students grasp key vocabulary in an ecosystem unit. Research indicates that bilingual glossaries improve scientific vocabulary retention and concept comprehension among MLs (Buxton & Caswell, 2020). Mrs. Ramirez emphasized the importance of peer collaboration and translated vocabulary lists, aligning with studies showing that peer-assisted learning enhances language acquisition and content mastery in science classrooms (Lee et al., 2013).

Furthermore, Ms. Caldwell suggested incorporating real-world data and graph analysis to help students develop critical thinking and data interpretation skills in science. This aligns with research demonstrating that scaffolded data interpretation activities support MLs in making evidence-based scientific claims and improve their ability to engage in scientific discourse (Januszyk et al., 2016). Mrs. Ramirez proposed using video clips and labeled diagrams to reinforce content visually, a strategy supported by studies showing that multimodal learning—integrating images, videos, and text—enhances science comprehension and language acquisition for MLs (Nam & Cho, 2016).

Additionally, language objectives were integrated into science instruction in teachers' modifications. The National Science Teachers Association (NSTA) emphasizes that embedding language development into science lessons ensures that both linguistic and content goals are met, fostering greater scientific literacy among MLs (NSTA, 2020). As suggested by participants, using sentence stems, guided discussions, and structured writing prompts aligns with research indicating that explicit language instruction within science supports MLs in developing academic language and scientific reasoning skills (Lee et al., 2022).

Through the transformative learning process, teachers moved beyond simply recognizing the challenges MLs face to actively restructuring their instructional approaches to create more accessible and linguistically inclusive science education experiences. Mezirow (1991) describes perspective transformation as a process in which individuals critically reflect on their prior knowledge, recognize limitations, and implement new ways of thinking and acting. As Ms. Caldwell shared:

> Before this PD, I assumed ELLs just needed more time to understand concepts, but now I realize that the way I structure my lessons can make or break their success. I didn't fully

> grasp how much I needed to change my own approach until I saw the difference in the small adjustments, I can make in my lesson plans to better support the students.

This part of the study's findings illustrates this transformation in practice, as teachers revised lesson plans to accommodate MLs and enhance their pedagogical expertise in science education.

Exit Interviews: Transformational Learning Reflections

The exit interview (Appendix K) provided rich evidence of participants' transformative learning experiences, aligning with Mezirow's (1991) framework. Educators demonstrated shifts in perception, the adoption of culturally and linguistically responsive strategies, and a commitment to continued professional growth. Through critical reflection and applied practice, participants expressed a deeper understanding of multilingual learners' (MLs) challenges and made significant instructional adaptations to foster inclusivity in science education.

Development of Empathy

Language immersion served as a powerful empathy-building tool by allowing participants to personally experience the frustration, confusion, and cognitive overload that multilingual learners (MLs) often endure in science classrooms. This experience forced them to reflect on the barriers MLs face daily and consider how instructional strategies could be adjusted to alleviate these struggles. Mrs. Ramirez reflected on the emotional and cognitive demands of this experience:

> There is an emotional element of powerlessness and confusion when you don't understand a language. Recognizing these feelings helped me think intently as to what could possibly become a barrier during instruction so that students are not constantly in a state of confusion.

Shifts in Perception and Understanding

A critical element of transformative learning is experiencing a disorienting dilemma that challenges prior assumptions (Mezirow, 1991). Participants described moments of realization regarding the academic and emotional struggles of MLs in science classrooms. Mr. Parker acknowledged:

> This PD has really helped me understand how hard it is to be an ELL student in a non-ELL classroom. I have heard students say they felt isolated, lost, confused, and embarrassed to ask questions.

Reevaluating MLs' Abilities and Potential

One of the most significant transformations occurred in how participants viewed MLs' academic capabilities. Mr. Parker acknowledged that MLs often face dual challenges—not only learning science content but also navigating an entirely new language:

> This PD has helped me see that many of the ELL students have the potential to be very strong science students if the science teacher finds ways to include them in the lessons and connect with them on a social level.

Mrs. Ramirez reinforced the belief that MLs have the right to learn and that educators must actively remove barriers to ensure equitable access: "It reinforces the belief that students not only have the right to learn but that there are many methods we can try to maximize learning." These reflections highlight a shift from a deficit-based perspective to an asset-based approach, aligning with research on culturally responsive science instruction (Buxton & Caswell, 2020).

Instructional Adaptations for Inclusivity

Participants made substantial changes to their lesson planning and instructional materials to better support multilingual learners (MLs). A comparison of early and later lesson plans revealed a marked increase in scaffolding techniques, reflecting a shift toward more linguistically responsive instruction. Mr. Parker described how their approach evolved over time:

> My lesson plans in September barely touched upon ENL students. Now my plans include glossaries, translations of worksheets, and YouTube videos with language options so my ELL students can follow along.

Mrs. Ramirez emphasized the importance of reducing teacher talk time and incorporating multimodal supports to enhance accessibility:

> I try as much as possible to limit the amount of time I am talking, making sure instructions and activities include visuals and incorporating peer discussions to allow the ENLs to collaborate in their home language.

These adaptations align with research emphasizing the effectiveness of scaffolding strategies, such as visual aids, peer collaboration, and translanguaging, in supporting MLs' comprehension and engagement (Buxton & Caswell, 2020; Echevarria et al., 2011).

A deliberate effort to incorporate culturally relevant examples also emerged as a recurring theme. Participants recognized that connecting scientific concepts to students' lived experiences fosters engagement and deepens understanding:

> I've tried to include examples of volcanoes from Latin America or other culturally relevant topics to help make a connection and engage students. If we speak about plants, I add examples from their home countries. (Ms. Caldwell)

Mr. Parker reflected on a shift in their vocabulary instruction, moving from an assumption that students would absorb new terms naturally to a more intentional, structured approach:

> I used to assume that all students could just pick up the vocabulary as we went along. Now, I pre-teach key terms using visuals, bilingual glossaries, and student-

> friendly definitions. It has made a huge difference; my MLs are more engaged and contribute more to class discussions.

In addition to modifying lesson delivery, participants also adapted their assessment strategies to provide MLs with multiple avenues to demonstrate understanding:

> I started allowing my ELLs to demonstrate their understanding in different ways, drawing diagrams or explaining in their home language before translating to English. I realized that their science knowledge was much stronger than I had assumed when I only looked at written responses. (Ms. Caldwell)

These instructional shifts illustrate a key tenet of transformative learning: deep reflection leading to meaningful, sustained changes in practice (Kitchenham, 2008). The findings align with Collier and Thomas' (2002) research, which emphasizes that linguistically responsive instruction significantly enhances MLs' academic performance by reducing linguistic barriers while maintaining cognitive rigor.

Moreover, these adaptations reflect established best practices in science education for MLs, emphasizing the importance of multimodal instruction, explicit language support, and the integration of students' cultural backgrounds into learning experiences (Echevarria et al., 2011; Lee & Buxton, 2013). By adopting these inclusive strategies, participants demonstrated a commitment to fostering equitable learning environments where all students, regardless of language background, can effectively access and engage with science content.

Commitment to Continued Growth and Advocacy

A defining characteristic of transformative learning is sustained change beyond the initial learning experience (Kitchenham, 2008). Participants expressed a commitment to continuing their personal and professional development:

Mr. Parker shared:

> I plan on continuing my personal education in the Spanish language, hoping to become somewhat fluent so I can continue to foster relationships with my future ELL students.

Mrs. Ramirez reflected:

> Each lesson is a learning process. I plan on building upon my lessons, looking at what works and implementing those strategies to better support my ELLs." "Last year I had a student who spoke Urdu. I tried my best to support her linguistically but felt that I needed to do more. After this PD, I am committed to learning my students' language at least for basic communication and translating materials into their home language.

Ms. Caldwell noted:

> I plan to collaborate with other teachers who speak another language, try to learn bits of other languages myself, and keep myself humble about how challenging it can be.

These reflections reinforce the idea that transformative learning is an ongoing process, requiring continuous self-reflection and adaptation (Mezirow, 2003).

The exit interviews provide compelling evidence of transformative learning among participants. The findings reveal a clear progression from initial disorienting dilemmas to critical reflection and sustained changes in instructional practices and professional commitments. The PD program successfully fostered a shift in perceptions, the adoption of linguistically and culturally responsive strategies, and a commitment to continued advocacy for MLs. These reflections align with existing research on transformative learning in teacher education (Bell et al., 2016; Mezirow, 2003) and underscore the importance of immersive and experiential learning in shaping educators' beliefs and actions. Participants' reflections suggest that transformative learning is not a one-time event but an ongoing process with lasting implications for their teaching and their students' success.

Empathy, Reflection, and Action: Unpacking Science Teachers' Transformational Shifts

The findings of this study reveal a dynamic process in which science teachers moved beyond initial empathy toward meaningful instructional transformation. The language immersion experience elicited strong emotional and cognitive reactions, often mirroring the challenges faced by multilingual learners (MLs). However, empathy alone was not enough; structured reflection and ongoing professional development played a critical role in guiding teachers to rethink their instructional approaches and adopt more inclusive strategies. As they progressed, teachers shifted their perceptions of MLs' abilities, integrated scaffolding techniques, and embraced multilingual support strategies to enhance student learning. Despite these advancements, they also encountered barriers to implementation, which underscored the need for institutional support and a sustained commitment to equity and advocacy. The following sections explore these emerging themes, illustrating the key transformations that took place throughout the study.

Cognitive and Emotional Impact of Language Immersion

The language immersion experience served as a disorienting dilemma, forcing teachers to confront the cognitive and emotional challenges that multilingual learners (MLs) experience daily. Participants described feelings of frustration, anxiety, and cognitive overload, mirroring the struggles of MLs navigating science content in an unfamiliar language. Many reported experiencing mental fatigue, disengagement, and self-doubt, reinforcing the importance of linguistic scaffolds in instruction.

One participant reflected, “I couldn’t understand anything, and I eventually just tuned out. I realized this is exactly what happens to my students when I don’t provide support.” This realization aligned with Mezirow’s (1991) assertion that perspective shifts occur when individuals critically reflect on disorienting experiences. Teachers who initially underestimated the linguistic barriers MLs face acknowledged the need for explicit instructional support to reduce cognitive overload and promote engagement.

From Awareness to Action: The Role of Reflection

While the immersion experience heightened teachers' awareness of MLs' challenges, structured reflection and professional development (PD) translated this awareness into instructional change. Empathy alone was not sufficient; teachers needed opportunities to analyze, discuss, and apply strategies to rethink their instructional approaches.

Participants engaged in video-elicited reflections, reviewing their experiences and discussing effective strategies for supporting MLs. Teachers identified gaps in their previous teaching methods through these discussions and explored research-based approaches to make science content more accessible. One participant shared, "I knew my ELLs struggled, but I didn't fully understand how overwhelming it was until I listened to the former ELLs tell their story. Listening to their stories was powerful." (Mr. Parker)

This finding aligns with research emphasizing that transformational learning requires critical reflection and sustained professional development (Taylor, 2017). Teachers who engaged in structured reflection were more likely to modify their instructional practices in meaningful ways, rather than making surface-level adjustments.

Shifting Perspectives on MLs' Potential

Initially, some teachers viewed MLs' language barriers as deficits, often associating silence or disengagement with a lack of effort or understanding. However, as they reflected on their immersion experiences and engaged in research on language acquisition, they began to recognize MLs' linguistic assets rather than focusing solely on limitations. One LIPD participant admitted, "Before, I assumed students weren't trying hard enough when they didn't participate. Now, I realize they might just need more processing time or a way to express themselves in their home language."

This shift aligns with asset-based pedagogies, which emphasize leveraging students' linguistic and cultural knowledge as strengths rather than obstacles (Bonilla & Morales-Doyle, 2024). As teachers developed a better understanding of bilingualism and language acquisition, they expressed a greater willingness to incorporate students' home languages into their instruction, recognizing that linguistic diversity enriches the learning environment rather than hindering progress.

Scaffolding and Differentiation in Science Instruction

Following the immersion experience and PD sessions, teachers adopted more structured scaffolding techniques to support MLs in science instruction. Many emphasized visual aids, bilingual glossaries, slower pacing, and repetition as key strategies to reduce MLs' cognitive load while maintaining academic rigor. For instance, Mr. Parker shared, "I started using labeled diagrams and bilingual word banks to support vocabulary development, and I noticed my ELLs engaging more with the content." Mrs. Ramirez implemented sentence frames and structured group discussions, allowing MLs to participate in scientific discourse without the pressure of perfect English proficiency.

These strategies align with research on scaffolded instruction, which highlights the importance of providing multiple entry points for language and content acquisition (Echevarria et al., 2011). Teachers who initially relied on simplified content shifted toward differentiated instruction, ensuring that MLs had access to grade-level science concepts with appropriate linguistic support.

Inquiry-Based Learning as a Language-Supportive Strategy

Many participants moved beyond rote memorization and teacher-centered instruction, incorporating hands-on, inquiry-driven activities that provided MLs with opportunities to engage in scientific exploration while developing language skills. Ms. Caldwell reflected, “I used to think ELLs needed direct instruction and simplified content to succeed. Now, I see that when they engage in hands-on investigations, they naturally develop the language of science through collaboration.” This approach aligns with research on science as a context for language development, demonstrating that interactive, student-centered learning environments support both content mastery and language acquisition (Lee et al., 2022). By allowing MLs to actively engage in scientific inquiry, teachers observed increased student participation, collaboration, and conceptual understanding, reinforcing the importance of multimodal learning experiences in science education.

Translanguaging and Multilingual Support

A major instructional shift involved embracing translanguaging strategies, moving away from the belief that English-only instruction was the best approach. Many teachers began incorporating dual-language word banks, peer-based language support, and home-language discussions to bridge MLs’ understanding of scientific concepts. Ms. Caldwell explained, “I now encourage students to discuss ideas in their home language before expressing them in English, and I've seen a big difference in their confidence and comprehension." This aligns with research showing that translanguaging enhances MLs' engagement, critical thinking, and comprehension (Karlsson et al., 2019).

Barriers to Implementation

Despite meaningful instructional shifts, teachers faced systemic challenges that hindered the full integration of ML-inclusive strategies. Time constraints, lack of administrative support, and standardized testing pressures were cited as major obstacles to sustaining equitable teaching practices. Ms. Caldwell noted, "I want to use these strategies all the time, but the pressure to cover content quickly and prepare students for state exams makes it difficult." Additionally, some teachers expressed frustration over limited professional development opportunities, emphasizing the need for institutional support to sustain inclusive teaching practices. Others noted that time constraints during the school day limited opportunities for meaningful collaboration with ENL teachers, making it difficult to effectively align instructional strategies and support multilingual learners. These findings align with research indicating that systemic barriers often prevent teachers from fully implementing equity-driven instructional changes (Darling-Hammond et al., 2017). Without policy and administrative backing, sustaining ML-supportive strategies remains a challenge.

Commitment to Equity and Advocacy

Despite these barriers, teachers demonstrated a long-term commitment to improving ML instruction and advocating for systemic change. Many planned to refine their instructional practices, collaborate with colleagues, and engage in ongoing professional growth to better support MLs. Mr. Parker reflected, "This experience changed the way I see my ELLs. I need to plan more intentionally to ensure that all of my students, including my ELLs, receive the best science learning experiences in my class." This response highlights a transformational shift as teachers moved beyond individual classroom adjustments toward broader efforts to promote equity in science education.

Connecting Phases to the Recursive Nature of Transformative Learning

Mezirow's (1991) Transformative Learning Theory is often described as a nonlinear progression through phases, beginning with a disorienting dilemma and moving through self-examination, planning, and action. Rather than following a fixed sequence of phases, learners often revisit stages such as reflection, exploration, and planning as their understanding evolves in response to new experiences (Taylor, 2007). Findings from this study illustrate this recursive process, particularly during Phase III, in which participants engaged in repeated cycles of critical reflection and instructional refinement.

After completing each professional development task, whether the article analysis, video reflection, or lesson plan revision, participants often returned to earlier phases of thinking and planning. These revisitations were not regressions, but clear indicators of ongoing professional growth. Teachers drew on new insights gained from each task to adjust their instructional strategies with greater intentionality, particularly in their efforts to better support multilingual learners. This continuous pattern highlights how professional growth is rarely linear. As participants' empathy and perspective-taking deepened, so did their motivation to refine instruction. Teachers explored new scaffolds and experimented with instructional techniques that more effectively integrated language development and science content. Each cycle of reflection and planning allowed participants to reimagine their roles in the classroom, not solely as content specialists but as advocates for equity, access, and inclusive pedagogy.

Conclusion

The findings of this study illustrate how language immersion, structured reflection, and professional development led to meaningful shifts in teachers' perspectives and instructional practices. Through empathy development, scaffolding techniques, translanguaging strategies, and inquiry-based learning, participants redefined their approach to ML instruction, moving toward more inclusive, linguistically responsive classrooms. However, sustaining these changes requires institutional support, ongoing professional development, and systemic policy changes to ensure that MLs receive equitable access to high-quality science education.

Chapter 5: Discussion, Implications and Conclusion

Introduction

This chapter presents a comprehensive discussion of the study's findings, situating them within the broader field of science education and multilingual learner (ML) instruction. This research aimed to examine how a language immersion experience, combined with ongoing professional development, fosters empathy in science teachers and initiates instructional transformation to better support MLs. By utilizing Mezirow's (1991) Transformational Learning Theory as a conceptual framework, this study explored how experiential learning serves as a catalyst for shifting teachers' perceptions, refining instructional strategies, and advocating for systemic change in science education.

The findings highlight the progression from empathy-building to pedagogical shifts, demonstrating that while immersion experiences play a crucial role in fostering awareness, sustained reflection and professional development are necessary for translating empathy into meaningful instructional change. Teachers who initially perceived themselves as empathetic gained a deeper, more nuanced understanding of the cognitive and emotional barriers MLs face in science classrooms. Their immersion in a linguistically unfamiliar environment prompted perspective shifts that ultimately led to instructional modifications, including the integration of bilingual glossaries, visual scaffolds, and inquiry-based learning strategies tailored to MLs' needs.

This chapter addresses the research questions and discusses their implications for science teacher education, professional development, and policy reform. Additionally, it explores the barriers to implementing empathy-driven, linguistically inclusive science instruction, emphasizing the institutional and systemic changes needed to create equitable learning environments for MLs. Finally, the chapter concludes with recommendations for future research, highlighting opportunities for further exploration into transformative professional development models that bridge science and language instruction. The discussion is structured around the study's three guiding research questions:

1. In what ways can a language immersion experience foster empathy and perspective-taking to initiate the transformation of science teachers' dispositions toward MLs?
2. How does a language immersion experience followed by ongoing focused professional development encourage science teachers to develop empathy and perspective-taking as they reflect on MLs' needs and begin transforming their teaching practices?
3. How does a language immersion experience followed by continuous professional development cultivate empathy and perspective-taking that support the transformation of science teachers' practices to create more inclusive learning environments and better support ML learners?

By framing the discussion through these research questions, this chapter articulates the significance of the study in advancing both STEM education and ML pedagogy, reinforcing the idea that teacher empathy, when coupled with action, has the power to transform science classrooms into equitable, inclusive spaces for all learners.

Research Purpose and Key Findings

This study explored how a language immersion experience and ongoing professional development influenced science teachers' empathy toward multilingual learners (MLs) and shaped their instructional practices. Using Mezirow's (1991) Transformational Learning Theory as a guiding framework, this study examined how educators' perceptions evolved through experiential learning, structured reflection, and pedagogical shifts.

Findings reveal that immersion alone was insufficient to create lasting instructional change; instead, a combination of perspective-taking experiences, guided reflection, and sustained professional development was necessary to translate empathy into action. Initially, teachers self-identified as empathetic, yet their reflections indicated gaps in their understanding of MLs' linguistic and academic challenges. Through the immersion experience, teachers encountered cognitive and emotional overload, mirroring the language barriers, frustration, and disengagement experienced by MLs. However, the subsequent structured professional development, article reflections, video analyses, and lesson plan modification enabled teachers to critically examine their biases, reframe their instructional strategies, and implement research-supported approaches to ML-inclusive science education.

This discussion chapter connects these findings to the research questions and broader literature, emphasizing how science educators' dispositions, reflections, and instructional practices evolved through the transformative learning process.

Fostering Empathy and Shifting Teacher Dispositions

Research Question 1

In what ways can a language immersion experience foster empathy and perspective-taking to initiate the transformation of science teachers' dispositions toward MLs?

The findings demonstrate that immersion in a linguistically unfamiliar environment serves as a catalyst for empathy-building, prompting teachers to reconsider assumptions about language learning and recognize the cognitive and emotional demands placed on MLs in science classrooms. The immersive experience triggered disorienting dilemmas, a key component of Mezirow's (1991) Transformational Learning Theory, which led teachers to critically reflect on their biases, instructional methods, and support strategies for MLs.

Cognitive and Emotional Overload in Language Immersion

During the first phase of the language immersion experience, where science instruction was delivered entirely in Polish without linguistic scaffolds, teachers exhibited cognitive overload, frustration, and disengagement, mirroring the barriers MLs face when learning complex scientific content in a second language. Several teachers described feeling anxious, lost, and overwhelmed, which resulted in withdrawal from the learning experience. One participant shared, “This PD has really helped me understand how hard it is to be an ELL student in a non-ELL classroom. I have heard from students who felt isolated, lost, confused, and embarrassed to ask any questions.” Another teacher described feeling powerless, stating, “Being in a science lesson where the entire lesson was taught in a foreign language taught me how frustrating it can be. I felt like my ELL students.”

The emotional toll of the immersion experience further reinforced the need for compassionate, scaffolded instruction in science education. Teachers experienced firsthand the fear of failure and disengagement that MLs often face, which served as a pivotal moment in their perspective transformation. A teacher acknowledged, “Scaffolds such as graphic organizers need to be explicitly taught and not assumed to be automatically understood—especially for students who are new arrivals or Students with Interrupted Formal Education (SIFE).” These experiences reinforced the necessity of intentional instructional scaffolds to support MLs. One participant explained, “Recognizing these feelings helped me think intently about what could become a barrier during instruction so that students are not constantly in a state of confusion.”

At the end of the PD, one teacher still expressed frustration, reflecting, “Wow, now I know how the ENL kids feel. I need to do better.” This perspective shift marks the beginning of cognitive empathy development, where teachers acknowledged MLs' challenges and recognized their role in alleviating them through instructional modifications.

Coping Strategies for Navigating Unfamiliar Language in Science Learning

Despite the overwhelming cognitive and emotional challenges, participants employed various compensatory strategies, paralleling the adaptive techniques MLs use in science classrooms. Some teachers used Google Translate, while others relied on visuals, gestures, or linguistic pattern recognition (e.g., identifying cognates and prefixes like "nie" to infer meaning). However, teachers quickly realized that these strategies were insufficient in keeping pace with instruction, reinforcing the need for structured language support in science classrooms.

Connecting Findings to the Literature on Empathy Development in Teacher Education

The study's findings align with existing research on empathy development and linguistically inclusive pedagogy, particularly regarding the impact of perspective-taking experiences on teachers' dispositions toward multilingual learners (MLs). Warren (2018) and He et al. (2017) emphasize that immersive experiences, such as language immersion, play a key role in fostering empathy and shifting educators' perspectives. These findings reinforce their assertions by demonstrating that when teachers encounter linguistic and cultural barriers, they become more aware of their students' challenges, motivating them to adopt more inclusive instructional practices. However, as de Jong and Harper (2005) cautioned, empathy alone is not sufficient; it must be accompanied by explicit knowledge of second language acquisition and evidence-based instructional strategies. This underscores the importance of integrating experiential learning opportunities with structured pedagogical training to ensure that teachers translate their empathy into effective classroom practices. Additionally, Transformative Learning Theory (Mezirow, 1991) provides a useful lens for interpreting these findings, as it posits that significant shifts in perspective occur when individuals confront disorienting dilemmas and experiences that challenge their existing beliefs. In the context of teacher education, language immersion serves as such a dilemma, prompting educators to critically reflect on their biases, deepen their empathy, and actively seek instructional approaches that better support MLs (Taylor, 2017).

Structured Professional Development and Transforming Science Instruction for MLs

Research Question 2

How does a language immersion experience followed by ongoing focused professional development encourage science teachers to develop empathy and perspective-taking as they reflect on MLs' needs and begin transforming their teaching practices?

While the initial language immersion experience heightened teachers' awareness of the challenges faced by multilingual learners (MLs), it was the structured professional development that facilitated the transition from empathy to concrete instructional change. Mezirow (1991) asserts that experiential learning alone does not ensure transformation; instead, it must be accompanied by critical reflection, perspective reframing, and action-oriented learning. This study's post-immersion debriefs, video reflections, and article analyses allowed teachers to engage deeply with ML-inclusive teaching strategies, enabling them to move beyond emotional awareness toward proactive instructional shifts.

As teachers reflected on their experiences, they modified their lesson plans to incorporate instructional support that enhanced science accessibility for MLs. Many implemented bilingual glossaries and scaffolded vocabulary instruction to facilitate scientific language acquisition, ensuring students could engage with complex concepts in both their home language and English (Buxton & Caswell, 2020; Gottlieb, 2021). Others adopted multimodal learning strategies, such as visuals, labeled diagrams, and gestures, to reduce cognitive overload and improve comprehension of scientific processes (Ryoo & Bedell, 2017). Additionally, teachers restructured classroom dynamics by incorporating collaborative learning structures, including peer-assisted discussions and inquiry-based exploration, fostering an inclusive science discourse where MLs could actively participate in scientific argumentation (González-Howard et al., 2024; Lee et al., 2013).

These pedagogical shifts illustrate the transformation from passive awareness to active instructional change, reinforcing the role of structured professional development in sustaining long-term impact. Rather than perceiving linguistic diversity as a barrier, teachers began leveraging students' linguistic and cultural assets as integral to scientific learning. This transition aligns with culturally responsive teaching, emphasizing that MLs thrive in environments that validate and incorporate their linguistic backgrounds into the learning process (Gay, 2018; Hernandez & Shroyer, 2017). Ultimately, these findings underscore the necessity of sustained, structured professional development to ensure that teacher empathy evolves into equity-driven pedagogical transformation in science education.

While the language immersion experience served as a catalyst for shifting teacher perspectives, the findings demonstrate that structured professional development was critical in deepening and sustaining instructional transformation. Reflection and guided learning opportunities bridged the gap between heightened empathy and actionable pedagogical change. Through video reflections, article analyses, self-assessments, and iterative lesson plan revisions, teachers engaged in a continuous learning cycle, reassessing their prior assumptions, identifying instructional gaps, and refining their teaching strategies to better support MLs. These findings align with Mezirow's (1991) Transformational Learning Theory, particularly regarding the role of critical reflection in lasting perspective shifts. The data suggests that without ongoing professional development, the impact of language immersion may be temporary, remaining at the level of emotional awareness rather than leading to sustained pedagogical change.

The Role of Structured Reflection in Deepening Empathy and Pedagogical Growth

Research underscores the role of structured reflection in developing cultural competence, deepening teacher empathy, and fostering instructional shifts (Warren, 2018). Video reflections provided teachers with firsthand accounts of MLs' educational experiences, allowing them to connect emotionally and intellectually with the challenges MLs face in science classrooms. These reflections served as "disorienting dilemmas" (Mezirow, 1991), prompting educators to critically examine their biases, instructional approaches, and the systemic barriers MLs encounter in STEM fields. Mrs. Ramirez reflected, "Listening to these former ELL students describe their struggles made me realize that even though I thought I was helping, I wasn't doing enough. I wasn't making my class as accessible as I thought." By hearing from former MLs who overcame language barriers to pursue careers in science, participants recognized the power of teacher influence in shaping students' academic and career trajectories. Many teachers expressed a renewed commitment to fostering an inclusive and supportive science learning environment, aligning with prior research highlighting teacher empathy's role in student engagement and success (Lee & Buxton, 2013; Warren, 2018).

Further, scholars argue that teacher empathy alone is insufficient if not accompanied by shifts in pedagogical practice (Gay, 2018; Lucas et al., 2008). This study affirms that structured PD integrating reflection with instructional redesign is crucial for translating empathetic awareness into equitable teaching strategies.

Article Reflections and Connecting Research to Practice

The article-based reflection exercises provided teachers with opportunities to engage with evidence-based strategies for ML instruction, reinforcing the necessity of linguistic and conceptual scaffolds in science education (Echevarria et al., 2011; Lee et al., 2022). Through these exercises, participants recognized the importance of valuing students' native languages to foster cognitive and linguistic development (Collier & Thomas, 2002). They also acknowledged the critical role of foundational literacy in science comprehension, which underscored the need for explicit vocabulary instruction (Cummins, 2008). Additionally, participants reflected on the impact of culturally responsive teaching in making science more accessible and relevant for MLs, aligning with prior research on equitable instruction (Gay, 2018; Hernandez & Shroyer, 2017). These reflections bridged the gap between theory and practice, enabling teachers to evaluate their current methods and identify areas for growth. Prior research supports this process, indicating that structured reflection activities lead to more adaptive, equity-driven instructional changes (Januszyk et al., 2016).

Lesson Plan Modifications: From Awareness to Action

The most concrete evidence of instructional transformation emerged in the lesson plan revision activity, where participants were tasked with modifying a science lesson to incorporate ML-inclusive strategies. This process reflected their evolving understanding of language scaffolding, multimodal instruction, and inquiry-based learning. Teachers integrated bilingual glossaries and sentence frames, enabling MLs to access scientific vocabulary in their home language while gradually transitioning to English (Buxton & Caswell, 2020). They also implemented visual aids, labeled diagrams, and graphic organizers to reduce linguistic barriers and enhance comprehension (García & Kleifgen, 2018). Collaborative learning structures also became more prevalent as teachers incorporated peer-assisted discussions and inquiry-based activities to foster language-rich science engagement (Lee et al., 2013).

Additionally, teachers explored alternative assessment methods, including project-based evaluations and oral explanations, to provide MLs with opportunities to demonstrate their understanding beyond traditional written exams (Gottlieb, 2021). These modifications illustrate a deliberate shift from awareness to action, ensuring that instructional practices better support the diverse linguistic and academic needs of MLs. These findings align with previous studies on science education for MLs, which argue that science instruction should be structured to build upon students' linguistic strengths rather than penalizing them for language acquisition (Lee et al., 2013).

Connecting Findings to the Literature on Instructional Transformation

These results reinforce existing scholarship on science education for MLs and the role of professional development in fostering instructional change. Lee et al. (2013) argue that content and language learning are mutually reinforcing processes, and this study provides further evidence that teachers must receive explicit training on integrating these elements in STEM instruction. Calderón et al. (2011) also found that ongoing coaching, mentorship, and peer collaboration enhance teachers' ability to implement ML-inclusive strategies. This study's findings confirm that without structured follow-up, immersion experiences may lead to temporary attitudinal shifts rather than sustained instructional change.

Furthermore, these findings contribute to Mezirow's (1991) Transformational Learning Theory by demonstrating that teachers must move through multiple phases of reflection, perspective transformation, and action before lasting change occurs. This study highlights how experiential learning (immersion), guided reflection (video and article analyses), and practical application (lesson revisions) worked together to facilitate meaningful pedagogical transformation.

Research Question 3

How does a language immersion experience followed by continuous professional development cultivate empathy and perspective-taking that support the transformation of science teachers' practices to create more inclusive learning environments and better support ML learners?

While Research Question 2 examined the role of structured professional development in initiating instructional change, this section explores how continuous professional learning and reflection facilitated long-term transformation in teachers' practices. The findings suggest that a one-time professional development (PD) session or language immersion experience is insufficient to produce sustained pedagogical change. Instead, consistent engagement with evidence-based strategies, collaborative learning communities, and experiential reflection supported teachers in embedding ML-inclusive practices into their science instruction.

The results reinforce Mezirow's (1991) Transformational Learning Theory, demonstrating that lasting instructional shifts occur through a cyclical process of perspective transformation, reflection, and repeated application. Additionally, this study's findings align with research emphasizing that high-quality, sustained PD leads to deeper teacher learning, improved instructional practices, and stronger student outcomes (Darling-Hammond et al., 2009; Lee et al., 2022).

From Empathy Awareness to Action-Oriented Instructional Change

The findings indicate that instructional transformation began during the immersion PD, shifting from empathy to action-oriented instructional change. Initially, teachers implemented basic scaffolding strategies, such as sentence frames, bilingual glossaries, and visuals, to support multilingual learners' comprehension. However, their instructional practices evolved as teachers engaged in sustained professional development and ongoing self-reflection. They moved beyond fundamental scaffolds to intentionally designing opportunities that fostered student collaboration, discourse, and engagement.

Furthermore, teachers adopted culturally and linguistically responsive teaching, incorporating students' home languages and cultural knowledge to enhance engagement and understanding. In science education specifically, studies suggest that when teachers engage in meaningful, long-term professional learning that integrates ML-inclusive strategies, they are more likely to implement equitable practices that promote student agency and participation in scientific discourse (Lee et al., 2013). By embedding these instructional shifts into their classrooms, teachers created learning environments that better supported ML learners through inquiry-based learning, language-rich interactions, and equitable access to science practices.

Building Inclusive Learning Environments: Key Instructional Shifts

Over time, teachers moved beyond isolated scaffolding techniques and implemented broader instructional redesigns that cultivated more inclusive science learning environments. The most significant transformations occurred in three key areas. Teachers increasingly integrated translanguaging and multilingual discourse strategies into their classrooms. Early in the PD process, many teachers believed that English-only instruction was the most effective way to support MLs in developing academic language. However, sustained engagement with research on multilingual discourse strategies (Karlsson et al., 2019) led to a fundamental shift in perspective. Teachers began actively encouraging students to use their home languages as a bridge to scientific understanding. This transformation aligns with research demonstrating that translanguaging enhances MLs' comprehension, critical thinking, and engagement in science discussions (Karlsson et al., 2019).

A second major instructional shift was a move from rote memorization to inquiry-based science learning. Early in the study, some teachers expressed concerns that MLs would struggle with open-ended, inquiry-driven tasks due to language barriers. However, through continuous PD, they recognized that inquiry-based learning naturally supports both language and content development (Lee et al., 2022). These findings reinforce research advocating for science as a context for language development, demonstrating that MLs thrive in environments where they can engage in interactive, hands-on scientific inquiry rather than passive content absorption (Lee et al., 2013).

Another major area of instructional change was a shift toward more flexible and culturally responsive assessment practices. Teachers transformed their assessment practices, shifting from traditional, language-heavy exams to more flexible and culturally responsive assessment methods. Initially, many relied on standardized assessments that placed MLs at a disadvantage by emphasizing written English proficiency over conceptual understanding. However, through sustained professional learning and structured reflection, teachers recognized the need for alternative assessment strategies that provided MLs with multiple avenues to demonstrate their scientific knowledge. One of the most significant changes was the integration of multimodal assessments, such as oral explanations, visual models, and interactive presentations, which allowed MLs to showcase their understanding in ways that did not solely rely on their proficiency in written English (Gottlieb, 2021). Teachers also began incorporating group-based assessments, where MLs collaborated with peers to analyze and present scientific findings, fostering both content mastery and language development.

Additionally, many educators implemented scaffolded writing assignments, which included structured sentence starters, guided questions, and bilingual support tools to help MLs articulate their scientific reasoning more effectively (Lee et al., 2022). The transition toward differentiated and culturally responsive assessments aligns with research on equitable assessment practices, which emphasizes that MLs need multiple pathways to demonstrate their scientific reasoning in ways that reflect both their content knowledge and linguistic development (Gottlieb, 2021; Lee et al., 2022).

Connecting Findings to the Literature on Continuous Professional Development

This study reinforces the growing consensus that one-time professional development (PD) sessions are insufficient for producing sustained instructional change, particularly for educators working with MLs. Research indicates that continuous, reflection-based PD is essential for fostering deep shifts in teachers' beliefs and instructional practices (Farrell & Macapinlac, 2021). Teachers require ongoing opportunities to engage with new pedagogical strategies, analyze their effectiveness, and refine their approaches through collaboration and structured reflection. The findings of this study highlight that those who engaged in sustained PD through article analysis, video reflections, collaborative discussions, and refining lesson plans demonstrated more substantial and lasting changes in their instruction than those who participated in only a single training session.

The importance of continuous PD is particularly pronounced in the context of ML instruction, as teaching MLs requires an evolving skill set that integrates linguistic scaffolding, culturally responsive pedagogy, and equitable assessment strategies. Prior research underscores that MLs thrive when teachers implement asset-based approaches that build upon students' linguistic and cultural strengths rather than viewing them as obstacles (Bonilla & Morales-Doyle, 2024). However, such shifts in instructional mindset and practice do not occur overnight. Teachers need structured, long-term professional learning experiences that allow them to internalize ML-inclusive strategies, reflect on their effectiveness, and continuously adjust their instruction to better support diverse learners.

Furthermore, this study aligns with research demonstrating that inquiry-based science instruction provides a powerful framework for supporting MLs' language and content development (Lee et al., 2013; Lee et al., 2022). Science educators who participated in sustained PD were more likely to transition from teacher-centered, rote memorization approaches to student-driven, inquiry-based learning environments that naturally promote language acquisition and scientific reasoning. This shift underscores the need for ongoing PD that helps teachers build confidence in implementing inquiry-based methods while simultaneously addressing the linguistic needs of MLs.

Equally important, this study contributes to research on the role of ongoing PD in fostering equitable assessment practices. Traditional, language-heavy assessments often fail to capture MLs' true understanding of scientific concepts (Gottlieb, 2021; Lee et al., 2022). Teachers who engaged in continuous professional learning were more likely to implement multimodal and scaffolded assessments, allowing MLs to demonstrate their knowledge through oral explanations, visual models, and interactive presentations. This reinforces the idea that effective PD must not only focus on instructional strategies but also equip teachers with the tools to assess MLs in ways that reflect their scientific reasoning and language development.

Overall, this study affirms that continuous professional development is not an optional enhancement but a fundamental necessity for science teachers working with MLs. Without sustained opportunities for reflection, collaboration, and strategy refinement, instructional improvements may remain surface-level and unsustainable. Long-term PD ensures that teachers are equipped to make meaningful, equity-driven changes in their practice, ultimately creating more inclusive and effective science learning environments for MLs.

Implications for Science Education

The findings of this study have significant implications for science education, particularly in fostering more inclusive and equitable learning environments for Multilingual Learners (MLs). As classrooms become increasingly linguistically diverse, science educators must be equipped with the knowledge, strategies, and institutional support necessary to ensure MLs have full access to rigorous and meaningful science learning experiences. This study highlights several key areas where systemic changes are needed to improve science instruction for MLs.

The Necessity of Continuous Professional Development

One of the most critical implications of this study is the need for sustained high-quality professional development (PD) for science teachers working with MLs. Research has consistently shown that one-time PD sessions are insufficient for producing long-term instructional change (Darling-Hammond et al., 2009; Desimone, 2009). Instead, science educators require ongoing opportunities for structured reflection, collaborative learning, and iterative instructional refinement. The findings of this study align with research indicating that teachers who engage in sustained PD are more likely to implement effective, asset-based instructional strategies for MLs, leading to improved student engagement and achievement (Hart & Lee, 2003; Lee et al., 2008).

Science as a Context for Language Development

This study reinforces the idea that science education and language development should not be treated as separate domains but as mutually reinforcing processes (Lee et al., 2013). Inquiry-based science instruction naturally fosters language-rich learning environments where

MLs can simultaneously develop academic discourse, critical thinking, and content mastery (Stoddart et al., 2002). Science educators must be trained to integrate language scaffolds seamlessly into inquiry-based instruction, ensuring that MLs are not merely memorizing scientific terms but actively engaging in scientific discourse, questioning, and problem-solving (Lee et al., 2013). Curriculum developers should embed language development objectives within science education standards rather than relegating them solely to language-focused courses (Lee & Buxton, 2013).

Expanding the Use of Culturally and Linguistically Responsive Teaching Practices

The study underscores the importance of culturally and linguistically responsive teaching (CLRT) in science classrooms (Gay, 2018; Hernandez & Shroyer, 2017). Traditional, one-size-fits-all science instruction often fails to engage MLs, as it does not account for their prior knowledge, linguistic strengths, and cultural perspectives (Collier & Thomas, 2002). Research has demonstrated that when science instruction incorporates students' linguistic and cultural resources, MLs demonstrate greater engagement, confidence, and academic success (González-Howard et al., 2024). Science educators must be encouraged to incorporate diverse examples, connect scientific concepts to students' lived experiences, and highlight contributions from scientists of diverse backgrounds (Buxton & Caswell, 2020). Educational leaders should support this shift by developing curriculum resources that integrate cultural and linguistic diversity into science instruction and by ensuring that science educators have access to ML specialists and co-teaching models that promote equitable instruction (Buxton & Caswell, 2020).

Rethinking Assessment to Promote Equity in Science Learning

Another significant implication of this study is the need for more equitable assessment practices in science education. Traditional, language-heavy assessments often fail to capture

MLs' true understanding of scientific concepts, as they prioritize English proficiency over conceptual knowledge (Gottlieb, 2021; Lee et al., 2022).Teachers who engaged in continuous professional learning were more likely to implement multimodal and scaffolded assessments, allowing MLs to demonstrate their knowledge through oral explanations, visual models, and interactive presentations (Echevarria et al., 2011). Additionally, science educators should receive training in designing assessments that reduce linguistic barriers while maintaining rigorous content standards (Llosa et al., 2016). Districts and state education agencies should review and revise science assessment frameworks at the policy level to accommodate MLs' diverse linguistic backgrounds (NASEM, 2018).

Institutional Support and Systemic Changes

While teacher commitment and instructional change are essential, institutional barriers often hinder implementing ML-inclusive science instruction. This study highlights teachers' ongoing challenges, including time constraints, standardized testing pressures, and limited access to ML specialists. Research has shown that without administrative support, even well-intentioned teachers struggle to implement ML-supportive strategies effectively (Friend et al., 2009). To address these challenges, school administrators and policymakers must actively support teachers by providing resources, reducing the emphasis on high-stakes standardized testing, and integrating ML-supportive strategies into broader educational policies (Harper & de Jong, 2004; Samson & Collins, 2012). Additionally, science teacher preparation programs should include coursework and field experiences that focus on ML-inclusive pedagogy, ensuring that new educators enter the profession with the necessary skills to support linguistically diverse students (Hansen-Thomas et al., 2016; de Jong & Harper, 2005).

Limitations and Future Research Directions

The findings of this study highlight several areas where future research is needed to further advance the understanding of effective science instruction for Multilingual Learners (MLs). While this study provides valuable insights into how language immersion and sustained professional development impact science teachers' instructional practices, additional research is necessary to explore the long-term effects, implementation challenges, and systemic factors that influence sustainable change in ML-inclusive science education.

Impact of Professional Learning Communities (PLCs) and Mentorship

While this study underscores the importance of continuous professional development, more research is needed on the most effective PD models for supporting science teachers working with MLs. Specifically, future studies should investigate how ongoing mentorship, instructional coaching, and participation in Professional Learning Communities (PLCs) influence teachers' ability to sustain ML-inclusive practices (Friend et al., 2009). Understanding how collaborative learning environments shape instructional growth could inform the development of more structured, scalable PD programs for science educators (Hart & Lee, 2003). Research on effective PLC structures, particularly those incorporating ML specialists and peer coaching models, could provide insights into strategies that ensure long-term teacher engagement with inclusive practices (Hansen-Thomas et al., 2016).

Institutional and Policy-Level Barriers to ML-Inclusive Science Education

This study identified systemic challenges, including time constraints, lack of ML specialists, and standardized testing pressures, as a significant obstacles to implementing ML-supportive instruction. Future research should explore how district policies, state educational mandates, and school leadership decisions impact teachers' ability to integrate equitable science teaching practices (Harper & de Jong, 2004; Rutt et al., 2020). Investigating ways to align policy reforms with best practices in ML instruction could lead to more effective strategies for overcoming institutional barriers (Samson & Collins, 2012). Further research could explore how school administrators and policymakers can develop systemic frameworks that provide both material and pedagogical support to science teachers working with MLs (NASEM, 2018).

Equity in Science Assessment for MLs

This study highlights the need for alternative, linguistically inclusive assessment practices in science education. Future research should focus on developing and evaluating equitable assessment models that allow MLs to demonstrate their scientific understanding beyond language proficiency-based measures (Gottlieb, 2021; Lee et al., 2012). Investigating how multimodal assessments, performance-based evaluations, and portfolio assessments impact MLs' science achievement could provide valuable insights into creating more accurate and fair assessment frameworks (Llosa et al., 2016). Research could also explore how standardized science assessments can be modified to accommodate MLs' diverse linguistic abilities while maintaining rigorous content standards (National Academies of Sciences, Engineering, and Medicine, 2018).

Student Perceptions and Learning Experiences

While this study primarily focused on teacher transformation, future research should center on the voices of MLs to better understand their learning experiences, challenges, and engagement in science classrooms. Studies that utilize student surveys, interviews, and classroom observations could provide deeper insights into how instructional modifications impact MLs' confidence, participation, and long-term interest in STEM fields (Lee et al., 2013). Additionally, research should examine how students perceive different instructional scaffolds—

such as guided inquiry, collaborative learning, and visual aids—and which methods are most effective in promoting deep learning and engagement (Weinburgh et al., 2019).

Future research should continue to explore how professional development, instructional strategies and institutional policies can collectively enhance science education for MLs. By addressing these gaps, researchers can contribute to the development of sustainable, equity-driven models of science instruction that ensure MLs receive the support needed to thrive in STEM disciplines. Additionally, examining the long-term impacts of sustained professional development and equitable assessment models will be essential for shaping policies that support inclusive science education.

Limitations of the Study

Longitudinal Studies on Sustained Instructional Change

One limitation of this study is its focus on short- to mid-term instructional transformations. Future research should employ longitudinal designs to examine how teachers' instructional shifts evolve over multiple years and whether these changes improve MLs' engagement, science achievement, and language development. Long-term studies could also assess whether professional development experiences translate into permanent shifts in teaching philosophies and institutional policies (Darling-Hammond et al., 2009; Lee et al., 2008). Given the transformative potential of structured reflection in teacher development (Koubek & Wasta, 2022), longitudinal studies could explore how self-reflective practices shape instructional choices over time.

While this study provides valuable insights into the impact of language immersion and professional development on science teachers' instructional practices, several limitations should be acknowledged. One key limitation is the small sample size, as the study includes only three participants. A larger sample could have provided more diverse perspectives and stronger generalizability to broader educational contexts (Creswell & Poth, 2018). With only three participants, findings may reflect individual experiences rather than widely applicable trends in science teacher professional development.

Additionally, the study relies on self-reported data from teacher reflections and written responses, which are subject to self-perception biases and individual interpretations of experiences (Patton, 2015). Participants may have overestimated or underestimated their growth in empathy and instructional changes, limiting the objectivity of the findings. The lack of longitudinal data further constrains the study, as it captures only short-term transformations without assessing whether teachers sustained ML-inclusive instructional practices over time (Lincoln & Guba, 1985).

Moreover, while the study incorporates triangulation and member checking to enhance credibility, the small participant pool means that findings are not fully transferable to other contexts (Nowell et al., 2017). The experiences of the three teachers may not represent the broader challenges and successes that other educators face in implementing ML-inclusive instructional strategies. Finally, institutional barriers such as curriculum constraints, standardized testing pressures, and limited administrative support may have influenced participants' ability to fully implement inclusive teaching practices, further limiting the applicability of the findings (Lincoln & Guba, 1985).

Despite these limitations, this study provides valuable qualitative insights into how language immersion and professional development influence teachers' instructional approaches. The findings highlight the need for ongoing professional development and systemic support to sustain meaningful instructional change for multilingual learners.

Conclusion

The findings of this study indicate that language immersion experiences, followed by sustained professional development, lead to long-term instructional transformation among science teachers. Rather than relying on surface-level scaffolding strategies, teachers adopted more profound pedagogical shifts emphasizing linguistic inclusivity, inquiry-based engagement, and flexible assessment practices. Through ongoing reflection and collaboration, they moved beyond empathy awareness, actively embedding ML-inclusive strategies into their teaching. This transformation ultimately fostered more equitable and student-centered science learning environments where MLs could thrive.

Despite these instructional gains, several challenges remain. Limited access to professional development opportunities hinders educators from acquiring the specialized training necessary to support MLs effectively. Additionally, time constraints within instructional schedules make it difficult for teachers to fully engage in reflective practices and collaborate with colleagues. The pressures of standardized testing further limit curricular flexibility, often prioritizing test preparation over culturally and linguistically responsive teaching.

Continuous professional learning and systemic support are essential to sustain these instructional improvements. Addressing these barriers requires an institutional commitment to providing high-quality professional development, restructuring schedules for collaborative planning, and re-evaluating assessment policies to better align with the diverse needs of MLs. Without these systemic supports, inclusive instructional strategies may remain inconsistent and unsustainable.

The impact of sustained professional development is best exemplified by Mrs. Ramirez, who reached out after the study had concluded. She shared a message that illustrates the lasting influence of the study on their instructional practices and the power of ongoing learning:

> "I wanted to let you know that today my students clapped when I spoke Haitian Creole. My lesson slides were translated in Haitian Creole and English. JB complimented me. I explained that Duolingo was helping me. Another student after class said to me that if her grandmother were there, she would be proud of my Haitian Creole. Completing the exit interview invigorated my interest. Continual professional development is key for educators to develop empathy in the classroom, especially for ELLs. I now modify all of my assignments. I add more images. I simplify the language and highlight key points. I add guiding questions. I rewrite passages to connect it to other topics."

This reflection encapsulates the transformative power of continuous professional learning. It reinforces that professional development is not merely about acquiring strategies but about building an evolving, responsive approach to teaching that fosters genuine inclusion, engagement, and student success. This participant's experience highlights the importance of teacher commitment to lifelong learning, the role of professional development in deepening empathy, and the direct impact that inclusive instructional modifications can have on student perception and participation.

Ultimately, this study affirms that continuous professional development is essential to equitable science education for MLs. Modifying lessons, intentionally implementing scaffold instruction, and incorporating students' linguistic and cultural backgrounds require ongoing reflection, practice, and refinement. Without sustained support and structured learning opportunities, instructional improvements may remain surface-level and unsustainable. However, when teachers are given consistent opportunities to engage in reflective practice, collaborate with colleagues, and integrate evidence-based strategies, they are better equipped to create inclusive, student-centered learning environments where MLs can thrive.

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Appendices

Appendix A-Demographic Questionnaire

Please complete the following Demographic questionnaire by filling out the digital Google form:

1. Age
    - 18-24
    - 25-30
    - 30-34
    - 35-39
    - 40-44
    - 45-49
    - 50-54
    - 55-59
    - 60-64
    - 65 or older

2. Gender
    - Female
    - Male
    - Non-binary
    - Prefer not to say

3. Race/Ethnicity
    - White/Caucasian
    - Black/African American
    - Hispanic/Latinx
    - Asian
    - Native American/Alaska Native
    - Native Hawaiian/Pacific Islander
    - Mixed race
    - Other

4. Years of Teaching
    - Less than 1 year
    - 1-4 years
    - 5-10 years
    - 10-15 years
    - 15-20 years
    - 20 or more years

5. Certification Area
    - Childhood Elementary
    - Special Education
    - Biology
    - Earth Science
    - Biology
    - Physics
    - Other (please specify)

6. Grade(s) Currently Teaching
    - Pre-K
    - Kindergarten
    - 1st grade
    - 2nd grade
    - 3rd grade
    - 4th grade
    - 5th grade
    - 6th grade
    - 7th grade
    - 8th grade
    - 9th grade
    - 10th grade
    - 11th grade
    - 12th grade

7. Highest Degree of Education
    - Bachelor's Degree
    - Master's degree
    - Doctorate/Ph.D.

8. What percentage of students in your school are MLs?
    - Less than 5%
    - 5-10%
    - 10-15%
    - 15-20%
    - 20-25%
    - 25-30%
    - 35-40%
    - >40%

9. When did you last complete a course to support teaching Multilingual Learners?

10. Are you fluent in another language? If so, what language?

11. Setting of your school
    - Rural
    - Suburban
    - Urban

Thank you for participating in this demographic questionnaire. Your responses will help us gain valuable insights for my research.

Appendix B-Empathy Survey

Please complete the following Empathy Survey y (adapted from Warren, 2013 & Davis, 1980) by filling out the digital Google form:

1. Write your personal definition of empathy in only one sentence

2. Read the two statements below and select the statement that best describes what you think of when you hear the word "empathy":
   - ○ Having some kind of emotional reaction that would be similar to [the emotional reaction of] another person in [the same] situation"
   - ○ Putting yourself in someone else's shoes and attempting to feel what they feel in that moment."

3. Choose the statement that best describes how you feel about acquiring empathy:
   - ○ Everyone is born with the ability to empathize. Empathy is cultivated over time.
   - ○ Everyone is not born with the ability to empathize. Empathy is a learned behavior.

4. Based on the personal definition you just provided, complete the following sentence with the appropriate selection: “Empathy is __________ in my work as a classroom teacher”:
   - ○ of great importance
   - ○ important, but not a priority
   - ○ not important at all

5. I personally consider empathy to be a necessary disposition for teachers of Multilingual learners:
   - ○ Strongly agree
   - ○ Agree
   - ○ Disagree
   - ○ Strongly disagree

6. In general, I consider the student-teacher relationship I have with Multilingual Learners to be a positive one:
   - ○ Strongly agree
   - ○ Agree
   - ○ Disagree
   - ○ Strongly disagree

Appendix C-Email Script

Hello, my name is Lurdez Berrios, I am an EdD candidate at Teachers College, Columbia University, a former Bilingual/ENL Science teacher, and currently a Long Island Public School Administrator. I am conducting my dissertation research study to fulfill the requirements for the completion of the EdD in Science Education. This study will inquire as to how newly hired science and mathematics teachers in a suburban district perceive working with Multilingual Learners before and after continuous professional development.

This study is divided into three phases. I would like to invite you to participate in Phase I & II of the study. You were chosen to participate because you are a new hire to your district. Your participation includes participation in Phase I, completing a questionnaire and survey, and Phase II, "What it feels like to be a Multilingual Learner" workshop.

If you choose to participate, you will have your identity protected. Also, your name will be omitted from the final report and replaced with a pseudonym. You can opt out of participating in the study at any time with no penalty, but your participation is very much appreciated. The time commitment will be about 2.5 hours for Phase I and Phase 2 combined. The study will greatly improve the education field's knowledge of how new hires in suburban school districts perceive working with MLs. Also, I am hoping that this research will add to what we know about teacher education, recruiting, and professional development for teachers to be successful in suburban classrooms with linguistically diverse students. Choosing not to participate in this research will in no way have negative implications on your relationship with the school, students, families, or administration.

If you are interested in participating, I would like to begin with administering a demographics questionnaire and a perception assessment. This should take no more than 30 minutes to complete both items. If you have questions or would like more specifics for this project you can email me at lab2276@tc.columbia.edu.

Thank you in advance for your time.

Appendix D-Preparation for Teaching ML Survey

Adapted from Lucas, Reznitskaya & Villegas 2008

Using a google form, select the number that best captures how well or poorly prepared you feel in each area:

1=Extremely Poorly Prepared 6=Extremely Well Prepared

1. Understanding of how people learn a second language. 1 2 3 4 5 6
2. Understanding of the nature of academic English and the challenges it poses for MLs. 1 2 3 4 5 6
3. Skills and strategies for learning about the cultural backgrounds of MLs. 1 2 3 4 5 6
4. Skills and strategies for teaching academic content to MLs. 1 2 3 4 5 6
5. Understanding of how culture influences learning. 1 2 3 4 5 6
6. Understanding of how language influences. 1 2 3 4 5 6
7. Understanding of language variation and dialects. 1 2 3 4 5 6
8. Ability to assess MLs academic abilities in a classroom setting. 1 2 3 4 5 6
9. Understanding of the difference between proficiency in oral language and in written language. 1 2 3 4 5 6
10. Ability to modify classroom instruction for MLs 1 2 3 4 5 6
11. Ability to modify classroom instruction for MLs. 1 2 3 4 5 6
12. Ability to access MLs prior knowledge and experience as part of instruction. 1 2 3 4 5 6
13. Skills and strategies for reaching out to MLs parents/guardians/family members. 1 2 3 4 5 6

Table 2

Preparation for Teaching MLs Score Categories

13–26 points	You are aware of the challenges you face when teaching MLs but need a great deal more information on language, culture, prior knowledge, and modification of instruction for MLs. You also don't have an in-depth understanding of the interplay between language, culture, instruction, and learning.
27–52 points	You are aware of the challenges you face when teaching MLs and have a beginning understanding of language, culture, prior knowledge, and modification of instruction for MLs. You have an understanding of the interplay between language, culture, instruction, and learning.
53-78 points	You have an in-depth understanding of language, culture, prior knowledge, and modification of instruction for MLs. You have a deep understanding of the interplay between language, culture, instruction, and learning. There may still be some topics on this survey that you would like to develop further.

Appendix E-PPTML Survey Reflection Questions

1. How did you feel after taking the survey regarding your preparation to teach ELs?
2. Did your responses to specific questions surprise you? Which ones? Why?
3. Do you think your final score on the Preparation to Teach ELls/MLs survey aligns with the description of the category you fall into? Why or why not?
4. Which areas are the strongest for you?
5. Which areas would you like to develop further?

Appendix F-LIPD Reflection Questions

Lesson 1 Reflection (No Language Support)

1. How did you feel as a Second Language student?
2. What support(s) did you require to comprehend the content?
3. What strategies did you employ to understand the content?
4. How did the facilitator modify their instruction to accommodate your linguistic needs?
5. Have you encountered any students who might have experienced a situation similar to yours?

Lesson 2 Reflection (With Language Support)

1. How did you feel as a Second Language student in Lesson 2 compared to Lesson 1. Reflect on the differences in your experience.
2. What specific tasks or activities were assigned to you in this lesson? How were you able to determine your objectives?
3. Which skills did you employ to comprehend and grasp certain aspects of the content?
4. Describe the support you received to address your linguistic needs and enhance your understanding of the lesson.
5. What assistance or support would you require to comprehend the lesson further and actively participate in the informal assessment?

Group discussions guiding questions

1. How did this experience contribute to your understanding of the challenges and needs of ELLs in the science classroom? What insights did you gain about ELLs' language and instructional needs in science lessons?
2. What did you learn about yourself as a language learner during the immersion workshop?

How did this impact your approach to planning science lessons for ELLs? How can your language learning experiences inform your understanding and support of ELLs in the science classroom?

3. Were there any strategies you found effective in improving your language skills during the workshop? How could these strategies be adapted to support ELLs in science learning? What language learning strategies or instructional approaches would benefit ELLs in science lessons?
4. What key moments or experiences during the language immersion workshop helped you develop empathy toward English Language Learners (ELLs) in your science lessons and activities?
5. Is there anything else you would like to share about your experience or suggestions for future professional development focused on supporting ELLs in science education?

Appendix G-Phase III Email Script

Thank you for participating in Phases I & II of my study. The data gathered will impact teachers' perspectives on multilingual daily experiences. You are now invited to participate in Phase III. This phase will inquire as to how newly hired teachers in a suburban district perceive working with Multilingual Learners before and after continuous professional development. Your participation includes participation in interviews, focused groups, planning sessions, intervisitations, and classroom observations.

If you choose to participate, you will have your identity protected. Also, your name will be omitted from the final report and replaced with a pseudonym. You can opt out of participating in the study at any time with no penalty, but your participation is very much appreciated. The time commitment will be about 15-20 hours over 9 months.

The study will greatly improve the education field's knowledge of how new hires in suburban school districts perceive working with MLs before and after continuous professional development. Also, I am hoping that this research will add to what we know about training, recruiting, and professionally developing teachers to be successful in suburban classrooms with linguistically diverse students. Choosing not to participate in this research will in no way have negative implications on your relationship with the school, students, families, or administration. If you are interested in participating, I would like to begin with a short 20-minute individual interview. Please email me to set up your date, time, and location.

If you have questions or would like more specifics for this phase, you can email me at lab2276@tc.columbia.edu.

Thank you in advance for your time.

Appendix H-Article Reflection Guiding Questions

Article by Ziegenfuss, Odhiambo, and Keyes, “How Can We Help Students Who Are English Language Learners Succeed?”

1. What were key ideas presented in the article that stood out to you?
2. How did the article enhance your understanding of the challenges faced by Multilingual Learners (MLs) in the classroom?
3. Were there any strategies or approaches discussed in the article that you found particularly effective or innovative in supporting MLs’ success?
4. Reflecting on your current instructional practices, are there any areas where you think you could improve your support for MLs based on the insights shared in the article?
5. Are there any specific questions or concerns that arose from reading the article that you would like to discuss further or seek additional information on?

Appendix I-Video Reflection Guiding Questions

1. What aspects of the former MLs' middle/high school experiences resonated or surprised you?
2. How did the former MLs describe their journey into science fields, and what influenced their decisions?
3. What challenges did the former MLs face, and how did they overcome them?
4. How can the experiences shared by former MLs inform your approach to supporting current MLs in your science classroom?
5. What strategies or practices mentioned by the former MLs can be incorporated into your teaching to better support MLs in pursuing science?

Appendix J-Lesson Plan Editing Reflection Questions

1. What changes or additions would you recommend ensuring that multilingual learners (MLs) can fully participate and benefit from the lesson
2. How would you modify instructional materials to make the lesson more accessible to MLs?

Appendix K-Exit Interview

1. How has the professional development experience increased your understanding of the unique challenges and experiences faced by Multilingual Learners in the science classroom?
2. What specific strategies or techniques have you learned during professional development that have helped you develop empathy toward Multilingual learners?
3. In what ways has this professional development influenced your interactions and communication with Multilingual Learners in the science classroom?
4. How has this professional development changed your perception of Multilingual Learners' abilities and potential in science?
5. How have you incorporated culturally responsive teaching practices into your science instruction to better connect with and support Multilingual Learners?
6. What steps have you taken to create a more inclusive and welcoming learning environment for Multilingual Learners in the science classroom?
7. In comparing a lesson plan from September to a lesson plan in April, what observations can you make regarding the additions or omissions made to enhance the inclusivity of MLs learning science?
8. How have you adapted your instructional materials and methods to address the linguistic and cultural needs of Multilingual Learners in science class?
9. Have you observed any positive changes or improvements in the engagement, participation, or academic achievement of Multilingual Learners in your science class since participating in professional development? If so, what do you attribute these changes to?

10. How do you plan to sustain and continue building empathy toward Multilingual Learners in the future beyond the professional development experience?