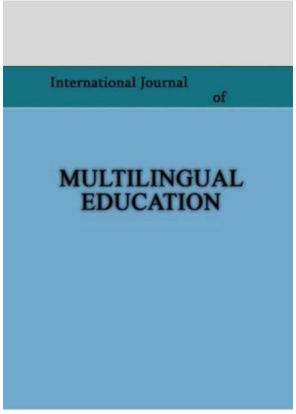

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ABSTRACT

Climate change remains a complex issue at the intersection of science, emotion, and politics, yet it is often denied or misunderstood by people worldwide, including young learners. Despite growing global attention, initiatives to address climate change remain limited in scope, particularly in K–12 education. This mixed-methods study (*N*=73), conducted in an urban city in New England, explores the knowledge, beliefs, and intentions of multilingual middle-school learners, a population frequently overlooked in climate education research. Using a survey with both open-ended questions and Likert scale items, I analyzed key dimensions of students' climate literacy (system knowledge, action knowledge, effectiveness knowledge), beliefs, and willingness to engage in climate-protective behaviors through quantitative and qualitative methods. The study analyzed both a full linguistically diverse sample (N=73) and an active multilingual subgroup (N=11) to explore how immigration experience and heritage language use may shape climate literacy.

Keywords: *Multilingual students, Climate change Education, Self-efficacy, Language development, Urban middle school.*

Introduction

I understand the science, but the English words are too hard for me to explain." This statement, made by a bilingual student in a science workshop (Buxton et al., 2019), shows an important but often overlooked problem in education. For some multilingual learners (MLs), it can be difficult to connect what they know with how to express it in English. This challenge can make it harder for them to explore complex topics like climate change. The climate crisis is an urgent worldwide problem that requires an extensive amount of awareness, action, and non-discriminatory methods of learning. Climate change is not a hypothetical risk anymore; it is currently a fact that has dire and long-term outcomes (Diffenbaugh, 2019). More severe and frequent weather events, such as wildfires, droughts, and hurricanes, are a result of global warming and pose a threat to the ecosystem and human life. In both developed and developing countries, many youths do not have an all-encompassing knowledge of the underlying issues of climate change (UNESCO, 2023). Whereas some students are involved in eco-clubs and are centered on tree-planting projects, these activities are not accompanied by long-term

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discussions and definite action.

The key to dealing with these global problems is to give young people the correct information and to make them feel that they have the power to change the situation. Climate Change Education (CCE) has emerged as the critical mechanism to increase climate literacy and empower young people to take climate action. However, CCE is often not implemented even in important cases, particularly in multilingual classrooms (Morrison et al., 2024). Multilingual students represent one of the fastest-growing population groups in public school systems across the United States. The proportion of the English Language Learners (ELLs) grew by a margin of 5.3 million between 2011 and 2021, which is 9.4 to 10.6 (National Center for Education Statistics, 2024). This change indicates that the need for inclusive pedagogy and the potential importance of multilingual students in climate change discourse is growing. UNICEF (2025) states that numerous students in American public schools can be displaced, in land degradation, and food insecurity areas that are disproportionately impacted by climate change. Their personal experience in life could present meaningful insights into the actual implications of climate change, but the studies of incorporating those possible insights in scholarly areas are still not widespread.

The increasing rate of the ELL population is also a contributor to the inequity in access to science education. It has been noted in the research that the comprehension of major ideas and communication with others are constrained by linguistic barriers and the technical language of climate science among MLs (Buxton et al., 2019). These issues require specific materials and instruction methods that would consider every student, irrespective of his or her language background, to be engaged with the subject of climate change. In the absence of this, a significant percentage of the student population stands balanced to stand out in debates that directly impact their destinies.

Although the inclusion of multilingual learners in climate education is an important field of study, the needs of these learners have not been fully addressed in the current literature. Goulah (2017) criticizes the TESOL (Teaching English to Speakers of Other Languages) profession by noting that it does not pay enough attention to ecological crises because climate change is not only a scientific problem but also a cultural and religious one. Likewise, Salloum, Siry, and Espinet (2020) note the difficulties of teaching science in multilingual settings and state that the language, culture, and science knowledge intersect. There are also gaps in the existing studies in areas where empirical research is required, specifically in middle school, where the foundation of understanding science and climate literacy is developed. There exists an urgency to fill these gaps using longitudinal studies, interdisciplinary interventions, and multi-layered programs (Ahmed et al, 2024)

This study aims to address some of these gaps and identify climate change learning of students in middle schools situated in urban, language-heterogeneous settings. The study investigates how multi-linguistic and immigration status factors impact the participation of middle school students in climate change education. While the initial research participants included students with diverse communication situations, the analysis of students' variables allowed for voices to provide a more complex notion of language identity in today's classrooms. A substantial number of respondents were born in the United States and used English at home, alongside the use of other languages were considered part of their language identity. For other respondents who had emigrated more recently, evidence of their language identity included their continued use of heritage languages.

Since the various experiences may affect climate learning differently, the study uses a dual analysis method. I provide the results of the entire sample of students in this linguistically diverse environment (N=73) and also consider the patterns of a certain subgroup of the students with direct immigration experience and active heritage language maintenance (N=11). This approach allows me to examine both the broader patterns in linguistically diverse educational settings and the more specific experiences of students navigating climate education while maintaining strong connections to heritage languages and cultures.

Theoretical Framework

Theory of Planned Behavior (TPB), Triadic Reciprocal Causation (TRC), and Knowledge Deficit Model (KDM). Combined, these theories give a logical means of examining the way knowledge, attitudes, social factors, and motivation affect the adoption of climate change education in multilingual learners. These orientations are combined, and the study explores the way of learning about climate change, constructing beliefs, and arriving at intentions in all instances by considering the distinctiveness of linguistic and cultural situations in the work of multilingual learners.

Knowledge Deficit Model (KDM) is premised on the relationship existing between knowledge acquisition and pro-environmental behavior. The most important assumption of this framework is the belief that individuals would be more willing to engage in environmentally friendly activities provided that they possess enough knowledge about the causes, effects, and measures to eradicate the problem of the state of the environment (Kolenatý, Kroufek, and Činčera, 2022; Scherer et al., 2022Another application of this paper is the use of the Theory of Planned Behavior (TPB) developed by Ajzen (1991) to analyze climate change knowledge, beliefs, and intentions among multilingual middle school students. TPB is a systematized method of comprehending how people make intentions and behave according to their attitudes, perceived social expectations, and their perceived control over a behavior.

Bandura's Triadic Reciprocal Causation (1999) describes mutual influence among cognition, behavior, and environment, framing how multilingual students' beliefs form through both knowledge and social context. This model compounds unilateral explanations of behavior using the fact that people are both consumers and creators of their surroundings, i.e., that climate beliefs and intentions of students are not only informed by knowledge, but also by their social settings and previous experiences.

I use the Triadic Reciprocal Causation model of Bandura to discuss the interactions of knowledge, beliefs, and intentions to create climate-related behavior among the students. Unlike linear models, this approach reveals how environmental factors—including peer discussions, cultural influences, and institutional messaging—mediate these relationships.

Grounded in these theoretical perspectives, the study aims to investigate the following research questions:

i. What climate change knowledge do urban middle school multilingual students possess?
ii. What intentions and beliefs regarding climate change exist among urban middle school multilingual students?
iii. How does urban middle school multilingual learners' climate change knowledge relate to their intentions and beliefs regarding climate change?

The theoretical frameworks combine to address the three research questions by considering how multilingual learners' climate knowledge (KDM), beliefs and intentions (TPB), and interactions with social and environmental context (TRC), intersect with the frameworks around language and identity (BICS/CALP and raciolinguistic critique). This synthesis directly supports the examination of multilingual students' climate literacy and their behavioral intentions.

Literature Review

Context of Climate Change Education (CCE)

Climate change in education has evolved over the past twenty years as environmental problems have become more urgent. But the traditional teaching methods still are not preparing students for what is coming. Eilam (2022) puts it well: effective climate education needs to go beyond just making students aware of problems. Students need to really understand how climate systems work, how humans affect them, and what can be done about it.

In the early days, environmental education was all about personal responsibility. Schools taught students to recycle, turn off lights, and buy eco-friendly products (Courtenay-Hall & Rogers, 2002;

Stern, 2000). That's not necessarily bad, but critics like Jacobsson and Lauber (2006) and Stevenson (2007) started asking: Can individual actions really solve such a huge, systemic problem? This created a tension that we are still dealing with today: do we focus on personal choices or bigger changes to systems? When climate classes ignore these power imbalances, they can make inequalities worse (Burt, 1993).

Today's researchers see climate knowledge as much more complicated than just memorizing facts. Building on earlier work by Frick and colleagues (2004), Bofferding and Kloser (2015) teamed up with Boyes, Skamp, and Stanisstreet (2009) to show that students need to navigate multiple knowledge systems at once. They broke it down into three parts: understanding how climate systems work, knowing what actions help, and figuring out which solutions work best. But in my opinion, this framework does not consider how multilingual students' different backgrounds might offer new ways of thinking about environmental problems. Schools often dismiss the environmental knowledge that students bring from home. When we only value things like buying green products instead of community organizing or traditional practices, we miss out on insights from families who have real strategies for dealing with environmental challenges.

The push for broader approaches is gaining momentum. Wibeck (2014) argues for strategies that get people thinking critically about power structures, while McNeill and Vaughn (2020) found that middle school programs work better when they mix science with social studies. Some graduate programs are even more ambitious, and Rawling (1996) describes approaches that combine research with reflection, encouraging students to examine how politics shapes environmental problems.

Community partnerships offer another promising direction. Peel, Robottom, and Walker (1997) show how school-community connections can integrate different types of knowledge, scientific, traditional, and experiential. International examples back this up: Burt (1993) worked in St. Lucia and Rungsayatorn (1994) studied programs in Thailand, both showing how building on local cultural knowledge can motivate real environmental action.

This is important because multilingual students might know things about climate impacts from different parts of the world, but we know almost nothing about how to recognize and use these insights. Most research has focused on developed nations like the U.S. and U.K., and even within the U.S., studies typically look at suburban, mostly white schools (Wolf & Moser, 2011; Wibeck, 2014). It's not just about practical stuff like setting up partnerships; it is about bigger questions: What knowledge do we value? Who gets to decide what matters?

Even with all this progress, many schools still use what Kollmuss and Agyeman (2002) call the "information deficit model." The model assumes that if you just give people more information, they will automatically change their behavior. But this ignores emotions, social pressures, and structural barriers that influence what people do (Lorenzoni et al., 2007). My research challenges this deficit thinking by looking at what multilingual students know and believe, instead of assuming they do not understand.

Second Language Learning and Academic Content

To understand how multilingual students experience climate change education, it is needed to examine what decades of research have taught me about second language learning in academic contexts. What is coming out of this literature is the fact that academic language development is truly complex, particularly when considering the assumptions that teachers tend to make about multilingual students.

The concept of language learning by educators was changed fundamentally by Jim Cummins when he proposed the difference between Basic Interpersonal Communication Skills (BICS) and Cognitive Academic Language Proficiency (CALP) in 1979. His model developed out of his observations that most teachers could then misunderstand conversational fluency in the students as they're ready to take academic assignments, and thus withdraw language assistance prematurely, only to falter academically.

BICS (Cummins, 1979) entails the language skills required in daily social interactions and the skills to communicate face to face, where meaning can be provided through gestures, facial expressions, as well as shared physical environments. Students typically develop BICS within two to three years of exposure to a new language. CALP, by contrast, involves the abstract, decontextualized language required for academic success, including complex grammatical structures, specialized vocabulary, and the ability to manipulate language for hypothetical reasoning.

For science education, this distinction has profound implications. Climate science exemplifies the challenges of CALP, requiring students to navigate passive voice constructions ("heat is trapped by greenhouse gases"), conditional statements ("if emissions continue to rise, then temperatures will..."), cause-and-effect relationships spanning multiple systems, and technical terminology often derived from Latin and Greek roots. Climate science forces students to think across multiple scales—from molecules to the globe, from daily weather to climate patterns spanning millennia. All of these require exactly the abstract reasoning that makes academic language so demanding.

However, I argue that this framework, while useful, may miss how multilingual students' diverse linguistic backgrounds could be assets for understanding complex climate concepts. Cummins' framework evolved notably over subsequent decades, particularly in response to critiques about its potential to reinforce deficit perspectives. In his 1996 work "Negotiating Identities," Cummins expanded his analysis to incorporate issues of power and identity, arguing that academic language development cannot be separated from broader questions of cultural validation and social justice. This framework's development faced notable challenges. Cummins came to realize that treating CALP as simply a technical skill ignored the linguistic hierarchies and social inequalities it could perpetuate.

By 2000, Cummins had adopted a different strategy. He started paying attention to equality and equity in education. He claimed that students should not be seen as weak because schools should appreciate their home language as a strength. This was a big shift. He acknowledged academic language as power-related, rather than it being neutral. Nevertheless, his framework continued to have issues with the critics. These changes notwithstanding, scholars doubted that subdivision of language into such categories as BICS and CALP would always lead to the unfair judgment of the abilities of the students.

MacSwan (2000) has claimed that the BICS/CALP framework suggests the existence of a language hierarchy, making some language use cognitively superior. Valdés (2004) showed good intentions of promoting the development of academic language to result in marginalization when individualized to what students are deemed to lack. The main idea of these criticisms is simple: models that separate languages into ideas of academic and non-academic run the risk of recreating the injustices they are meant to cover.

This criticism can be described by Flores and Rosa (2015) as their discussion of raciolinguistic ideologies. They state that frameworks such as BICS/CALP can reinforce the existing harmful ideologies, as it does not aim at acknowledging the linguistic resources of the learners; instead, they emphasize the gap between learners and what they are allegedly lacking. They demonstrate how policies and practices in education tend to place the varieties of languages in multilingual students in a situation where their forms are viewed as inadequate forms of standard English rather than as autonomous systems of language with logic and communicative strength of their own. The criticism applies especially to climate change education, in which the home language practices of students may entail elaborate methods of talking about environmental observations and seasonal patterns, which are categorized as non-academic.

This critique is a central part of my research stance. I investigate multilingual students' understanding of climate through an asset-based perspective, hoping to unearth sophisticated environmental knowledge that might be missing. The theoretical tensions of CALP are embodied in my research findings. When students respond to the prompt, "It's getting cold, more than it should be," or explain climate change using formative observations rather than abstract theoretical principles, I could take these reactions/responses in several ways. From a traditional CALP perspective, I could view these responses as evidence of underdeveloped academic language. On the contrary, Flores and Rosa's framework calls upon considering whether students are demonstrating a legitimate means of understanding and expressing environmental knowledge that is not recognized in narrow definitions of academic discourse.

Scientific Knowledge and Everyday Understanding

One of the biggest challenges in science education is helping students think about natural phenomena in ways that often go against their everyday experience and intuition. Climate change education makes this even trickier. Students have to grasp processes that unfold over thousands of years, make sense of confusing data, and see how problems in one area affect completely different systems.

Wells (2008) describes a key tension in science learning: what students learn through daily experience often clashes with scientific explanations based on evidence and reasoning that isn't immediately obvious. For climate education, this creates real problems. What students experience with local weather doesn't show long-term climate trends. Their neighborhood conditions might not reflect global patterns. And it's hard to see how personal actions connect to big environmental changes.

I argue that for multilingual students, this tension may be different; their "everyday" experience might include knowledge from multiple geographical and cultural contexts that could enrich scientific understanding rather than conflict with it. Researchers are paying more attention to the cultural side of this challenge. Valdés (2004) stresses how important it is to listen to students and put their experiences at the center of learning. She wants teaching that connects students' cultural backgrounds with academic language development. This matters a lot for climate education. Students often know about environmental changes from daily observations, family conversations, or their cultural traditions. When climate classes ignore these voices, they miss valuable insights and push students to the margins, exactly what Valdés warns against.

Ojalehto and Medin (2015) found that students approach scientific thinking differently based on their languages and cultures. They demonstrate the need to have culturally responsive instruction that acknowledges that the backgrounds of students influence their interactions with science. In the case of a student whose family has information about seasonal patterns or drought cycles, they have valuable environmental knowledge, but again, this is just structured differently than what would be expected in a normal science course. The trick is to develop lessons that respect this cultural knowledge and, at the same time, teach scientific thinking.

The aspect of my research is how various cultural and experience backgrounds of multilingual students affect their climate cognition, beyond the presumption that science and everyday knowledge should always be mutually exclusive. The knowledge of such tensions between scientific and everyday knowledge is important, yet I also have to observe the results of such tensions in real classrooms. There is a very different response to these challenges in schools, which I see when I consider real climate education.

Current Practices in Urban Middle School Educational Settings

Climate change education in middle school in the U.S. is exciting, innovative, and complicated in various states, districts, and classrooms. The policy context varies such that in states like Connecticut, climate change caused by humans is specifically listed in the science standards for students to study, while in Massachusetts, climate change policy provides minimal guidance, thus leaving it up to teachers and faculty to decide if and how they integrate climate change topics into the classroom (Cho, 2023). The differences in policy context create challenges for urban schools, which often serve impoverished and multilingual populations and are often less equipped with resources to develop curricula and prepare staff. If states, like Massachusetts, push for schools to develop curricula, they leave it up to schools to decide if and how to address climate change. Systematic climate change education presents opportunities for students to connect what they learn academically to their lived experiences in a hands-on manner and systematically acknowledge students' needs to develop tools to study the environmental changes that impact their everyday lives.

Cho (2023) documents how schools in economically disadvantaged areas face additional barriers, including inadequate materials, limited professional development opportunities, and competing demands that leave little time for curriculum innovation. These resource constraints are especially problematic for climate education, which benefits from interdisciplinary approaches, community connections, and hands-on learning experiences that require time and materials to implement effectively.

Despite these constraints, promising practices have emerged in some urban settings.

Monroe and colleagues (2019) describe successful approaches that emphasize experiential learning, including structured discussions that help students process complex information, collaborations with practicing scientists that provide authentic research experiences, and community-based projects that connect classroom learning to local environmental issues. These approaches seem particularly well-suited to urban contexts because they can draw on rich community resources and diverse perspectives that characterize many city neighborhoods. Yet this very diversity, particularly the linguistic and cultural diversity that characterizes many urban schools, introduces additional complexities that remain underexplored in literature.

What concerns me about this research is that while Monroe et al. describe "diverse perspectives" as an asset, they don't specifically examine how linguistic diversity affects climate learning, a notable gap my research addresses. What is less clear from Monroe et al's research is how these approaches work specifically with multilingual populations. While they document general effectiveness, they do not examine whether students with different linguistic backgrounds experience these pedagogical approaches differently or whether additional support might be needed to ensure equitable participation.

International examples provide some additional insights about participatory approaches to climate education. Educational reforms in Korea, Taiwan, and Singapore have emphasized student involvement in sustainability initiatives, with encouraging results in terms of engagement and learning outcomes (Chang & Pascua, 2017; Lee et al., 2017). However, these contexts differ notably from U.S. urban schools in terms of linguistic diversity, immigration patterns, and educational structures, making it difficult to draw direct parallels.

Other teachers have promoted more systemic directions that make the students perceive climate change as a social and political phenomenon, not just as a scientific issue. Williams and colleagues (2017) and Öhman and Öhman (2013) outline the programs where the collaboration with the community organizations is introduced to place climate education into the greater context of environmental justice, economic inequality, and political power. These strategies acknowledge the fact that various societies are impacted by climate change, and the appropriate responses must be a collective one through policy reform.

Jones and Davison (2021) highlighted the affective aspects of climate education and stated that students should have secure environments to manage the sense of anxiety, grief, and overwhelming feelings that climate information may evoke in students. According to their work, there should be a combination of cognitive and emotional learning to create resiliency and agency instead of feelings of despair and paralysis. This view appears to be especially applicable to urban students, who can belong to the communities already experiencing the effects of environmental health and can feel the acuity of climate challenges more than their counterparts in more advantaged environments.

Nevertheless, it is possible to note that in many modern practices, the focus on systemic analysis is less emphasized than on individual behavior change. This trend was observed by Courtenay-Hall and Rogers (2002) and remains active in most current programs focusing on personal energy use, reduction of waste, and consumer behavior, but pay less attention to policy campaigns, community organization, or structural analyses. I believe that this individualistic attention is especially problematic in the case of multilingual students who belong to a community experiencing systemic environmental injustices because it shifts the burden onto the young people without discussing the structural injustice they have to endure (Tolbert, Schindel, & Rodriguez, 2019). This individualistic orientation can be quite dangerous in the context of multilingual students representing communities with systemic disadvantages, since it puts the burden on younger people without considering the institutional aspects of the limitation of their agency.

Multilingual Learners and Climate Change Education

Although there has been an increase in awareness of the significance of inclusive and culturally responsive education, multilingual students have been mostly excluded from the research on climate change education. This disjuncture is indicative of more general issues with education: climate change is perceived as an elective subject, and many teachers do not touch upon this issue at all. In the case of multilingual learners, the lack is especially vivid since multilingual communities are increasingly represented at the urban schools and since a significant number of such students belong to the communities unequally impacted by environmental issues.

It is this gap that is the catalyst behind my study because multilingual students form one of the fastest-increasing student groups in urban schools, and I know almost nothing about their experiences of climate education. The question of oversight appears particularly problematic in relation to what multilingual students could contribute to climate education. Students who have experienced life in several countries are equipped with firsthand experience on how various environmental conditions and adaptation methods are. The people who are still attached to other parts of the world through extended families might be able to receive information regarding the environmental changes that do not even reach international news. Learners with traditional ecology backgrounds can also know environmental associations that can be used in addition to the scientific view.

Goulah (2017) and Garcia and colleagues (2019) suggest that linguistic diversity has the potential to increase critical thinking and problem-solving in learning institutions. A student who switches between different language systems acquires metacognitive awareness that facilitates intricate thinking. They are taught to take into account various opinions and ask questions that may seem to be evident to monolingual speakers. These mental abilities appear to be directly applicable to climate change education, which needs students to reason on a variety of scales, consider a wide range of opinions, as well as synthesize information provided by different sources.

Nonetheless, the studies that have been conducted on multilingual students in science learning have concentrated more on limitations as opposed to resources (Cohen, 1992). The language proficiency issues are real and significant: the texts of science are linguistically complicated, instruction in laboratory should be clear and correct, and the discussion in the classroom proceeds rapidly and may disadvantage those students who have to process the information more slowly. Cultural disconnections are also a hurdle in cases where the curriculum contents are not relevant to the experiences of students, or the instructional methods are against cultural beliefs regarding the learning and participation.

Salloum and colleagues (2020) have created models of culturally responsive science teaching, which view linguistic diversity as a tool instead of a weakness. Their methods underline the interrelation of the scientific ideas with the cultural background of the students, the collaborative learning framework that facilitates the language growth and the justification of the numerous modes of showing knowledge. Nevertheless, they admit that it is highly unlikely to implement such approaches without significant professional growth and institutional backing.

The scanty research on multilingual students as a specific target group and climate education, presents both opportunities and challenges. According to STEM Teaching Tools (2024), multilingual students can become useful platforms in cross-cultural communication on environmental problems, and their insights into the topic may not be represented in the classroom. Their multicultural backgrounds can make their classmates have more global views about the effects of climate change and ways to solve the problem.

Interestingly, the same source admits a serious gap: this field practically lack longitudinal studies that would help me to monitor the experience of multilingual students in climate education over the years. It is difficult to understand how their comprehension is built, what helps them work best, or how their views alter as they gain more academic language proficiency. The overall overview shows that significant advances have been achieved in climate education and the research of multilingual learning independently, but the relationship between them has not received thorough research. This study addresses this gap by examining what urban middle school multilingual students know, believe, and intend to do about climate change, moving beyond deficit assumptions to recognize the unique assets these students bring to environmental learning.

Methodology

Participants

The study involved participants from a middle school located in an urban area of New England, known for its notable population of English Language Learners (ELLs). This research was part of a multi-year federally funded initiative, which included a tutoring component aimed at offering academic assistance to multilingual middle school students in a small New England city. The program is designed to tackle the educational difficulties encountered by ELL students while promoting their language learning and overall academic growth.

Participants were selected from grades 5 through 8. The process of identifying students for the tutoring program was two-tiered. First, the grants' external evaluator randomly selected student teams from these grades. From these teams, individual participants were then chosen by their teachers based on the following criteria:

- Language Background: Students identified as multilingual, including those currently classified as English Learners (EL), former ELs, or ELs not actively receiving services.
- Potential Benefit: Students whom teachers believed would particularly benefit from one-on-one connections with undergraduate tutors from the local University.

Ethical Approval and Consent Procedures

This study was conducted as part of a larger research project titled *"STEM Language Arts Teaching/Learning Ecosystems"* and received approval from the University of New Hampshire Institutional Review Board (IRB Protocol #IRB-FY2022-238, approved through April 11, 2025). A modification to the original protocol, approved October 1, 2024, included the addition of surveys and doctoral student research activities specific to this climate change education study.

All student participants provided informed assent, and written parental consent was obtained for all participants before data collection. Participants were informed that their participation was voluntary and that they could withdraw at any time without penalty or impact on their involvement in the tutoring program. Data collection and storage procedures followed IRB protocols to protect participant confidentiality. All personally identifying information was removed during data analysis, and pseudonyms were assigned to protect student privacy in this manuscript.

Sample Composition and Dual Analysis Approach

The research included 73 students from 5th to 8th grade. Of the participants, 45.5% identified as male, 53% as female, and 1.5% preferred not to disclose their gender. In terms of linguistic background, while most participants reported English as their primary home language, several students indicated speaking additional languages, including Spanish, Portuguese, Nepali, Somali, Arabic, Vietnamese, and Luganda.

The Active Multilingual Subgroup (N=11) is analytically nested within the larger Linguistically Diverse Student Sample (N=73). This means that the same 11 students' responses contribute to both the subgroup and the overall dataset. This nested structure reflects authentic classroom realities, where students with active multilingual practices learn alongside peers from varied linguistic backgrounds.

Analyses were therefore designed to highlight both broad population patterns and subgroup-specific insights rather than to treat these groups as independent samples.

In my study, I use the term multilingual students to refer to all students who use or are developing proficiency in more than one language, regardless of their English proficiency or whether they receive formal English Language Learner (ELL) services. This approach is consistent with asset-based frameworks (WIDA, n.d.; Yankelovich, 2023) that recognize the full range of students' linguistic abilities, not just their status as English learners.

To provide comprehensive insights into multilingual climate learning, this study employs a dual analysis approach. The research presents findings from both the Linguistically Diverse Student Sample (N=73) and a focused subset of the Active Multilingual Subgroup (N=11). Upon examination of participants' backgrounds, the research team identified meaningful distinctions within the broader multilingual population. While many students in the full sample were linguistically diverse, they were predominantly born in the United States and primarily spoke English at home alongside other languages.

The subset of 11 students represents a distinct multilingual experience, characterized by:

- Immigration experience: Students who were born outside the United States or immigrated from other countries
- Active heritage language maintenance: Students who primarily speak languages other than English at home
- Cross-cultural educational experience: Students who have navigated educational systems or cultural contexts beyond the U.S. experience

The comparison between the full sample and the subset reveals important patterns that might otherwise remain masked when analyzing all multilingual students as a homogeneous group. Demographic details for participants are summarized in **Appendix A (Figures 1–5).**

Within the full sample (N=73), 27.3% of participants indicated they were born outside of New Hampshire, while 19.7% reported immigrating to the United States from other nations. The subset of truly multilingual students (N=11) consists entirely of students who were born outside the United States or immigrated from other countries, representing a portion of this 19.7% who also maintain active heritage language practices at home.

This demographic composition is notable for climate education research, as the truly multilingual subset brings direct immigration experiences and diverse environmental perspectives informed by different geographical and cultural contexts. These students have lived in or have family connections to regions that may experience different climate-related phenomena such as droughts, floods, or environmental changes. This firsthand or familial environmental knowledge represents a valuable resource for climate learning that differs qualitatively from climate understanding developed primarily through U.S.-based educational experiences. This distinction is crucial for interpretation: while the broader sample represents the linguistic diversity typical of many urban schools, the Active Multilingual Subgroup provides a focused view of learners maintaining strong heritage language engagement.

Data collection

The investigation of this study utilized a combination of quantitative and qualitative methods within a mixed-methods approach. Data was collected through an online survey, which included 13 multiple-choice items (offering responses on a Likert scale) and five open-response items. The survey was divided into four sections, each investigating different constructions:

Background Information – Collected demographic and linguistic background data. Climate Change Knowledge (Conceptual Understanding) – Included four open-ended questions to assess system and action knowledge (Bofferding & Kloser, 2015).

Beliefs about Climate Change – Comprised nine Likert-scale items and one open-ended question exploring personal and familial experiences with climate change.

Intentions to Act on Climate Change – Contained four Likert-scale items assessing willingness to engage in climate action.

The survey was designed based on the study's definition of climate literacy and research questions. Intention and belief items were taken from the Climate Change Attitude Survey (Christensen & Knezek, 2015), and knowledge items were developed through multiple rounds of revisions and expert consultations for validity. The reliability of the survey was assessed using Cronbach's alpha (see Table 1). The Beliefs scale demonstrated questionable reliability (α = .643), while Knowledge (α = .328) and Intentions (α = .528) scales showed poor internal consistency. Though these alpha values fall below conventional standards, they are acceptable given the small number of items (4 items each for the Knowledge and Intentions scales) and the exploratory nature of this study (Nunnally, 1978). However, the particularly low reliability of the Knowledge scale (α = .328) means that all correlations involving knowledge scores should be interpreted with considerable caution, as measurement error may obscure true relationships or create spurious ones.

The particularly low alpha for the Knowledge scale (.328) likely reflects the diverse nature of climate knowledge measured, including weather versus climate distinctions, greenhouse effect understanding, human impacts, and natural causes, which may represent distinct rather than unified constructs. The Intentions scale's modest reliability (.528) suggests the four intention items, while related, capture different aspects of environmental action orientation.

Table 1: ***Reliability Analysis of Survey Items Using Cronbach's Alpha***

Survey Dimension	No of items	Cornbach's Alpha
Knowledge	4	.328
Belief	11	.643
Intention	4	.528

All quantitative data collection was fully anonymous.

The qualitative data collected from open-ended responses were recorded, transcribed, and coded. Transcriptions were analyzed using thematic analysis (Marshall & Rossman, 2014). To convert qualitative responses into quantitative data (on a scale of 1–5), a coding system was developed by reviewing a selection of student responses:

Survey Administration

To ensure consistency, all undergraduate tutors received standardized written and verbal training before survey administration. They were instructed to read each survey item verbatim and to use only approved examples or visual cues when clarifying vocabulary for students. Tutors were prohibited from rewording or interpreting questions beyond these standardized supports.

Surveys were administered individually in quiet classroom settings to reduce distractions. Each session followed the same time frame and structure. Audio recordings documented student–tutor interactions, which were later reviewed to confirm procedural adherence. Although minor differences in phrasing may have occurred, these checks indicated overall fidelity to the standardized protocol.

While tutors provided accessibility support to multilingual learners, such as explaining unfamiliar English words, these accommodations were implemented within the approved guidelines. Thus, survey delivery was largely uniform while remaining responsive to students' linguistic needs. Despite standardized training, some variability in tutors' delivery or clarification of items may have influenced student responses. While checks confirmed overall procedural fidelity, inconsistent linguistic support cannot be fully ruled out.

Data Analysis

Research questions were addressed through a mixed-methods approach, integrating quantitative and qualitative data.

Quantitative Analysis: Using SPSS Statistics (Version 29), I calculated Pearson correlation coefficients to examine relationships among Knowledge, Belief, and Intention **for the full sample (N = 73)**. For the analytically nested Active Multilingual Subgroup (N = 11), only descriptive statistics (means and standard deviations) are reported. Because the N = 11 subgroup is too small to meet the assumptions required for Pearson correlation (insufficient sample size and limited statistical power), inferential correlational analyses were not performed for that subgroup.

Qualitative Analysis: Qualitative data, consisting of open-ended responses to questions about the difference between weather and climate, beliefs about natural climate change, and the impact of cars on climate change, were analyzed using thematic analysis (Marshall & Rossman, 2014). Thematic analysis provided richer insights and helped identify specific examples. The coding schemes were developed by carefully reading and organizing the ideas brought up by participants. Each code was assigned a definition and examples to ensure standardization.

To ensure reliability in the qualitative analysis, a systematic approach to coding was applied. The researcher conducted multiple rounds of coding on a subset of responses, refining the codes and their definitions to maintain consistency. Coded segments were regularly reviewed and compared throughout the analysis process. While inter-rater reliability could not be calculated due to the independent nature of the research, this iterative approach enhanced the reliability and consistency of the coding scheme.

Results

The result section is structured according to the research questions.

What climate change knowledge do urban middle school multilingual students possess?

I assessed students' climate change knowledge through four questions designed to address key foundational concepts. These included distinguishing between weather and climate, understanding natural versus human causes of climate change, examining students' awareness of the human role in contributing to global warming through everyday actions (e.g., driving cars), and understanding underlying scientific mechanisms of climate change, such as the greenhouse effect.

Given the diversity within my sample of students classified as multilingual learners, I present findings in two ways: patterns across the full sample (N=73) and focused analysis of students with direct immigration experience and active heritage language maintenance (N=11).

Assessment results indicated that students' responses to climate change questions scored relatively low across the full sample (mean scores ranging from 1.32 to 2.45 out of 5). The lowest mean scores were observed in responses regarding the greenhouse effect (mean 1.32).

When examining the subset of students with immigration experience and heritage language maintenance (N=11), descriptive patterns differed from the full sample, though the small sample size limits the generalizability of these observations: weather/climate distinction showed moderate scores (M=3.00, SD=0.775), natural climate causes remained challenging (M=2.45, SD=1.293), human impacts demonstrated the highest scores (M=3.64, SD=1.206), while scientific mechanisms like the greenhouse effect remained the lowest scoring area (M=1.64, SD=1.027).

Table 2: *Summary of Findings from Student Responses*

Key knowledge area	Theme	Response Pattern	Students quote
System Knowledge	Difference between weather & climate; greenhouse effect- Heat and gas trapping in the atmosphere	Confusing weather with climate; lack of familiarity with the greenhouse effect	“They’re the same.” “Heat and gases trapped in Earth’s atmosphere.”
System Knowledge	Natural causes of climate change	Vague or irrelevant examples of natural changes	“Volcanoes.” “It’s natural when it’s hot, then cold.”
Action Knowledge and Effectiveness Knowledge	Impacts of cars on the climate	Focusing on functionality, not emissions	Cars are for driving.” “Cars release gas that affects the environment.”

Given the low internal consistency of the knowledge scale (α = .328), these results should be interpreted with caution. The variability across items suggests that the construct of climate knowledge may not have been measured as a single dimension.

Many students displayed gaps in their conceptual understanding of climate change, reflecting both partial knowledge and misconceptions. For example, when asked about the difference between weather and climate, Alex, who demonstrated an accurate understanding, explained, "Weather is short-term, and climate is overall." However, Maria expressed confusion, stating, "They're the same," while Sam added, "Climate is earthquakes, and weather is storms." When asked about natural examples of climate change, Liam correctly identified volcanic activity, saying, "Volcanoes contribute to natural climate change." On the other hand, Sophia offered vague responses, such as, "It's natural when it's hot, then cold." Similarly, Olivia admitted uncertainty, stating, "I don't know." The question regarding the impacts of cars on climate change revealed gaps in systemic knowledge. Ethan demonstrated an accurate understanding, noting, "Cars release gas that affects the environment." However, others, like Noah, focused solely on functionality, stating, "Cars are for driving, so they don't cause problems." Lastly, students' understanding of the greenhouse effect was notably weak. While Isabella correctly explained it as "Heat and gases trapped in the Earth's atmosphere," most students expressed uncertainty, with Mason stating, "I don't know," and Emma adding, "Not sure."

What intentions and beliefs regarding climate change exist among urban middle school students?

Survey responses reveal that learners generally agreed with statements about climate change and its environmental effects, but showed more varied responses regarding human influence and personal agency.

Participants generally responded positively to statements about climate change and its environmental consequences. Most students strongly agreed that climate change is occurring ($M = 4.08$, $SD = 0.968$) and that it will impact the environment ($M = 4.00$, $SD = 1.167$). They also agreed that climate change hurts their lives ($M = 4.10$, $SD = 0.670$). Students showed moderate agreement with the existence of proof for global climate change ($M = 3.93$, $SD = 1.134$) and expressed moderate concern about the issue ($M = 3.48$, $SD = 1.029$). However, responses showed more uncertainty regarding human responsibility, with lower agreement on whether human activities cause global climate change ($M = 3.42$, $SD = 1.301$).

Descriptive analysis of students with immigration experience and heritage language maintenance ($N=11$) showed some different response patterns, though the small sample size limits generalizability. These students showed strong agreement with the existence of climate change proof

(M = 4.00, SD = 1.000) and that climate change negatively affects lives (M = 4.09, SD = 0.539). However, their personal agreement with climate change statements was more moderate (M = 3.64, SD = 1.362), and concern levels were lower than the full sample (M = 3.18, SD = 1.328). They showed moderate agreement that climate change will impact the environment (M = 3.82, SD = 1.537) and that human activities cause climate change (M = 3.73, SD = 1.489). Responses indicating personal experience with climate change effects remained limited (M = 1.91, SD = 1.044).

Intentions Toward Climate Action

While students expressed strong environmental concern (M = 4.08, SD = 1.115), response patterns regarding personal agency were more complex. In this study, personal agency refers to beliefs about one's capacity to engage in purposeful actions that notablely impact their surroundings. Students strongly agreed that trying to fix environmental problems is worthwhile (M = 4.18, SD = 1.229) and showed moderate confidence in their personal capacity to help solve environmental problems (M = 3.53, SD = 1.435). However, they expressed uncertainty about whether their individual actions actually impact the environment (M = 2.93, SD = 1.378) and showed moderate agreement that individuals can help stop global climate change (M = 3.11, SD = 1.420). Students also demonstrated moderate skepticism about whether environmental problems are exaggerated (M = 2.56, SD = 1.258) and strong agreement that they can make the world better for future generations (M = 3.85, SD = 1.210). There was notable ambivalence about collective action, with moderate agreement that "we cannot do anything to stop global climate change" (M = 3.45, SD = 1.546), suggesting mixed responses about collective efficacy.

Among students with immigration experience, response patterns regarding personal agency and environmental perceptions were similarly complex. These students demonstrated very strong environmental care (M = 1.73, SD = 0.647), indicating high concern for environmental issues. They disagreed that people make environmental problems sound worse than they really are (M = 2.27, SD = 1.272) and rejected the notion that their actions don't impact the environment (M = 2.45, SD = 1.440). However, they were more ambivalent about whether trying to fix environmental problems is worthwhile (M = 3.64, SD = 1.629) and showed moderate uncertainty about their ability to help solve environmental problems (M = 3.18, SD = 1.537). They also showed confidence in making the world better for future generations (M = 3.82, SD = 1.168) and disagreed that we cannot do anything to stop climate change (M = 2.45, SD = 1.368), but had lower confidence that individuals can help stop climate change (M = 2.45, SD = 1.695), revealing complex response patterns regarding individual versus collective efficacy.

Table 3: ***Descriptive Statistics for Climate Change Beliefs (N = 73) and (N=11)***

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
I believe our climate is changing.	73	1	5	4.08	.968
I am concerned about global climate change.	73	1	5	3.48	1.029
I think there is proof of global climate change.	73	1	5	3.93	1.134
Climate change will impact the environment.	73	1	5	4.00	1.167
Individuals can help stop global climate change.	73	1	5	3.11	1.420
Human activities cause global climate change.	73	1	5	3.42	1.301
Climate change has a negative effect on our lives.	73	3	5	4.10	.670
I can do my part to make the world a better place for future generations.	73	1	5	3.85	1.210
We cannot do anything to stop global climate change.	73	1	5	3.45	1.546
I care about environmental problems and issues.	73	1	5	4.08	1.115
Valid N (listwise)	73				

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
I believe our climate is changing.	11	1	5	3.64	1.362
I am concerned about global climate change.	11	1	5	3.18	1.328
I think there is proof of global climate change.	11	2	5	4.00	1.000
In what ways have you or your family felt the effects of climate change? please provide an example	11	1	4	1.91	1.044
Climate change will impact the environment.	11	1	5	3.82	1.537
Individuals can help stop global climate change.	11	1	5	2.45	1.695
Human activities cause global climate change.	11	1	5	3.73	1.489
Climate change has a negative effect on our lives.	11	3	5	4.09	.539
I can do my part to make the world a better place for future generations.	11	2	5	3.82	1.168
We cannot do anything to stop global climate change.	11	1	5	2.45	1.368
I care about environmental problems and issues.	11	1	3	1.73	.647
Valid N (listwise)	11				

Table 4: *Descriptive Statistics for Climate Change Intentions* (N=73) and N=(11)

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
People make environmental problems sound worse than they really are.(R)	73	1	5	2.56	1.258
The things I do don't impact the environment.(R)	73	1	5	2.93	1.378
Trying to fix environmental problems is a waste of time.(R)	73	1	5	4.18	1.229
There's not really anything I can do to help solve environmental problems. (R)	73	1	5	3.53	1.435
Valid N (listwise)	73				

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
People make environmental problems sound worse than they really are.	11	1	5	2.27	1.272
The things I do don't impact the environment.	11	1	5	2.45	1.440
Trying to fix environmental problems is a waste of time.	11	1	5	3.64	1.629
There's not really anything I can do to help solve environmental problems.	11	1	5	3.18	1.537
Valid N (listwise)	11				

How does urban middle school multilingual learners' climate change knowledge relate to their intentions and beliefs regarding climate change?

A Pearson correlation analysis examined relationships between environmental knowledge, beliefs, and behavioral intentions. Analysis of the full sample (N=73) showed the following correlation patterns: Knowledge-Belief: r = .160, p = .177, Knowledge-Intention: r = .067, p = .571, and Belief-Intention: r = .365, p = .002. Only the belief-intention correlation reached statistical significance, suggesting that responses to climate change belief statements were associated with responses to intention statements in this sample, while knowledge scores showed no notable relationships with either beliefs or intentions.

For the Active Multilingual Subgroup (N = 11), I present only descriptive statistics (means and standard deviations) for knowledge, belief, and intention scores due to the subgroup's small sample size. The sample of 11 students is insufficient to meet the distributional and power assumptions required for valid Pearson correlation analyses; therefore, correlation coefficients and inferential tests were not computed for this subgroup. Descriptive patterns for the subgroup are reported in Tables 3–

4 (where subgroup means and SDs appear), and any comparisons between subgroup and full-sample means are treated as exploratory and descriptive rather than inferential.

The lack of notable knowledge-belief and knowledge-intention relationships across both analyses indicates that, in this sample, students' climate change knowledge scores were not strongly associated with their belief or intention responses, consistent with research suggesting that the relationship between environmental knowledge and attitudes is complex and mediated by multiple factors.

Discussion

By integrating cognitive-behavioral theories (TPB, TRC) with language and identity frameworks (BICS/CALP and raciolinguistic critique), this study interprets multilingual learners' climate literacy as shaped by both internal beliefs and sociolinguistic contexts. The findings illustrate how limited academic language proficiency may constrain expression of climate knowledge even when conceptual understanding exists.

More than Language Barriers

My assessment found that students' understanding of climate change concepts varied across different areas. Many participants demonstrated misconceptions such as equating the 'greenhouse effect' with physical greenhouses or conflating natural disasters with climate change phenomena. These patterns are consistent with Reid's (2019) findings among secondary students, though Reid's study focused on monolingual English speakers, raising questions about whether the misconceptions observed stem from linguistic challenges or reflect broader conceptual difficulties common across student populations.

The comparison between the full sample of students in this linguistically diverse setting (N=73) and students with immigration experience and heritage language maintenance (N=11) provides some insights into this question. Both groups showed challenges with formal scientific mechanisms, particularly the greenhouse effect, which remained the weakest area for students with immigration experience (M=1.64). This consistency across groups supports Wibeck's (2014) research, indicating that students from different contexts struggle with scientific concepts like greenhouse gases, suggesting this may reflect pedagogical challenges that transcend language backgrounds. However, a notable difference emerged in responses about human impacts on climate change. While the full sample showed limited knowledge across domains (M=1.32-2.73), students with immigration experience showed higher mean scores on human impacts (M=3.64). This pattern suggests that students with immigration experiences and heritage language maintenance may respond differently to conventional environmental assessments, though whether this reflects different ways of understanding environmental issues or limitations in my assessment approach requires further investigation (Fien & Rawling, 1996).

The linguistic patterns observed such as incomplete sentence constructions or reliance on everyday vocabulary were evident across both samples. Audio transcription analysis revealed responses like "I believe so" or "It getting cold more than it should be," suggesting that students may still be developing the cognitive/academic language proficiency (CALP) necessary for scientific discourse, as articulated by Cummins (1979). However, the different performance patterns between groups on human impacts suggest that academic language challenges do not uniformly affect all domains of climate understanding.

Prior research highlights how cultural narratives and everyday experiences shape students' understanding of climate change (Rousell & Cutter-Mackenzie-Knowles, 2019). The students with immigration experience may have been exposed to different cultural frameworks for understanding human-environmental relationships, possibly informed by experiences from their countries of origin where environmental changes may be more directly observable.

Beyond Linear Models: Complex Response Patterns

The varied responses illustrate this complexity clearly. When asked about weather versus climate, Alex demonstrated scientific understanding, explaining "Weather is short-term, and climate is overall," while Maria expressed confusion, stating "They're the same," and Sam added "Climate is earthquakes, and weather is storms." These varied responses suggest that students may show different patterns when encountering formal climate science concepts.

The response patterns are consistent with Bandura's (1999) triadic reciprocal causation model, which suggests that personal factors (knowledge and beliefs), behavioral patterns, and environmental influences interact in complex, non-linear ways rather than through simple causal pathways. For students navigating multiple cultural and educational contexts, these interactions may be particularly complex.

Correlation analyses showed that while climate change beliefs notablely correlated with behavioral intentions in the full sample ($r=.365$, $p=.002$), this relationship was not observed among students with immigration experience ($r=.095$, $p=.781$). While the small subset size prevents definitive interpretation, these different correlation patterns suggest that students with different educational and cultural experiences may show varied response relationships. This is consistent with research indicating that relationships between knowledge, beliefs, and intentions are complex and mediated by multiple factors (Kollmuss & Agyeman, 2002). The limited reliability of the knowledge measure likely attenuated observed correlations, meaning true relationships between knowledge and beliefs may be stronger than detected. Future iterations should expand and refine these items to enhance psychometric reliability.

Environmental Engagement and Self-Efficacy

Response patterns regarding environmental engagement showed complexity across both the full sample and the subset of students with immigration experience. While the broader sample showed moderate agreement regarding human responsibility for climate change (M=3.42, SD=1.301) and uncertainty about individual environmental impact (M=2.93, SD=1.378), students with immigration experience showed different response patterns.

Despite higher agreement that human activities cause climate change (M=3.73) compared to the full sample, students with immigration experience expressed lower confidence that individuals can help stop climate change (M=2.45). Most notably, they demonstrated very high environmental concern (M=1.73, where lower scores indicate higher concern) while reporting limited personal experience with climate effects (M=1.91). This pattern high environmental concern paired with limited reported personal experience with climate impacts suggests complexity in how students relate to environmental issues, though the small sample size (n=11) limits the generalizability of this observation.

These patterns are consistent with Monroe et al. (2019), indicating that feelings of uncertainty may hinder pro-environmental behaviors, even when students acknowledge both human responsibility and possess strong environmental concern. The emotional complexity was evident in student responses. Many expressed concerns about climate change coupled with helplessness, as seen in comments like "What can one person do?" Such statements are consistent with Kollmuss and Agyeman's (2002) observation that worry, when combined with a lack of perceived efficacy, can lead to apathy. However, students who could envision actionable steps demonstrated different patterns. As one student said, "If we could plant trees in school, I'd do it," supporting Taber and Taylor's (2009) argument that concern, when paired with trust in mitigation strategies, can foster action. This suggests that the disconnect between high concern and low efficacy among students with immigration experience may be addressable through concrete, achievable environmental activities.

The response patterns suggest that many students demonstrated awareness of climate issues while possibly lacking what Kolenatý et al. (2022) term "action knowledge" understanding of how specific behaviors contribute to climate solutions. For instance, a student mentioned "Cars make the climate hotter," but could not connect this observation to broader systemic impacts like greenhouse gas emissions. This example illustrates the potential importance of integrating action knowledge into curricula, as advocated by Kolenatý et al. (2022).

By integrating quantitative survey patterns with students' open-ended responses, I was able to triangulate findings and capture both statistical trends and the contextualized reasoning behind them. This mixed-methods integration enhances the interpretive depth of the study and supports more nuanced insights into multilingual learners' climate literacy.

Limitations

This study has several important limitations that affect the interpretation and generalizability of findings.

Sample Size and Statistical Power

The focus on truly multilingual students (N=11) created statistical power limitations, preventing definitive conclusions about relationships among knowledge, beliefs, and intentions. While the descriptive patterns revealed meaningful differences, all correlations in the multilingual subset were non-significant due to small sample size. Additionally, because the Active Multilingual Subgroup (N=11) is part of the larger dataset (N=73), their responses contribute to both analyses. This overlap was intentional, designed to reflect the nested nature of multilingualism within diverse classrooms rather than to produce independent samples.

Multilingual Identity Measurement

The identification of multilingual students relied on self-reported home language use and immigration history, which likely underestimated the multilingual population. Students may have underreported multilingual practices due to social desirability bias or political sensitivities around immigration discourse during data collection.

Methodological Constraints

The cross-sectional design prevented examination of developmental processes. Survey instruments administered in English may have disadvantaged students developing academic language proficiency or those who might express understanding more fully in heritage languages. Climate knowledge measures focused on formal scientific concepts and may not have captured informal environmental knowledge from cultural backgrounds.

Instrument Reliability Limitations

The Knowledge scale demonstrated poor internal consistency (α = .328), which notablely limits the interpretability of all knowledge-related correlations and findings. While this low reliability may be partially attributed to the small number of items and exploratory nature of the study (Nunnally, 1978), it nonetheless means that the knowledge-belief and knowledge-intention relationships observed may reflect measurement error rather than true associations. This reliability limitation is particularly important when interpreting the different correlation patterns observed between the full sample and the immigration experience subset, as these differences may be artifacts of measurement inconsistency rather than meaningful group differences.

Geographic and Demographic Scope

The study was conducted in one urban middle school, limiting generalizability to other settings, grade levels, or geographic regions. The urban context may not represent multilingual student experiences in rural or suburban environments.

Survey Administration Variability

Although tutors followed standardized instructions, slight variability in assistance may have occurred due to individual communication styles. These differences could have influenced comprehension for some students. Additionally, since the survey was conducted entirely in English, accessibility may have been limited for participants who were more comfortable in other languages. Future studies should consider offering translated versions or bilingual administration to enhance validity across multilingual populations

Variation in tutor scaffolding during survey administration may have introduced subtle differences in student comprehension, particularly for complex climate terms.

Conclusion

This study looked at climate change knowledge, beliefs, and intentions among 73 students in a linguistically diverse middle school setting. In the full sample (N = 73), beliefs correlated positively with intentions (r = .365, p = .002). For the subgroup of students with immigration experience and heritage language maintenance (N = 11), results are reported descriptively only because the small sample size precluded valid correlation analysis. These students also showed a different correlation pattern where climate knowledge and beliefs were negatively related (r=-.315, p=.345), even though they demonstrated stronger understanding of how humans impact climate change (M=3.64). My preliminary findings suggest that students with different language and immigration experiences may respond differently to climate education, and future research with larger samples could explore whether schools might benefit from approaches that recognize and build on the diverse environmental knowledge these students bring.

Conflict of Interest Statement

The author declares no conflicts of interest.

Data Availability Statement

The datasets generated and analyzed during the current study are available from the author upon reasonable request.

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Appendix 1:

Figure 1 : *Gender distribution of Study Participants*

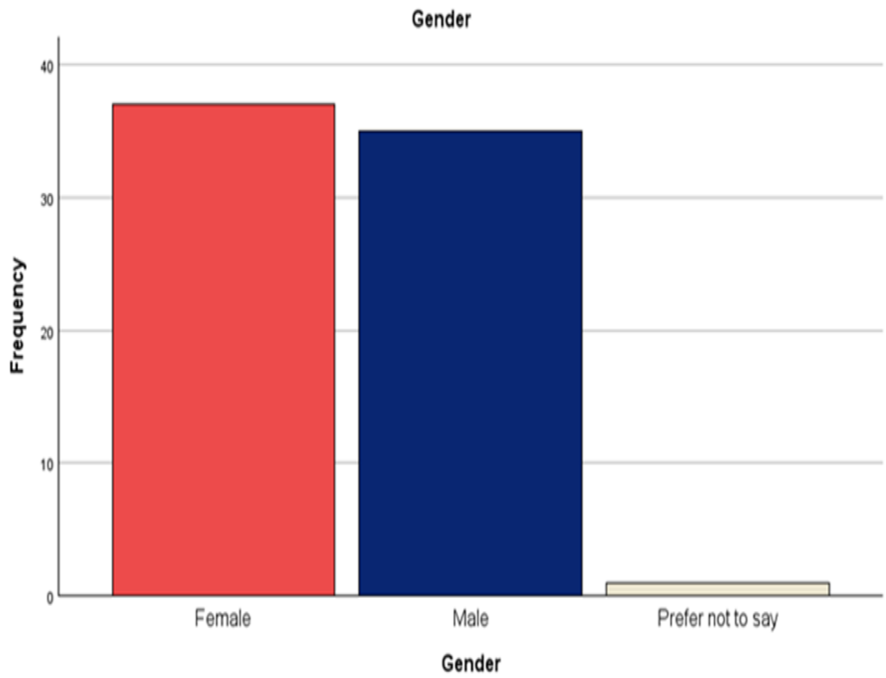


Figure 2: *Grade distribution of Study Participant*

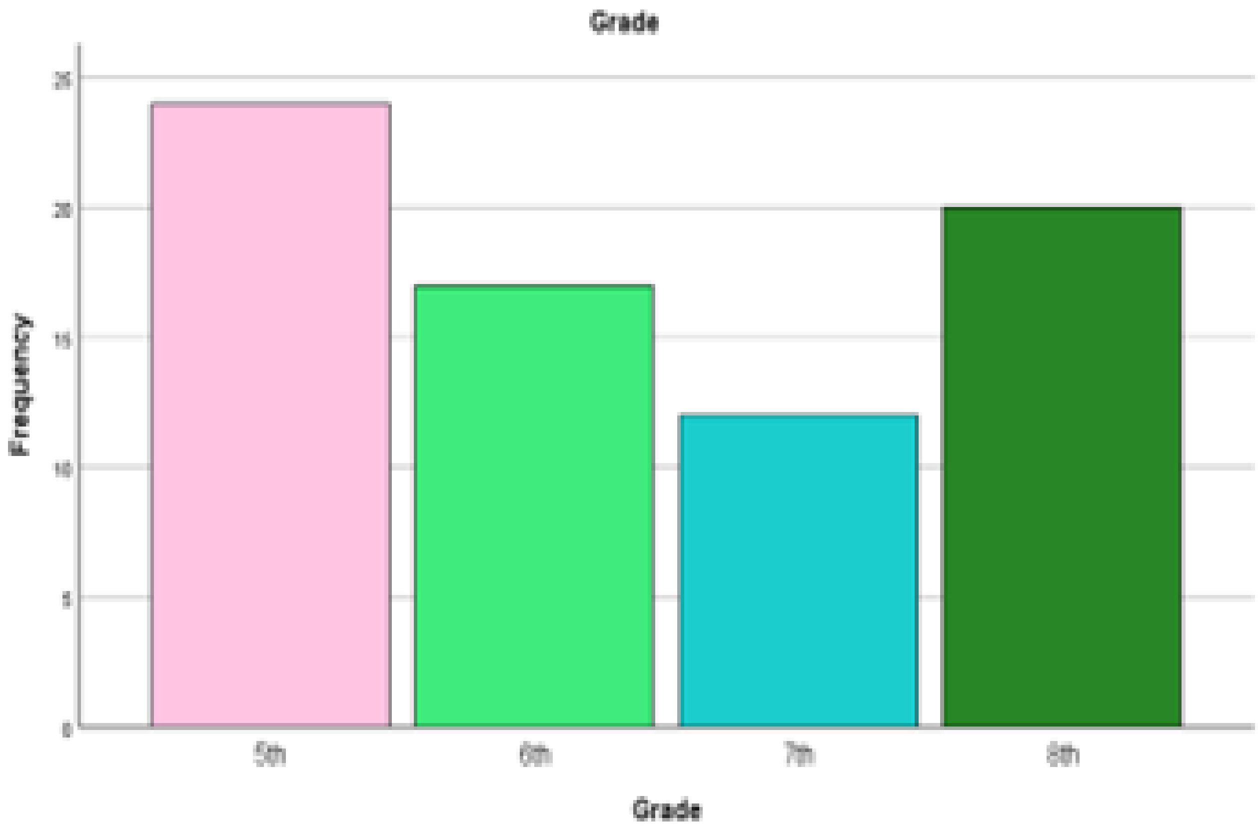


Figure 3: *languages Spoken at Home by Study Participants*

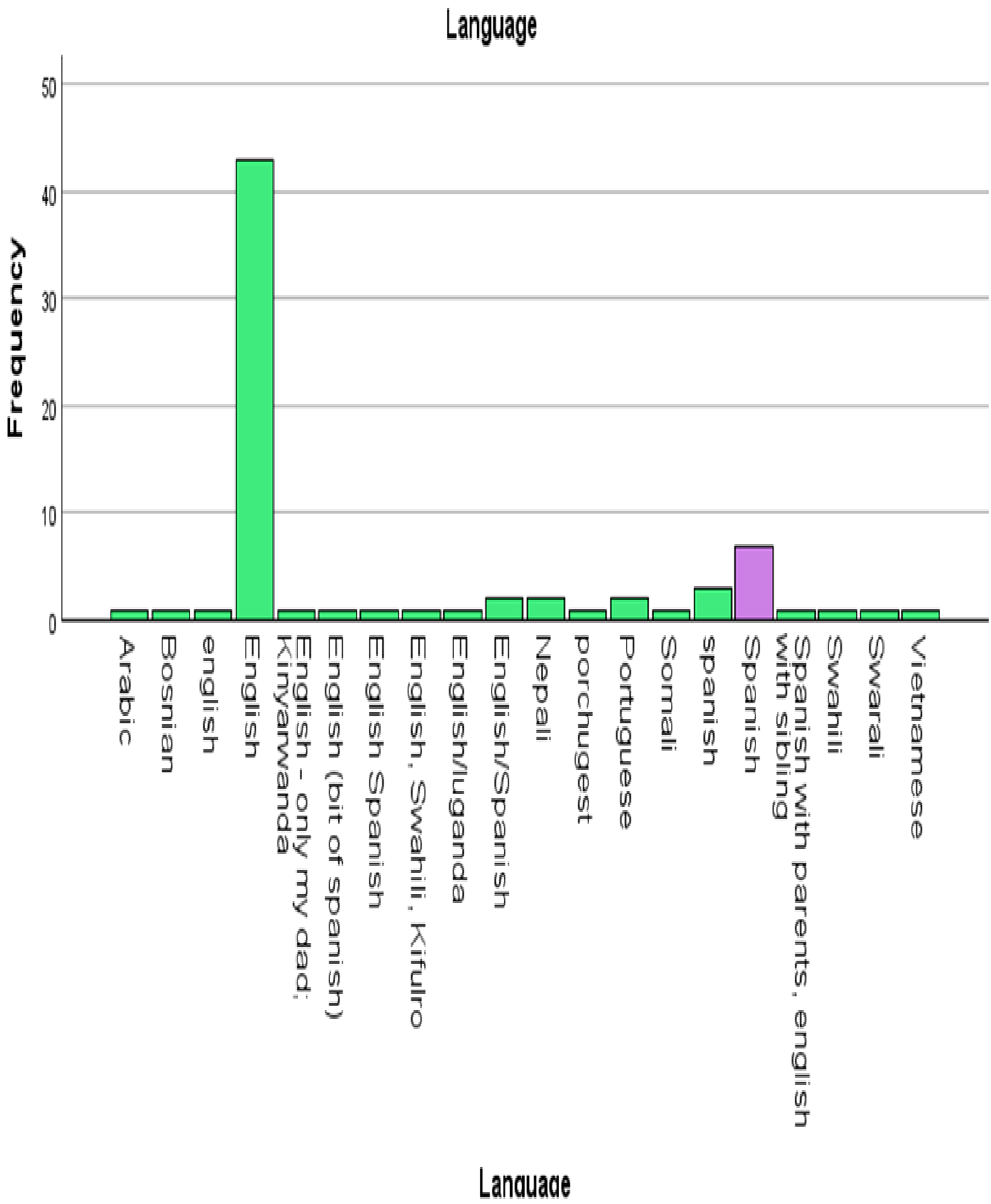


Figure 4: *Nativity of Study Participants*

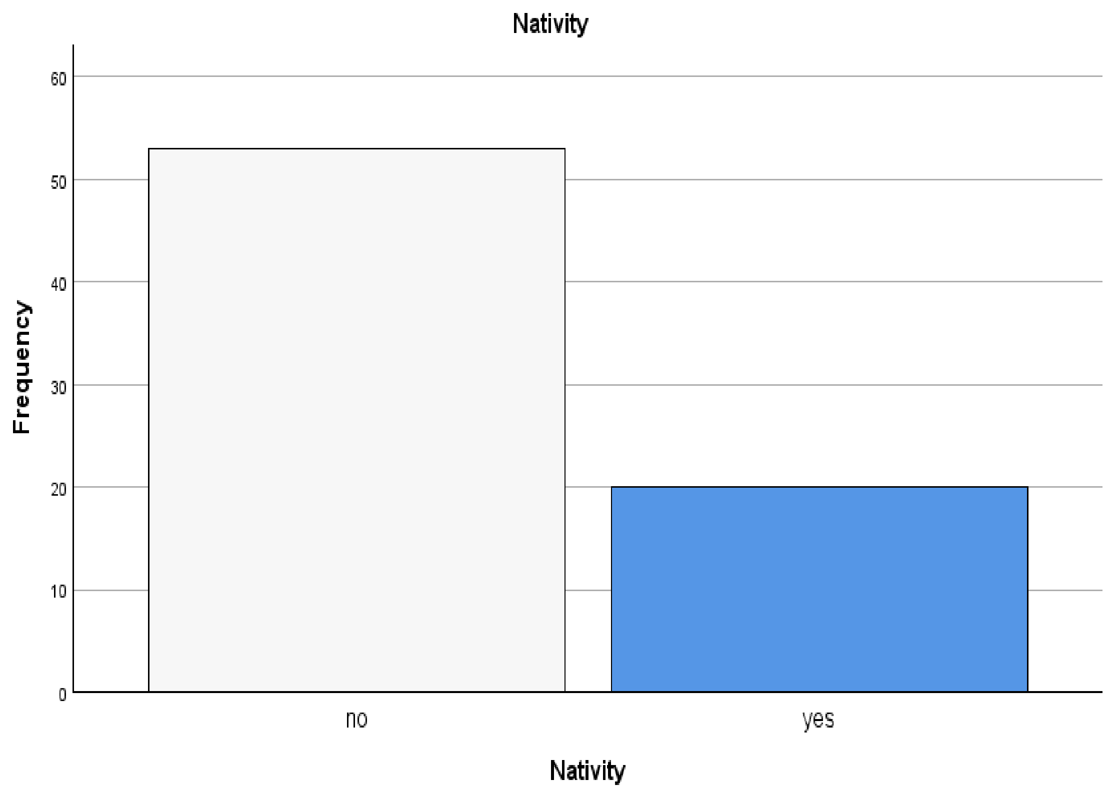
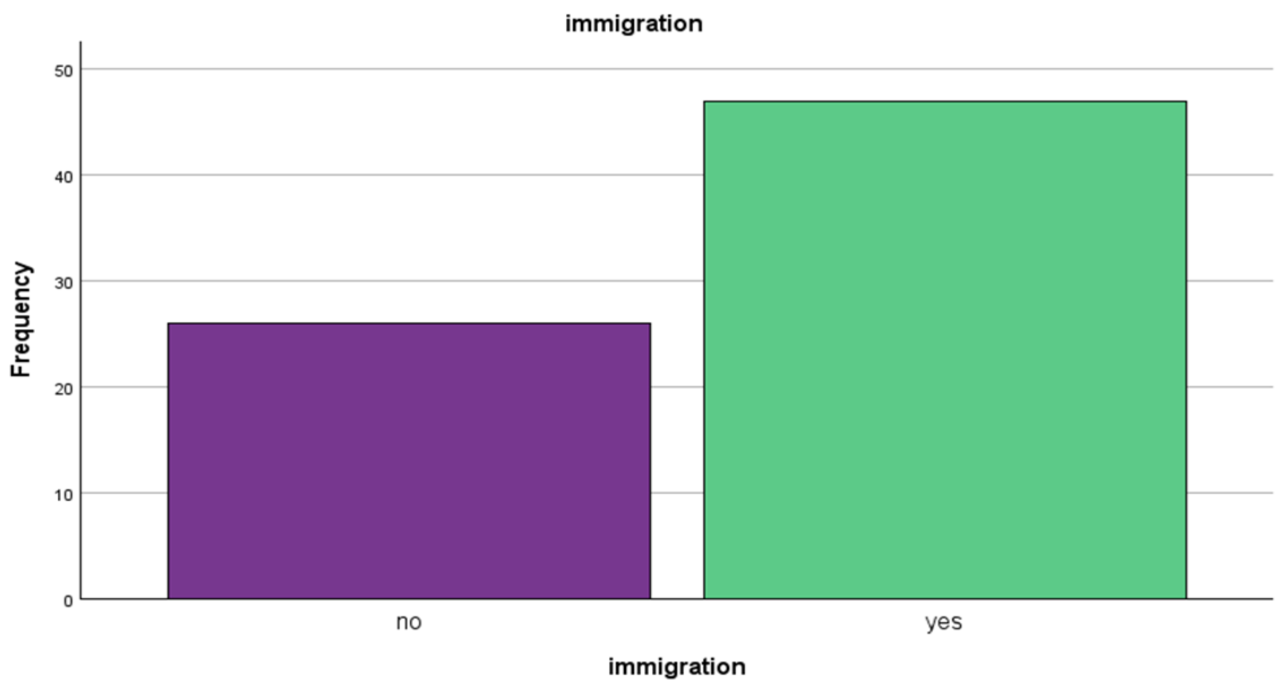


Figure 5: *Immigration Status of Study Participants*



Appendix 2

Climate Change Knowledge Survey

Start of Block: Introduction

Greetings, Middle School Students,

I warmly invite you to participate in my Climate Change Knowledge Survey. This survey aims to understand your views and knowledge about climate change, an important global issue.

Participation in this survey is voluntary. I understand that not everyone may want to take part; however, if you are interested in sharing your thoughts on climate change, I would greatly appreciate your input.

Your responses will be kept confidential and will be used for research purposes only. The information will help me understand what students know about climate change and guide future instructional practices.

Thank you for considering participation in this survey.

Section 1: Background Information

1. What is your gender?

   ☐ Male ☐ Female ☐ Prefer not to say

2. What grade are you currently in?

   ☐ 5th ☐ 6th ☐ 7th ☐ 8th

3. What language do you speak most often at home?
4. Were you born in New Hampshire (NH)?

   ☐ Yes ☐ No

5. Did you move here from another country?

   ☐ Yes ☐ No

Section 2: Knowledge

1. What (if anything) is the difference between weather and climate?

2. If you believe climate change can occur naturally, can you think of an example?

3. What (if any) are the impacts of cars on climate change?

4. How would you describe the greenhouse effect?

Section 3: Beliefs

For each statement, choose the response that best represents your opinion.

Statement	**Strongly Disagree (1)**	**Somewhat Disagree (2)**	**Neither Agree nor Disagree (3)**	**Somewhat Agree (4)**	**Strongly Agree (5)**
I believe our climate is changing.	☐	☐	☐	☐	☐
I am concerned about global climate change.	☐	☐	☐	☐	☐
I think there is proof of global climate change.	☐	☐	☐	☐	☐

Climate change will impact the environment.	☐	☐	☐	☐	☐
Individuals can help stop global climate change.	☐	☐	☐	☐	☐
Human activities cause global climate change.	☐	☐	☐	☐	☐
Climate change has a negative effect on our lives.	☐	☐	☐	☐	☐
I can do my part to make the world a better place for future generations.	☐	☐	☐	☐	☐
We cannot do anything to stop global climate change.	☐	☐	☐	☐	☐
I care about environmental problems and issues.	☐	☐	☐	☐	☐

Open-ended question:

In what ways have you or your family felt the effects of climate change? Please provide an example.

Section 4: Intentions

Statement	Strongly Disagree (1)	Somewhat Disagree (2)	Neither Agree nor Disagree (3)	Somewhat Agree (4)	Strongly Agree (5)

People make environmental problems sound worse than they really are.	☐	☐	☐	☐	☐
The things I do don't impact the environment.	☐	☐	☐	☐	☐
Trying to fix environmental problems is a waste of time.	☐	☐	☐	☐	☐
There's not really anything I can do to help solve environmental problems.	☐	☐	☐	☐	☐