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ORIGINAL PAPER

A science teacher's experiences when fostering intercultural competence among students in multilingual classrooms: a narrative study

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Abstract
Increased globalization of the world economy, growth in human migration, and rapid developments in science and technology have required people to develop intercultural communication skills. Teachers play a crucial role in developing intercultural competence among students in our globalized, multilingual classrooms. The need for fostering collaborative discourse among students with diverse cultural and linguistic repertoires and building intercultural competence among students is a common blind spot in Science, Technology, Engineering, and Mathematics teacher praxis. This can inhibit efforts to cultivate safe and supportive learning environments for *all* students and can ultimately threaten multilingual student success. As part of a larger study, this narrative inquiry explores the phenomenon of intercultural competence development through the lived experiences of a Midwestern secondary science teacher. Time series data were collected from the participant (11 semi-structured, in-depth, online interviews over 8 months). Field notes and artifacts served as secondary data. Informed by Michael Byram's Multidimensional Model of Intercultural Competence, interviews were designed, conducted, transcribed, and member checked. Then, transcripts, field notes, and artifacts were coded and analyzed using Jean Clandinin and Michael Connelly's three-dimensional narrative inquiry framework to arrive at synthesized stories of experience around coalescing themes. The findings revealed the participant utilized several strategies aimed at developing intercultural communicative competence, particularly in support of multilingual students. This paper focuses on the four themes that relate most directly to intercultural communicative competence development. The findings and implications are discussed within the context of Byram's model and conclusions are drawn to inform current and future work in this area.

Keywords Intercultural communicative competence · English language learners · Teacher's culturally responsive and sustaining pedagogies · Stories of experience · Restorying

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Identification of the research problem

Living in the twenty-first century means living in a globalizing world where borders continuously shift, blur, and/or tighten; cultures merge; and international relations become the basis for a well-functioning tomorrow. Living in this era of globalization requires all individuals to have more diverse competencies and requires the educational system to focus on teaching students the skills necessary for successfully mastering the demands of this new and ever-changing world (Schenker 2012). Equity literacy (Gorski 2016) and the ability to communicate across differences (LeBaron 2003) have become increasingly important as we all work to navigate current sociocultural complexities and the enduring educational and economic impacts of a global pandemic. Such skills serve as tools to help us overcome prejudice, discrimination, and misunderstandings between people of different cultural backgrounds (Reid 2015). Additionally, increased globalization of the world economy, growth in human migration in the twenty-first century, and rapid developments in science and technology have required people across disciplines to develop their competence in intercultural communication as well as their appreciation for and understanding of diverse cultures and languages (Huang 2014). Teachers play a crucial role in developing these competencies and dispositions among students in our increasingly globalized, multilingual classrooms (Gibbons 2003). One way to equip students with the linguistic and cultural skills to understand and communicate successfully with people from a wide range of backgrounds is to foster their development of intercultural competence (Schenker 2012).

Michael Byram (1997) defines intercultural competence as the ability to function efficiently within one's own as well as other cultures and having the skill to engage in meaningful and successful interactions with individuals from diverse cultural backgrounds. From the point of view of educators, intercultural competence is an educators' ability to relate to and communicate effectively and appropriately with students who represent a wide range of cultural and plurilinguistic identities. Teachers must continually develop this important skill in themselves and their students if they want to genuinely create a classroom ecology that supports and affirms the identities and experiences of all students. Research on intercultural competence development confirms and underscores the importance of preparing students to engage and collaborate across differences by discovering appropriate ways to interact with people with diverse cultural repertoires (Sinicrope, Norris and Watanabe 2007).

Science education for diverse learners in the twenty-first century

This study explores a Midwestern high school teacher's lived experiences within a multilingual science classroom. Therefore, it is important for us to provide some context of science education in the USA and how the field intersects with issues of ethnic-racial and linguistic diversity. Science educators and educational institutions have long been concerned about the status and quality of science content being taught in K-12 schools and the delivery of the content (McWright 2017). Educational reformers in the USA continue to strive to solve the problem of how to best teach science for optimal learning for all students, and US students' science and math literacy scores on international comparative assessments show little evidence of progress toward this goal (Cadle 2020). With mandatory testing nationwide, along with increased demands in

science, technology, engineering, and mathematics (STEM) jobs and a limited skilled workforce to fulfill these needs, the question of what to teach and how to teach science remains a concern among educators and stakeholders (McWright 2017).

The creation and implementation of the Next Generation Science Standards (NGSS) and the Common Core Standards in K-12 education have taken center stage in school improvement (NRC 2010). The purpose of NGSS is to better prepare students for the workforce and college by developing critical-thinking skills and scientific literacy as well as building interest in science, technology, engineering, and mathematics (McWright 2017). Many skills required in today's job market (both inside and outside STEM fields) can be developed in inquiry science classrooms (Bybee 2013).

Rodger Bybee (2010) emphasizes that in STEM programs, student investigations and projects present the time and opportunity for teachers to help students develop 21st-century skills, such as adaptability, complex communication skills, the ability to solve non-routine problems, self-management/self-development, and systems thinking (NRC 2010). According to a study by the National Research Council (2010), in classroom settings where teachers engage students with inquiry-based science teaching (E.g., using Bybee's 5E instructional model), there are greater increases in scientific reasoning ability among all students when compared to those in settings where more typical forms of science instruction are used.

Significance of the study

Some of the most widely used teaching models for effective instruction (such as Bybee's 5E Model, the Center for Research in Education, Diversity, and Excellence (CREDE) Model, and Krashen's Acquisition-Learning Hypothesis Model) utilize Lev Vygotsky's (1986) sociocultural theory of cognitive development and human learning as a foundation. Sociocultural theory argues that learning is a fundamentally *social process* where social interactions and *language* function as essential tools for scaffolding children's understanding. However, few instructional models give specific examples or strategies that foster the development of *intercultural competence* among students (Huang 2014). Furthermore, despite the fact that student populations in the USA continue to increase in cultural and linguistic diversity, these models do not attend to the role that ethno-racial-linguistic diversity (Herrera 2010) plays in shaping the *social ecology* of classrooms or the ramifications of not attending its salience (Morales and Raible 2021).

The need for fostering collaborative student discourse and building intercultural competence among students is a common blind spot in STEM teacher praxis (Lan and de Oliveira 2019). This can inhibit efforts to cultivate safe and supportive STEM learning environments for all students and can ultimately threaten multilingual student success (Sinicrope, Norris and Watanabe 2007). As part of a larger study (Ganesan and Morales 2022), this narrative inquiry explores the phenomenon of intercultural competence development through the lived experiences of a Midwestern high school science teacher. More specifically, it considers the ways in which one teacher fosters and facilitates the development of intercultural competence in her multilingual science classroom.

Research questions

The central research questions guiding this study were as follows: (1) What instructional strategies can foster, shape, and facilitate the development of intercultural competence among students in plurilinguistic and ethno-racially diverse science classrooms? and (2) What are the benefits of integrating science content and language instruction in support of English language learners (ELLs) specifically?

Philosophical assumptions

Our ontological and epistemological stance is that reality is ever emergent and fluid and knowledge is socially constructed and co-created between communicators. Jeong-Hee Kim describes traditional narrative inquiry as 'a storytelling methodology that enquires into narratives and stories of people's life experiences' (2016, p. 304). Rooted in philosophies of constructivism and symbolic interactionism, researchers engaged in narrative inquiry to collect data in the field, which Amos Hatch (2002) calls "extended firsthand engagement," in order to understand the problem or phenomenon of interest from the participants' points of view (Merriam and Tisdell 2016); which is also called the "emic" perspective (Bogdan and Biklen 2007).

This narrative study embraces the worldview of social constructivism or interpretivism as the paradigmatic framework (Creswell and Poth 2018) because as researchers, our goal is to interpret the participant's (science teacher's) constructions of the meaning of teaching science in her unique context and to understand how she builds students' intercultural competence. We chose to use the term ELL to describe emergent multilingual learners of English given that this is the term used by the teacher participant in the study.

Theoretical frameworks for intercultural competence

Based on the chronological and collective work of scholars and linguists such as Noam Chomsky (1957, 1965), Dell Hymes (1967, 1972), Michael Canale and Merrill Swain (1980), Michael Canale (1983), and Marianne Celce-Murcia, Zoltán Dörnyei and Sarah Thurrell (1995), Byram's (1997) *Multidimensional Model of Intercultural Competence* offers a comprehensive framework that encompasses diverse skills of intercultural competence, and it is widely accepted in the field (Moeller and Nugent 2014). Byram (1997) proposed a famous, five-factor model of intercultural competence in his book, *Teaching and assessing intercultural communicative competence*. According to Michael Byram, Bella Gribkova and Hugh Starkey (2002), intercultural competence consists of three components—knowledge, skills, and attitudes—and is supplemented by five values: (1) intercultural attitudes (curiosity and openness), (2) knowledge, (3) skills of interpreting and relating, (4) skills of discovery and interaction, and (5) critical cultural awareness. These five major intercultural competencies are strongly interrelated (Waliński 2012). Byram argues that the basis of intercultural competence is in the *attitudes of the person* interacting with people of another culture. Without this basic competence, the other four cannot truly develop (Waliński 2012).

Given that we consider intercultural competence (as described above) as important for science learners and highly relevant in inquiry-based science classrooms, we considered Byram's model as the central theoretical framework for our study. However, we also acknowledge the role of social constructivism. As stated by Weinburgh et al. "Science

educators have used social constructivism as a theoretical framework for research and practice for several decades. The constructivist learning theory suggests new knowledge is built by learners by integrating new ideas into what they had previously learned" (2014, p. 521). Similarly, Lev Vygotsky's (1978, 1986) sociocultural theory also shapes the philosophical and methodological orientations of this study. Vygotsky (1978, 1986) describes the concept of the Zone of Proximal Development (ZPD) as generating and leading development which is the result of social learning through the internalization of culture and interpersonal relationships, so the development of intercultural competence among students and between the teacher and the students taps into the profound potential of peers' supporting one another's growth within their zone of proximal development.

Literature review

In the extant literature relevant to this study, researchers reference different strategies that could help in fostering, shaping, and developing the intercultural competence of their students. Below we identify and synthesize salient points from the literature that explain, (a) the urgent need for instructional strategies, intercultural, content-specific classroom discourse strategies, and professional development for teachers to improve science literacy in STEM education, (b) the benefits of integrating science content and language instruction, and (c) the strategies for building intercultural competence of multilingual students.

Urgent need for instructional strategies, intercultural, content-specific classroom discourse strategies, and professional development for teachers to improve science literacy.

As indicated, as the school student population in the USA is becoming more linguistically and culturally diverse, it is essential to create learning environments that center on issues of equity and to provide learning opportunities that enhance academic achievement for all students (Lee 2003). With increasing demands in STEM fields and the need for students to enroll and succeed in STEM subjects, it is imperative that science education researchers focus on the strategies to improve the scientific literacy of linguistically diverse students who are the fastest-growing K-12 student population (Turkan and Liu 2012).

A study by Madhavi Tandon, Kara Mitchell Viesca, Colin Hueston, and Tamara Milbourn (2017) examined data from 36 teacher candidates and novice teachers of *multilanguage learners* (MLLs) to explore their perceptions and understandings of linguistic responsiveness. The findings illustrate that there are challenges faced by teachers in demonstrating linguistically responsive teaching practices in the early and initial stages of entering the teaching profession and that more research is necessary to understand how to support teachers in this complex mission.

Multilingual learners frequently confront the demands of academic learning through a yet unmastered language without the instructional support they need. As a result, ELLs often fall behind their English-speaking peers in content area learning, such as science (Lee and Buxton 2013). According to Shu Wen Lan and Luciana de Oliveira (2019), classroom discourse strongly influences the ability of all students to shift back and forth between the two linguistic registers represented by scientific language and everyday language; however, minimal scholarly attention has been paid to the content-specific language demands and challenges faced by upper elementary multilingual students learning science by participating (or failing to participate) in the discourses of multilingual science classrooms in US public schools. Because the concept of using home culture as a resource for teaching science is new to many teachers, they need extensive professional development

to understand how their students make sense of both home experiences and school science and how teachers play a role in helping their students bridge and articulate the two areas in ways that promote science learning (Lee and Buxton 2013). Schoolwide professional development opportunities should be provided for content (science) teachers. Content area teachers are often tasked with helping students develop language skills (English in the US school context) in addition to discipline-specific language (scientific language). Though content area (science) teachers are proficient in the academic language of their disciplines, few receive adequate training on how to teach students this discipline-specific language (Schleppegrell and O'Hallaron 2011).

Benefits of integrating heritage languages into the instruction of science content

In their study of science classrooms in Swaziland, Marissa Rollnick and Margaret Rutherford (1996) found the use of learners' heritage languages (e.g., SiSwati) to be a powerful means for learners to explore their ideas in science. Data analysis revealed that the use of SiSwati along with English served several important functions for students, including articulation and elimination of inaccurate conceptions, clarifying scientific concepts, and formulating ideas during group work.

In a study by Gibbons (2003), through their interactions with ELL students, two teachers mediated between the students' current linguistic levels in English and their commonsense understanding of science. Data revealed ways in which teachers build linguistic bridges to span the two types of discourse by showing how the interactions provide sites for L2 learning and promote specialist understandings of science. Iliana Reyes' (2009) study focused on the characteristics of discourse between Latino immigrant children and their teachers during science instruction. Peer interaction was analyzed to identify the use and importance of the native language (L1) for the development of content knowledge during group collaboration. In addition, the interaction between the teacher and fourth-grade students was analyzed to determine the importance of the adult's use of the L1 in providing instructional support to make science and literacy meaningful for linguistically and culturally diverse students. The findings indicated that students employed different discourse strategies to accomplish their communicative goals during the science activities. While Spanish was the main language of instruction during the science activity, children also used English and code-switches to challenge each other, reinforce major science concepts, and develop literacy skills. Reyes (2009) emphasized that discourse strategies in literacy and linguistic scaffolding can promote academic achievement among ELLs through the use of their native language. In another research study, Mary Hermes (2007) provided evidence of similar benefits associated with an Indigenous Language (Ojibwe) Immersion School she founded. In the school, all subjects were taught in Ojibwe, including science. Her findings revealed that Indigenous language immersion could be a key to producing both language fluency and academic success in *culture-based* (Hermes 2007) schools. Additionally, the study claimed that a powerful, culture-based curriculum could motivate and create cultural pride among Indigenous students, as Indigenous culture and traditions serve as assets to student success.

According to Oihana Leonet, Jasone Cenoz and Durk Gorter, "activities that promote language awareness are excellent scenarios for working with sociolinguistic concepts with students and for promoting the use of the minority language" (2017, p. 225). Findings from their study reveal that pedagogical translanguaging (an approach that allows and incorporates written and oral usage of different languages in the classroom) can be compatible

with the maintenance and development of minoritized and/or home languages. Student engagement increased when doing activities that promote language awareness. Similarly, connecting the sociolinguistic concepts by way of engaging in hands-on activities, plays, skits, and other arts-based work enthused and motivated students to connect more with the minoritized language. This evidence suggests that these approaches can both help in revitalization/maintenance of the minoritized language and can help in concept learning in content-based subjects like science and mathematics (Moschkovich 2002).

Teaching strategies for building science knowledge and intercultural competence of multilingual students

The topic of science teaching for multilingual learners has produced an immense array of research and teaching recommendations (Janzen 2008). One of the effective instructional strategies is *inquiry-based science* learning. The concept of inquiry learning is based on the National Science Education Standards (NSES). According to NSES standards, students should develop scientific behaviors such as asking questions, gathering data, and considering evidence through hands-on activities (Hampton and Rodriguez 2001). In their study titled "Inquiry Science in bilingual classrooms," Elaine Hampton and Rosaisela Rodriguez (2001) noted that when at least some instruction was provided to elementary school students in English as well as Spanish, there was evidence of increasing academic success over time. In addition, teachers in the study indicated that inquiry-based instruction increased students' language skills in both languages as well as their science content knowledge (Hampton and Rodriguez 2001).

Eva Reid (2015) and other scholars suggest many strategies and techniques to develop intercultural, sociolinguistic, sociocultural, and pragmatic competencies. Her techniques are as follows: (a) *comparison method* where two cultures are compared by showing short videos; (b) *cultural assimilation* where examples of critical incidents which could be misunderstood are given, for example, non-verbal greetings such as cheek-kissing; (c) *cultural capsule* where customs that are different in different cultures are shown, such as main meal of the day and eating habits; (d) *cultural island technique* where posters and pictures of actors, singers, films, writers, and authors can be put up on the walls to attract learners' attention, evoke comments, and maintain a cultural atmosphere; (e) *reformulation* where a student can retell a story to a partner in his/her own words, while noticing or paying attention to particular features; (f) *Total Physical Response (TPR),* which is a method used to teach language or vocabulary concepts by using physical movement to react to verbal input, for example, students act out songs, stories, skits, and even use non-verbal modes of communication, such as thumbs-up signs, handshake, and shaking of the head (Jackson 2014); (g) *prediction* where students engage actively by finishing (predicting) a half-told story or predicting the contents of a topic based on a few pieces of information, evoking students' curiosity and interest to talk; (h) *dance, role play, and drama* where students get opportunities to practice real life situations and get chances to "act out" their parts and "move" their bodies (Catalano and Leonard 2016); and (i) *research* where students get to research any topic of their interest and present their projects in various ways, such as posters, art, photographs, and computer graphics.

Intertextual analysis (when the teacher connects and draws meaning from across students' work (written, oral, visual, media-based, etc.) is another powerful tool in the multilingual classroom (Lan and de Oliveira 2019). When teachers engage more deeply with students' ideas and then design lessons around them, scientific-language expectations can

be made explicit (Sarroub 2007). This, in turn, can considerably benefit students' science-learning outcomes in the short and long term. Teachers working in multilingual educational contexts can and should be encouraged to make abundant, rich, and varied use of meaning-making resources in their instruction and assessment, including intertextual analysis (Lan and de Oliveira 2019). Loukia Sarroub (2007) remarks that in the case of ELL students, the enactment of intertextuality as a literacy event is a highly effective way to inform teachers of students' prior experiences with formal schooling and literacy; thus, creating some common understanding of the relevance of reading and writing instruction.

Similarly, Mary McGinnis (2007) states that students' social worlds are multilingual and multimodal; hence, inquiry-based projects (used widely in science instruction) are one type of pedagogical practice that can support students' literacy and language practices, create supportive classroom environments, and provide an avenue for teachers to learn more about the social worlds of their students. Two examples that the author gives in this article are combining visual and linguistic designs to create texts (story of Dragonball Z) and the use of hip-hop or rap in project presentations (Khmer rap boys). Science teachers can encourage multilingual students to use multimodal elements (such as those mentioned above) to demonstrate their understanding of science content.

Code-meshing offers another instructional framework that incorporates multiple languages into classroom discourse, curriculum, and assessment (Lee and Handsfield 2018). This framework blurs lines and challenges notions of which languages are "correct" or "appropriate" within those spaces and broadens how to approach writing instruction for linguistically diverse students. Alice Lee and Lara Handsfield (2018) have used the term Dominant American English in place of Standard English to reflect how dominant sociopolitical factors influence what is considered "standard". They provide strategies that include the use of mentor texts and the remixing of monolingual texts using code-meshing. They also provide principles for assessing students' code-meshed writing. These strategies could be used in science classrooms so that multilingual learners could benefit.

Okhee Lee and Cory Buxton (2013) state that effective science teachers model and support the use of a variety of academic language functions in the context of scientific inquiry, as students generate questions, formulate hypotheses, design investigations, collect and interpret data, draw conclusions, and communicate results (similar to discourse competence in Byram's model). Effective teachers use various graphic organizers (e.g., concept maps, word walls, Venn diagrams) to reinforce science concepts and literacy skills in a reciprocal process. For example, a Venn diagram is effective for comparing and contrasting science terms and concepts. Breaking down difficult scientific vocabulary into component root words and prefixes or suffixes is quite useful in enhancing multilingual students' understanding of scientific concepts, which is similar to linguistic competence in Byram's model (Lee and Buxton 2013).

Effective teachers communicate just slightly above students' level of communicative competence, thus pushing their language skills ahead a bit at a time (Jackson 2014). For example, during a lesson that involves the concepts of increase and decrease, a teacher in a class with many emergent speakers of English can help students understand by also using the terms go up and go down, as well as hand gestures or drawings (Reid 2015).

As stated, focusing on specific aspects of home language support is essential. Something as simple as introducing key science vocabulary in learners' home languages can exponentially increase students' understanding of new concepts. Spanish and other Romance languages are filled with words having their roots in Latin, the primary language of science, so teachers can use this connection to elicit and activate the students' prior knowledge (Lee and Buxton 2013). To further establish home culture connections in science classrooms,

effective teachers can ask questions that elicit students' funds of knowledge related to the science topics being explored (Lee and Buxton 2013).

The importance of inquiry-based and hands-on activities for science students was already highlighted by Hampton and Rodriguez (2001), as was discussed at the beginning of the literature review. To corroborate their work, Lee and Buxton (2013) highlight that effective science teachers emphasize hands-on, inquiry-based activities. Although this approach provides opportunities for all students to develop scientific understanding and engage in inquiry practices, it is especially effective for ELLs for several reasons.

First, hands-on activities are less dependent on formal mastery of the language of instruction, so reduce the linguistic burden on ELLs. Second, hands-on activities foster language acquisition in the context of authentic communication about scientific knowledge and practice (similar to sociolinguistic competence in Byram's model). Third, inquiry-based science promotes ELL students' communication of their understanding in a variety of formats, including gestural, oral, pictorial, graphic, and textual [similar to McGinnis's (2007) multimodal elements and Reid's (2015) research strategy]. Finally, inquiry-based science and process skills foster the acquisition of academic language functions. Therefore, we believe that the inquiry-based activities embody all three components and five values of Byram's (1997) model of intercultural competence.

Thus, the overall findings of the literature reveal the capability of multilingual learners to demonstrate high levels of intercultural competence and attain academic achievement in science if teachers foster, shape, and develop this important skill.

Qualitative research design: narrative inquiry approach

We have adopted Jean Clandinin and Michael Connelly's (2000) three-dimensional narrative inquiry framework of temporality, sociality, and place for this study to describe the life of the research participant through her stories of experience and our written narratives. Clandinin and Connelly state that "This set of terms creates a metaphorical three-dimensional narrative inquiry space, with temporality along one dimension, the personal and the social along the second dimension, and place along a third" (2000, p. 50). In addition to Clandinin and Connelly's (2000) 3D narrative inquiry approach, we also closely associate our narrative inquiry with John Dewey's theory of experience. More specifically our inquiry focused, as described by Clandinin and Connelly, on Dewey's notions of "situation, continuity, and interaction…personal and social (interaction); past, present, and future (continuity); [all] combined with the notion of place (situation)" (2000, p. 50).

Details of the participant and context

We utilized John Creswell and Cheryl Poth's "purposeful sampling" and "criterion sampling" (2018, p. 159) for identifying our participant for this study. To *purposefully* inform an understanding of the research problem in the study, *selection criteria* (Merriam 2009) with which we would identify and recruit the participant were established. The criteria integral to our research purpose and for the recruitment of the research participant were as follows:

1. The research participant should be a high school science teacher who has taught in at least one public high school in a large Midwestern city in the USA.
2. He/she/they should be accessible and willing to provide information when interviewed online for a period of at least ten weeks.
3. He/she/they should have teaching experience in diverse school environments with multilingual students in order to provide distinctive stories of experience.

At the time of the study, the research participant, Kristina Smith (pseudonym), had 12 years of teaching experience, working in two different schools in the same large Midwestern city where she was born and raised. She identifies as a white female and has only ever taught science at the high school level. In an effort to describe the context of the study in relation to Clandinin and Connelly's (2000) spatial dimension (schools as places), the authors give attention to the locale of her teaching experiences. She started her teaching career as a science teacher at a public school (Romney High, pseudonym) in an urban district serving predominantly low-income and ethno-racially diverse neighborhoods. She worked in Romney High for five years. However, major problems in Romney High, such as budget cuts that the school experienced (which led to lower salaries and zero funding for science lab materials—forcing her to buy materials out of her own pocket) and lack of support from school administration when dealing with classroom issues prompted Kristina to search for another job. In contrast, she is now working in a high-performing public school (Parkway High, pseudonym) in the same city, which serves predominantly high- to middle-income white neighborhoods. She has been working at Parkway High for 7 years now, fully satisfied with the classroom resources she is given, and the support provided by the administration in comparison to what she experienced at Romney High.

Methods

Data collection, data analysis, and validation strategies

While this is a co-authored project, the lead author led the design and implementation of the study. She engaged in a time series data collection process over an 8-month period. She collected data from the research participant using individual in-depth, semi-structured, online interviews via Zoom. There were eleven interviews in total, each lasting approximately 45 min. Informed loosely by Vygotsky's sociocultural theory, and more formally by Byram's (1997) *Multidimensional Model of Intercultural Competence* as a theoretical framework, the interviews were designed, conducted, transcribed, and member checked. Field notes from class observations and interview transcripts from Zoom recordings served as data.

Transcripts, field notes, and artifacts were coded and analyzed using Clandinin and Connelly's (2000) three-dimensional narrative inquiry framework of *temporality*, *sociality*, and *place* to arrive at synthesized stories of experience around coalescing themes. Finally, restorying and interpretation of the larger meaning of the story were done by representing and visualizing the data. The validation strategies used in our study are based on validation perspectives proposed by Creswell and Poth (2018) and Loh (2013). They are as follows: (a) multiple interviews (triangulation of data to ensure internal validity and credibility), (b) reliability (verifying whether the findings are consistent with the data collected), (c) rich, thick descriptions of the participant's lived experiences to allow the reader to make

decisions about transferability and external validity, and (d) member checking with the participant. A final phase of the study involved in-depth peer debriefing among the co-authors prior to data smoothing and writing up of the findings.

Research findings

The findings revealed the participant utilized several strategies aimed at developing intercultural communicative competence among her students—in particular in support of her multilingual students. The participant's narratives illustrated the utility of the following pedagogical and curricular considerations: (1) employing content-specific, linguistically responsive teaching resources; (2) using an inquiry-based instructional model for teaching science; (3) scaffolding scientific vocabulary by integrating word walls, concept maps, and intertextual elements; (4) encouraging multimodal projects; (5) facilitating group work; (6) promoting code-meshing and translanguaging in classrooms; and (7) employing non-verbal communication during instruction. Though all the above considerations are important within a rigorous and highly engaging science classroom of multilingual students, this paper focuses on the latter four themes as they relate most directly to intercultural communicative competence development.

While exploring and interpreting Kristina's teaching experiences within the three-dimensional narrative inquiry framework (in the temporal, spatial, and social-personal dimensions), we will briefly summarize our interactions with Kristina and then present her "stories of experience" (excerpts are included below from interviews and field notes) to arrive at dominant themes among the data. The dominant themes are listed as subheadings as given below.

Challenges in teaching science to linguistically diverse students

Initially, Kristina indicated that she had a tough time teaching science to all students early in her career. Romney High had a large population of native Spanish-speaking students (location of learning) and Kristina lacked prior access to training or experience working in multilingual contexts. When asked if she remembered any specific incidents where she encountered challenges while teaching ELL students at that school Kristina shared an account of one such challenge and how she managed it:

> I did not know how to teach ELL kids, like, teaching scientific terms and stuff like that. I did not know how to do that. But I did get help from a lady that taught at Romney High, and her specialty was just teaching English language learners to help them graduate out of the [English as a Second Language (ESL) program]. So, some kids were with her all day, just learning basic English, just to get some language development. Some kids were with her during parts of the day. And so, she kind of helped me a little bit. She gave me some tips on breaking down vocabulary and pieces of advice and stuff like that. So that helped (Kristina talking about her teaching practice at Romney High, Field notes, September 19, 2020).

Analyzing this excerpt with Clandinin and Connelly's (2000) temporal dimension, she might have perceived her problems to be overwhelming because she was new to the teaching profession, and she did not receive much support from her colleagues in the

department, nor was she provided support or professional development on current and effective ESL instruction from her district.

As admitted in the above narrative, she did not know how to teach science to ELL students effectively. To cope with this problem, she reached out to an ELL teacher at Romney High and gained permission to observe in that teacher's ELL classroom. Here she learned some methods that would help her overcome the difficulties she was experiencing. She learned that when ELL students are struggling to form even simple sentences, they will have many more difficulties learning complicated scientific terminologies without robust scaffolded support (linguistic competence).

Kristina learned that breaking down vocabulary is an essential initial step for supporting all students' understanding of scientific terms (in English particularly) and data indicate that Kristina continues to use scaffolding such as breaking down difficult scientific vocabulary with the use of scaffolded activity sheets with Latin/Greek-root words that include prefixes and suffixes, computer aided-pronunciation tools, and digital images/posters in her inquiry-based instruction. This served as evidence of her linguistic responsiveness and use of multimodality in teaching science.

Strategies for building intercultural competence in science classrooms

As an experienced and successful teacher, Kristina stated that she teaches five classes: two biology and three physical science classes for 9th- and 10th-grade students. Below are some excerpts from her interviews where Kristina talks about her preferred multimodal, multilingual, dialogic, and hands-on instructional strategies that build intercultural competence. The first example describes her use of dance, rap, and skits to engage students in embodied practices:

> I have done the "molecule dance" in class. It is when you show the kids that the molecules are shaking in their place, but then the nucleus has the electrons going around them and they are also spinning, going in circles. I will do, like, a duck flapping my arms. I will have kids stand up and do things. I have had kids do projects on cell division and cell cycle where they could create their own rap or a skit, and the kids love it. They can even make a 3D model of it too. I have had kids pretend to be solids, liquids, and gases to explain shape, rigidity, and volume – by just staying in a place like solids, shaking their bodies, or just flowing like liquids, then they kind of move by each other fast like gases (Kristina talking about her teaching practices at Parkway High, Field Notes, April 6, 2021).

Within activities such as the molecule dance, rap, and skits, students are invited to use their full linguistic repertoires as they relate to one another. This theme and in vivo codes (e.g., molecule dance) is an illustration of Theresa Catalano and Alison Leonard's (2016) use of dance to foster intercultural communication and McGinnis's (2007) use of the inquiry projects, such as rap and skits where students add multimodal and multilingual elements to their work.

The second excerpt illustrates Kristina's use of group work and partner work to develop intercultural competence. Kristina uses differentiated grouping strategies for all her students. Her homogenous grouping involved students with similar linguistic and cultural repertoires where students used their linguistic strengths to the maximum by collaborating with their peers in their heritage language. Her heterogeneous grouping involved students with different linguistic and cultural repertoires where students collaborated on group

projects and learned from one another about their own and other languages and cultures. These types of classroom interactions fostered the development of embodied sociolinguistic and discourse-related competencies as they "played with concepts" using their heritage and emerging languages and their bodies. Their communication with each other was scaffolded using class posters, word walls, and culture walls. Culture-specific videos were also used in class to increase overall awareness of the various cultures and languages within the class and to address gaps in knowledge.

> I'm a big fan of cooperative learning. Collaboration and stuff like that. They work with partners and groups. So, I would try to make groups and try to spread out their strengths and weaknesses (Kristina talking about her teaching practices at Parkway High, Field Notes, October 10, 2020).

The in vivo codes (cooperative learning; collaboration; work with partners and groups) connect well with McGinnis' (2007) strategy of peer bonding through collaboration and Vygotsky's (1978, 1986) sociocultural constructivist learning theory. Classroom observations also served as evidence that Kristina's use of differentiated grouping allowed for scaffolded language support for her multilingual students that simultaneously stretched them within their zone of proximal development and played to their strengths.

A third important strategy she has used for building intercultural competence among her students is centering students' cultures and valuing and normalizing the incorporation of students' home languages in the classroom through targeted supports, and the incorporation of code-meshing, and translanguaging. Below are three illustrative excerpts of this strategy:

> I would try to do a lot more culturally responsive education and just incorporate the stories of kids, having kids share their stories throughout their life experiences. We even did a culture wall as something cool to see who's in our classes (Kristina talking about her teaching practices at Parkway High, Field Notes, September 26, 2020).

> At Romney, I would have kids in the classroom speaking their native language. There, I had more of a variety of languages. I never cared if they spoke Spanish; I kind of always thought it was cool because I appreciated that they had someone that they could talk to in their native language and maintain that cultural part of their current lives in existence (Kristina talking about her teaching practices at Romney High, Field Notes, March 30, 2021).

> I'm totally fine with having multiple languages present, as long as they [the students] get the job done. I'd probably think it's cool if I got that. I'd be totally fine with it, and if it's something that I could still assess and know that they've learned and mastered the content, then by all means, like if there's a system that works, then let's use the system (Kristina talking about her teaching practices at Parkway High, Field Notes, April 8, 2021).

Kristina's statements (e.g., culturally responsive education; culture wall; having kids share their stories; their life experiences; kids in the classroom speaking their native language; I never cared if they spoke Spanish; totally fine with having multiple languages; let's use the system) connect well with the home language and home culture support strategies mentioned by Lee and Buxton (2013), the comparison method of Reid (2015), the language immersion strategies of Hermes (2007), the translanguaging methods by Leonet, Cenoz and Gorter (2017), and the code-meshing strategy described by Lee and Handsfield (2018). As already discussed above in the heterogenous

grouping strategy, students proficient in a heritage language served as the more knowledgeable other (MKO) and worked with their peers and the teacher within their ZPD so that learning was multi-directional: peer-to-peer learning and learning happening for the teacher and/or other students as a result of students having L1/L2 or heritage language proficiencies. In this way, students and the teacher are learning and practicing intercultural competence as the key constructs of Vygotsky's sociocultural theory are employed (MKO, ZPD, and scaffolding).

A fourth example of a strategy she reflected on was her use of non-verbal communication. She said:

> I point to words as I say them, or I will point at pictures as I explain it. I'm kind of a natural hand-talker. So, I'll point to the parts of the PowerPoint as I refer to it, just to keep the kids with me and where I'm going. It works for emerging bilinguals and for kids in special education, which can equate to a lot of the population. I use gestures, in general, as I talk or use creative pictures, or even like visual [video] demonstrations of how things work to anything I can, if I can find a way to make it visually concrete, whether it be with a movement or some sort of imagery, I'll try to do that (Kristina talking about her teaching practices at Parkway High, Field Notes, April 6, 2021).

The in vivo codes (point at pictures; point to words; natural hand-talker; use creative pictures; visual demonstrations; I use gestures) are in line with Jackson's (2014) non-verbal communication strategies to help in intercultural communication. The codes (make it visually concrete; with a movement or some sort of imagery) align with McGinnis' (2007) multimodal strategies of moving across linguistic, visual, and physical modes to create meaning, and all serve as evidence that Kristina embraces the value of non-verbal communication readily in her instruction.

Summary of findings

After a thorough analysis of all the field notes and interview transcripts, the findings of our narrative inquiry have provided insights into our research questions. Our interpretations and summary of findings revealed that science teachers could use several strategies to develop the intercultural competence of multilingual students. The strategies that emerged pertinent to this study are as follows:

1. Encouraging projects that incorporate multimodal elements to demonstrate learning, such as multilingual texts, pictures, photos, and videos from home cultures and other cultures, dance, skits, rap, and 3D models.
2. Facilitating partner or group work across both homogenous and heterogenous plurilinguistic and ethno-racially diverse groups.
3. Centering culture and integrating home languages in order to scaffold the development of the language of science and English for emergent bilinguals (code-meshing and translanguaging).
4. Employing non-verbal communication strategies for use in teacher-student and peer-to-peer interactions.

Discussion and implications for research and practice

The study findings align well with Byram's model with implications for current and future work in this area. Teaching with a focus on intercultural competence is crucial within our increasingly mobile, multilingual, globalized classrooms. Teachers should explore ways to foster and facilitate intercultural competence so that students can develop this important skill and become better global citizens. Teaching that is inclusive of a broad range of diversities is an important step in achieving intercultural competence in our classrooms. When students are able to engage in experiences that deepen their respect for and understanding of diversity, it enhances their openness and acceptance of social differences, encourages curiosity and their hunger for new information and perspectives, improves their decision-making and problem-solving skills, and eventually these competencies will lead to innovation and discovery.

Developing intercultural competence involves systematically observing and critically reflecting on our own, our students', and their families' identities and ways of knowing. This includes fostering respect for and appreciation of other cultures, worldviews, and communication styles; an understanding of other people's behaviors and customs (including the ability and willingness to acknowledge and accept different behaviors and ideas in a nonjudgmental way); a curiosity, flexibility and the willingness to adapt and be open to difference; and an awareness of our own biases and behaviors in order to respond in a culturally appropriate manner. The study offers several strategies where science teachers can develop their own and their students' intercultural competence, such as rap, skits, multimodal elements in group projects, and opportunities for collaborative student discourse that center students' heritage languages and cultures. These strategies provide examples of how students can critically reflect on their own and others' cultures and languages in a science classroom.

As the demographics of the USA continue to diversify and as there is a growing need for a larger scientifically trained workforce in the future, developing intercultural competence among all students is key to creating environments where students with diverse cultural and linguistic repertoires can thrive. This would lead to a more diverse and inclusive STEM workforce and provide a pathway toward economic advancement and social contribution for youth from historically marginalized communities. Furthermore, as the number of multilingual students continues to increase in US public schools (UN DESA 2015), it is ever more important for researchers to gain insights into science teachers' experiences working with students with diverse cultural and linguistic repertoires, which could aid in promoting educational equity in STEM.

Narrative studies such as this one can prove quite beneficial for the field of educational research as they provide insights that might help educators, educational leaders, policymakers, and researchers to better understand methods to improve science outcomes of multilingual learners (Kirmaci, Allexsaht-Snider, and Buxton 2018). As Clandinin and Connelly (1994) state, "it is in the research relationships among participants and researchers, and among researchers and audiences, through research texts that we see the possibility for individual and social change" (p. 425). Hence, exploring the experiences and practices of science teachers in multilingual classrooms can inform practices that better incorporate equity in science education and improve the science learning outcomes for all students.

Strengths and limitations of the study

The strengths identified in our study are that we have gained insights into a science teacher's lived experiences of developing intercultural competence in two different (high-income and low-income) schools, which is an underrepresented topic in the extant literature. The minoritized student population has been historically the oppressed class; they also do not have many opportunities to excel in STEM careers. Hence, our study could inform academia and policymakers about the ways to improve the academic outcomes of minoritized, multilingual students and their interest in pursuing STEM careers. Interview data are a great strength for this study, as they uphold the voice of the participant.

There are also some limitations to this study; the first one is the sample size, which is one participant. Kristina's interviews were done on Zoom because of the restrictive conditions during the COVID-19 pandemic, and we collected only online documents and artifacts for the larger study. So, maybe triangulating with more data collection procedures, such as site observations, teacher reflections, and lesson plans could be used in future studies. Another general limitation of narrative research is knowing how much information is needed to re-story someone's experience. The life story of an individual has multiple layers, and context is very important, which is what we attempted to do by using three dimensions of temporality, sociality, and place. The final limitation is that this narrative provides but only a small window into Kristina's life; it provides us with only one perspective, a midwestern female science teacher's perspective. However, as with all qualitative research, we argue that an individual's stories matter. They provide insights that could be transferable to others seeking understanding and who might share similar school/community variables and resources.

Suggestions for future research

As we have already stated, this topic is underrepresented in literature, and this study will hopefully open the doors for more research in this area. As indicated by the participant, studies based on culturally relevant strategies, dual language programs with accessible online dual language textbook resources, websites that cater to multilingual learners, and websites that help teachers find materials for multilingual learners in their classrooms are fertile areas for future exploration.

Some researchers have examined how students' perceptions of teachers' support may influence student engagement, motivation, and achievement (Kelly and Zhang 2016). Future studies in this area could consider the interactions between science teachers and minoritized students through researcher observations. Classroom observations could add another dimension to the data and serve to provide a more comprehensive view of the way science teachers operate within their classrooms to foster intercultural competence. Studies could be conducted about multilingual students' perceptions of science instruction as well. This could pave new ways to investigate the benefits of scaffolding, the use of inquiry methods, and the use of culturally and linguistically responsive teaching methods to teach science to multilingual learners.

Finally, an extension of this research could explore interactions between the teachers and their co-workers, parents, school administration, educational policymakers, and the wider community to develop intercultural competence. This could lead to better support

systems for science teachers that mitigate teacher burnout related to the complex and high-pressure environments they are navigating in both rural and urban settings.

Conclusion

In light of the rapidly changing demographics of the US student population, the urgent need to improve the science achievement of all students, high-stakes assessment and accountability policies, and the underrepresentation of this topic in the research literature, more research on science teachers' experiences in multilingual classrooms is definitely warranted, and this topic is a fertile area for future research. Future research on this topic could provide many more strategies and concrete ways for teachers to foster the intercultural competence of students. Multilingual learners represent a tremendous asset for the USA if their full potential can be unlocked and harnessed. Science teachers can play an important role in this process by helping to develop the intercultural competence of students when they support, nurture, and guide them in knowledge construction and teach strategies to effectively communicate with people of other cultures and languages successfully.

Author contributions U.G. and A.M. wrote the main manuscript text. U.G. designed and implemented data collection and analysis. Both authors reviewed the manuscript.

Data availability The data that support the findings of this study are available on request from the corresponding author/s [UG and AM]. The data are not publicly available due to them containing information that could compromise research participant privacy/consent.

Declarations

Conflict of interest The authors declare no competing interests.

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