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Mediating hybrid spaces in the bilingual science class by learning to cultivate children's metaphors

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ABSTRACT

Figurative language in science teaching has recently been explored to inform how teachers can scaffold scientific advancement without excluding children's cultural conceptualizations. By deeming metaphorical language as a mediational artifact that agentively encodes culturally relevant aspects of experience, this study analyzed how bilingual children's metaphor initiations were followed up by teacher candidates to create hybrid spaces for learning alongside zones of proximal development. Our findings indicate three different patterns of how teachers reacted to bilingual children's metaphors during a science lesson on geomorphology, and how their differing responses may have facilitated or hindered children's scientific understandings. This study highlights the significance of cultivating opportunities for metaphorical associations initiated by bilingual children as opportunities for science teaching and learning.

1. Introduction

The way science is generally taught can alienate many groups of students because it does not consider their cultural and epistemic resources (Mutonyi, 2015). The science register often involves highly complex and abstract constructs or processes, which are conveyed through language that favors worldviews of dominant speech communities, and makes the discipline appear to be separated from everyday experience (e.g., Lemke, 1990). While researchers have warned of the need to move toward "an articulation of dimensions of continuity between ordinary people and expert scientists" (Warren, Ballenger, Ogonowski, Rosebery, & Hudicourt-Barnes, 2001, p. 530), science pedagogy typically reinscribes a dichotomy between every day and more formal ways of sensemaking (Seiler, 2013).

Examining the interplay of home, school, and scientific cultural and linguistic practices is particularly relevant when working with non-dominant groups, such as the bilingual children of Latinx immigrant backgrounds and the bilingual teacher candidates who participated in this study. Research continues to reveal the limiting practices that minoritized learners encounter in the science classroom and how these practices are often discouraging for children whose understandings and experiences about the natural world continue to be disregarded (e.g., Barton & Yang, 2000). These current gaps also have implications for teacher preparation programs that aim to help teachers develop pedagogical practices attentive to the diversity encountered in programs serving language learners. Such programs constantly face the challenge of helping educators learn to relate the science register (as instantiated by curricular demands) to the culture and knowledge of the children they will be teaching, and to address tensions between the two.

In this study, we envision teaching and learning hybrid spaces by using metaphors to mobilize the sociocultural knowledge of minoritized children, to assist in achieving shared science conceptualizations aligned with curricular demands. To explore whether and how the bilingual teacher candidates who participated in this study used metaphors to foster such hybrid spaces in a science after-school, we followed the Discourse Dynamics approach to metaphor analysis (Cameron et al., 2009). This approach, which aligns with sociocultural theory, considers metaphors as mediational artifacts that encode culturally-relevant aspects of experience (Lantolf & Thorne, 2006). This framework views meaning-making through metaphors as a dynamic process, where speakers build upon each other's contributions, and develop their own and others' ideas by working with various interconnected dimensions of experience (Cameron, 2010).

2. Metaphorical language, funds of knowledge and the zone of proximal development

Metaphors involve describing something in terms of another seemingly unrelated entity (Littlemore, Krennmayr, Turner, & Turner, 2014), and have the potential to help make science learning

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relevant and accessible for bilingual learners. In metaphor theory *vehicle domains* include knowledge accumulated specifically from sensorimotor or bodily experiences, which are communicated on the linguistic surface by means of *vehicle terms*. Abstract and non-tangible notions, on the other hand, are termed *topic domains* (Kövecses et al., 2015), which are communicated using *topic terms*, and can include complex science topics that teachers intend to convey in class. In relation to our study, we propose that children draw vehicle domains (i.e., concrete and more bodily conceptual domains or experiences that are communicated using vehicle terms) from their sociocultural out-of-school knowledge, often referred to as *funds of knowledge*.

The term funds of knowledge (hereinafter referred to as FoK), or sociocultural out-of-school knowledge, denotes the "historically accumulated and culturally developed bodies of knowledge and skills essential for household or individual functioning and well-being" (Moll, Amanti, Neff, & Gonzalez, 1992, p. 134). Bilingual children navigate multiple social spaces that help them learn languages, content, and social norms, and these multiple sources of understanding are all part of children's FoK, which can be used to foster learning (González, Moll, & Amanti, 2005). In the field of science education, it has been shown that students are highly interested in science when the content of the lessons is connected to their lives, such as when they can make associations to how they visualize themselves in the future, or when activities allow for children's sense of agency (Basu & Barton, 2007; Upadhyay, 2006).

At the conceptual level, metaphorical associations arise when topic domains (i.e., complex and abstract science notions) are understood in terms of vehicle domains (i.e., sensorimotor experience from existing FoK). These associations can potentially facilitate access to science concepts, which are deemed to be topic domains. As mentioned previously, words or phrases on the linguistic surface that denote topic-domain content are called *topic terms*, and those denoting vehicle-domain information are called *vehicle terms*. Hence, language is considered to be metaphorical in contexts where a vehicle term is used to talk about a topic domain (Deignan, Littlemore, & Semino, 2013). For example, the abstract notion of UNDERSTANDING (small capital letters are conventionally used to represent topic and vehicle domains at the conceptual level) is typically talked about in terms of the physical experience of SEEING (e.g., Deignan & Cameron, 2009). Vehicle terms (underlined in the examples) denoting the conceptual metaphorical association UNDERSTANDING IS SEEING include "I see what you mean" and "what is your outlook on that?".

The understanding that metaphorical language can facilitate how we think about abstract topics was popularized by Lakoff and Johnson in their 1980 publication *Metaphors We Live By*. Years of metaphor research have given rise to the Discourse Dynamics approach to metaphor analysis (Cameron, 2010; Cameron & Deignan, 2006; Cameron et al., 2009; Deignan et al., 2013), which is a situated discourse perspective on the use of metaphorical language in context. This approach is inspired by sociocultural theory, where linguistic choices are not only deemed to reflect social group memberships, but have the potential to modify and transform how topic domains are understood based on culture-specific perspectives (Armstrong, 2015). From this view, a metaphorical analogy is seen as "a temporary stability emerging from the activity of interconnecting systems of socially-situated language use and cognitive activity" (Cameron et al., 2009). As Vygotsky (1978) suggested, cultural artifacts mediate cognition and are thus central to meaning-making. Science occurs within social and cultural interactions, which are in turn mediated by language (Gánem-Gutiérrez, 2013; Lee & Fradd, 1998). In the context of the present study, an important mediational artifact that reflects culturally-relevant and familiar aspects of bodily experience (rooted in children's FoK) is metaphorically-used language as defined above. Important in relation to metaphorical language and thinking is a discussion pertaining to the way topic domains are discussed when using science terms which are highly specialized. We refer to science topic terms used to explain and refer to abstract science topic domains as the *science register*, which is discussed next.

2.1. The science register and the role of metaphors in bilingual science education

Science is full of complex processes that generally cannot be experienced directly through bodily perception, and may hence constitute abstractions of what happens in the natural world (i.e., topic domains). Thus, constructs such as EROSION, TRANSPORTATION, DEPOSITION, and WEATHERING could be considered topic domains, which tend to be conceptually treated in isolation from culture-specific understandings. While children might have rich out-of-school understandings and experiences, including multilingual resources (i.e., FoK), the language used for meaning-making in science often contrasts with other ways of using language (Fang, 2005). In this sense, science topic domains fall under what is known as science register, which has been defined to constitute meanings or topics pertaining to the language of science (Halliday, 1975; Slater & Mohan, 2010). Bilingual children need to access ways in which language is used in science to make meaning, so they can understand and learn in the science classroom (Lee, Quinn, & Valdés, 2013). While there are science words (i.e., topic terms) that are used as part of everyday contexts with other meanings, it is important that teachers assist children in understanding how such words are used in science and for science learning (giving them access to particular science topic domains). However, the multiple meanings of science topic terms are rarely attended to in the science classroom (Snow, 2008), or are taught in ways that produce static views of science topic domains (Maxwell-Reid & Lau, 2016). The way language is used in science, in terms of linguistic features (e.g., word-level or sentence-level features) might result in language learners' poor performance in standard science measures (i.e., tests) even if they know the content (Kachchaf et al., 2016; Noble, Rosebery, Suárez, Warren, & O'Connor, 2014).

The science register communicates complex information in the form of abstract language (here called *topic terms* as explained above), which can cause extreme difficulties for learners, especially from different linguistic and cultural backgrounds (Fang, 2005). However, just like metaphors can help us understand concepts that can be difficult to grasp in everyday life (i.e., topic domains), they can also aid teachers in explaining complex science concepts. By using vehicle terms that reflect familiar vehicle domains (i.e., sensorimotor or bodily experiences which children draw from their FoK), teachers can help students understand science topic terms and domains (Saban, 2006). Thus, science cultural practices could be reinforced when children carry their personal meanings (i.e., vehicle domains) to the learning event (Gibbons, 1998) by initiating metaphorical descriptions of what they are learning with their own familiar vehicle terms. Allowing bilingual children to associate their vehicle terms and domains with the topic domains and terms of a science class could help them develop a 'voice' in their multiple languages (Littlemore & Low, 2006) within otherwise decontextualized definitions of science constructs separated from everyday experience.

The importance of differentiating language instruction toward developing the science register has been highlighted in the field of bilingual education (Beltran, Mora-Flores, Sarmiento, & Sarmiento, 2012). For example, it has been shown that negotiating ways to discuss scientific phenomena can promote gains in appropriating the science register, which in the context of this study comprise science topic domains and topic terms (Ciechanowski, 2014). Additionally, a process referred to as *metaphor scaffolding* has been used toward