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Design Principles for Engaging Multilingual Learners in Three-Dimensional Science

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Acknowledgments

As a joint endeavor between WIDA and the National Science Teaching Association, Making Science Multilingual works across the professions of science education and language education to create innovative approaches to more equitably engage multilingual learners in rigorous, high-quality science education.

WIDA, an organization within the University of Wisconsin–Madison's Wisconsin Center for Education Research, works to advance academic language development and academic achievement for culturally and linguistically diverse children and youth through high-quality standards, assessments, research and professional learning for educators. WIDA's resources are used by 42 domestic states, territories and federal agencies, and more than 475 international schools throughout the world.

The National Science Teaching Association promotes excellence and innovation in science teaching and learning for all. Membership comprises science teachers, science supervisors, administrators, scientists, business and industry representatives, and others involved in and committed to science education. The association offers professional learning opportunities for teachers, builds awareness of the importance of science literacy and education in the United States, and explores forward-thinking programs and initiatives that promote leadership, learning, and advocacy in science education.

The authors acknowledge the support of the National Science Teaching Association and WIDA in funding this collaboration across two disciplines and four organizations. Team members include: co-leader Rita MacDonald, WIDA; co-leader David Crowther, University of Nevada, Reno, National Science Teaching Association 2017–18 president; Melissa Braaten, University of Colorado Boulder; Wendy Binder, National Science Teaching Association; Justine Chien, WIDA; Troy Dassler, WIDA; Tricia Shelton, National Science Teaching Association; and Jennifer Wilfrid, WIDA.

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Abstract

The National Research Council's 2012 *Framework for K-12 Science Education* states that science education should "provide all students with the background to systematically investigate issues related to their personal and community practices … frame scientific questions pertinent to their interests, conduct investigations and seek out relevant scientific arguments and data, review and apply those arguments to the situation at hand, and communicate their scientific understanding and arguments to others" (p. 278). It also states, "Arguably, the most pressing challenge facing U.S. education is to provide all students with a fair opportunity to learn" (p. 281).

The continued growth of the multilingual learner K–12 population presents challenges for science teachers. A 2018 National Academies of Sciences, Engineering, and Medicine report emphasizes the cost of the persistent multilingual learner opportunity gap in science, technology, engineering, and mathematics, and it identifies exclusionary practices barring multilingual learners from equitable inclusion in rigorous science education. The report recommends changes in policy and practice to overturn this disparity by leveraging the strong connections between sense-making in science and the language-in-use approach to English language development.

In response, WIDA and the National Science Teaching Association formed Making Science Multilingual to support equitable and inclusive forms of science instruction through which all students, but especially multilingual learners, can learn science and language simultaneously. To guide this work, the Making Science Multilingual team devised eight design principles to define the integration of contemporary three-dimensional science and language-in-use pedagogies. These principles will guide educator resource development at both organizations and facilitate critical examination of how well educator resources support inclusion of multilingual learners in rigorous science learning.

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A Framework for K-12 Science Education (National Research Council, 2012) articulates the vision that "students should have gained sufficient knowledge of the practices, crosscutting concepts, and core ideas of science and engineering [the three dimensions of three-dimensional science] to engage in public discussion on science-related issues, to be critical consumers of scientific information related to their everyday lives, and to continue to learn about science throughout their lives" (p. 9). The framework continues to state that "a major goal for science education should be to provide all students with the background to systematically investigate issues related to their personal and community practices. They should be able to frame scientific questions pertinent to their interests, conduct investigations and seek out relevant scientific arguments and data, review and apply those arguments to the situation at hand, and communicate their scientific understanding and arguments to others" (p. 278).

The framework's three-dimensional approach presents challenges and opportunities for teachers of science to engage students in new ways of thinking and doing science—not only those students who have traditionally been successful in science, but also those who have not. "Arguably, the most pressing challenge facing U.S. education is to provide all students with a fair opportunity to learn" (p. 281), the framework states. "[T]raditional classroom practices have functioned as a gatekeeper" (p. 285) for students from historically nondominant groups, including multilingual learners—students whose first language is not English. "Recognizing that language and discourse patterns vary across culturally diverse groups, researchers point to the importance of accepting, even encouraging, students' classroom use of informal or native language and familiar modes of interaction" (p. 285), *Framework for K-12 Science Education* said in 2012.

Six years later, the National Academies of Sciences, Engineering and Medicine's *English Learners in STEM Subjects* (2018) reported English language learners "develop science, technology, engineering, and mathematics (STEM) knowledge and language proficiency when they are engaged in meaningful interaction in the classroom and participate in the kinds of activities in which STEM experts and professionals regularly engage" (p. 55). Yet, program models for the delivery of English language instruction often exclude multilingual learners from these opportunities, by pulling students out of science classrooms for English language classes or placing them in sheltered science classrooms in which highly simplified content often does not satisfy grade-level requirements (National Academies of Sciences, Engineering and Medicine, 2018). Additionally, state and district policies may simply preclude students classified as English learners from placement in STEM courses (National Academies of Sciences, Engineering and Medicine, 2018), based on the misconception that students must be proficient in English before they can engage meaningfully in science learning (Callahan, 2017; Gándara & Hopkins, 2010).

Science and English language educators need to collaborate to develop a new approach to integrate science and language to disrupt these exclusionary policies and practices.

To facilitate such partnerships, the WIDA has developed for 2020 release its *Instructional Framework for Science* that embeds language use and development in the communication-rich disciplinary practices of science and engineering. This view is foundational to contemporary science education and language education. Whereas traditional theories viewed language development as "the accumulation of elements of vocabulary (lexicon) and grammar (syntax) to be internalized by learners," contemporary approaches take a sociocultural approach to language development, viewing it as "a set of dynamic meaning-making practices learned through participation in social contexts" (National Academies of Sciences, Engineering and Medicine, 2018, p. 66). In contemporary language pedagogy, this approach is most frequently known as "language-in-use" (Lee, Quinn, & Valdés, 2013).

In the *Instructional Framework for Science*, WIDA asserts the value and importance of broadening the traditionally narrow definition of "academic language" to emphasize language-in-use and to include the range of language(s) and language practices, such as translanguaging, that multilingual learners use and that serve as the foundation for the rich exchange of ideas that constitute collective sense-making in science. Resources based on this approach can more equitably include multilingual learners in their simultaneous development of rigorous science reasoning and sophisticated language. Leveraging diverse students' broad range of linguistic assets in the science classroom can support the full inclusion of the United States' rapidly growing population of multilingual learners. This shift to a language-in-use approach will challenge traditional instruction, such as front-loading or preteaching vocabulary and content for multilingual learners, as well as the requirement of a certain level of language proficiency as a prerequisite for placement in science courses or precursor to engagement in science learning.

WIDA and the National Science Teaching Association created the Making Science Multilingual program to integrate language-in-use into contemporary science and language pedagogies to help all students, but especially multilingual learners, learn science and language simultaneously. WIDA and NSTA collectively are positioned to provide educators the resources to achieve the mission and vision below.

Making Science Multilingual Mission

Making Science Multilingual strives for equitable three-dimensional science instruction and learning where language is seamlessly contextualized and integrated for success for ALL students from all language backgrounds.

Making Science Multilingual Vision

The National Science Teaching Association and WIDA have formed this affiliation to address the opportunity gap in K–12 science education by collaboratively developing and supporting others' development of resources to foster the equitable engagement of multilingual learners in three-dimensional science. The work will focus on the following critical aspects:

1. **Science identity:** Making Science Multilingual supports the development of curricular materials that portray scientists and science-literate individuals working across many contexts, in formal and informal settings, and that provide examples of scientists of different genders and from many cultures and nations, both contemporary and historical.
2. **Equitable engagement:** Making Science Multilinguals supports the equitable engagement of multilingual learners in all instructional activities that constitute three-dimensional science teaching, from the exploration of phenomena to the elicitation of initial ideas and the iterative and collaborative co-construction of explanations.
3. **Language development:** Making Science Multilingual supports opportunities for multilingual learners to develop language through participation in three-dimensional science teaching. Rather than being a prerequisite for participation in science instruction, language development must be fully contextualized within classroom activities and classroom discourse.
4. **Formative assessment of science learning and language use:** Making Science Multilingual supports formative assessment and contingent instruction that integrates science reasoning and effectiveness in language use. Language-focused feedback and instruction should be contextualized in science discourses and practices, and expand students' understanding of and effective participation in these discourses and practices.

In this context, the Making Science Multilingual team has written eight design principles to define the integration of contemporary science and language pedagogy, and to guide collaborative development of resources by WIDA and the National Science Teaching Association. Based on review of numerous frameworks and position statements from national organizations in science education and language education, this articulation of the principles is not intended for teacher use, although a set of principles for teachers can and will be derived from these. Rather, these design principles will guide the joint development of educator resources across the two organizations. Educators also can use them to critically examine how well other proposed products or resources support language-in-use and the equitable inclusion of multilingual learners in rigorous science learning.

Design Principles for Engaging Multilingual Learners in Three-Dimensional Science

Foundational Commitments to Science Education

Principle 1: Students have the Right to Learn Science

All students have the *right to learn science* to understand the world around them and the science that relates to issues in their lives and communities, so that they may act responsibly to serve their interests and the needs of their communities. Equitable science education supports engaged civic participation and provides students *access to further education and STEM careers.*

Principle 2: The Legacy of Disparities in Science can be Disrupted

Science education more equitably engages multilingual learners when educators view the teaching and learning of science from multiple perspectives, and attend to historical and

contemporary disparities in power, authority, and status while working to disrupt those disparities and build a more just future with young people.

Four Pillars for Sense-making in Science Instruction

Principle 3: Phenomena Matter for Sense-Making

Learning science creates opportunity for *active, meaningful, collaborative engagement with phenomena* so that students work together to inquire into questions, figure out problems and design solutions, collect and make sense of evidence, build claims, and evaluate and communicate scientific information that matters to youth, their communities, and the world. When students have opportunities to engage with *real-world events*, new questions and problems arise, prompting students to pose and pursue additional questions using science and engineering practices. Creating opportunities for students to *conduct qualitative or quantitative observations explicitly linked to phenomena or problems in order to generate evidence* useful for building scientific explanations and arguments is essential for sense-making.

Principle 4: Student Contributions Matter for Sense-Making

Educator responsiveness to students' ideas, language, and multiple ways of making sense is central to cultivating students' interests and identities in science. Science is meaningful when *students build and expand identities as capable learners, sense makers, users of science, and full participants* in learning communities engaged in meaningful, consequential pursuits. Anchoring students' contributions in an ongoing effort to *build, test, revise, and justify scientific models* created by students is an important way to keep students' evolving meaning-making at the center of their scientific practice. Modeling, then, is a crucial component of students' scientific work as they strive to develop and *use models to explain, argue, or predict phenomena*. When working within a community of learners, students develop models that *can also serve as representations of thinking* useful for communicating ideas with others.

Principle 5: Science and Engineering Practices Matter for Sense-Making

Students build scientific understanding and language effectiveness simultaneously by engaging in *communication-rich science and engineering practices*, core ideas, and cross-cutting concepts. Engagement in science and engineering practices supports collective sense-making, both in the moment and across time, which supports gradual shifts in language use. Supporting students to gather evidence, coordinate that evidence with others' ideas and evidence, and *weigh strengths of evidence* allows for shared sense-making about phenomena and makes space for students to critique different ideas and to build knowledge and language together.

Principle 6: Positioning Students with Agency and Authority Matters for Sense-Making

Students can express ideas that are complex, precise, and explicit with everyday language. Therefore, positioning students in ways that elicit their ideas is central to supporting their engagement as competent members of a learning community. *Positioning* students and teachers as co-inquirers whose interests, questions, and contributions are valuable for sense-making is essential for making science and language meaningful for learners. Creating opportunities for

students to exercise agency as capable inquirers and problem-solvers fuels students' efforts to *build arguments from evidence* as they become authors of scientific explanations, models, and designers of solutions to real-world problems.

Assurance of Equity for Multilingual Learners

Principle 7: Educators must Leverage and Sustain Students' Cultural and Linguistic Assets
Equitable science education *leverages as assets* students' experiences, ways of knowing, and cultural and linguistic resources. Learners' life experiences, including family and community practices and pursuits, are essential for making sense of science and are worthy of being communicated, shared, and explored within a diverse learning community, ensuring that students develop science and language simultaneously in *culturally sustaining* ways.

Principle 8: Students Learn Through Expanding Science and Language Repertoires
Science is more culturally and linguistically responsive to multilingual learners when they have opportunities to explore ideas and questions, *beginning with their familiar language(s) and language practices,* and expanding science sense-making and developing language effectiveness gradually and over time through engagement in scientific discourse practices. Science teaching that leverages a broad range of language resources and multiple modalities (e.g., familiar and everyday language(s), translanguaging, gestures, and visual representations) helps students *expand their repertoires* of language use to enable expression of more complex ideas, explicitness, increased precision, and shifts in register.

The continued rapid growth of the K–12 multilingual learner population in the United States, in conjunction with policies and practices that unnecessarily exclude highly capable multilingual learners from engagement in rigorous science education, call for new approaches and resources. These design principles are intended to guide the development of new approaches and resources to overturn this inequity in science education.

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