NGSS-Aligned Science Instructional Materials for English Learners

Workshop on Instructional Materials for the Framework for K-12 Science Education and the Next Generation Science Standards
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The Framework (National Research Council, 2012) and the NGSS were developed with the vision of "all standards, all students" (NGSS Lead States, 2013). "Doing" science and engineering (e.g., developing models, constructing explanations, arguing from evidence) according to the vision of the Framework and NGSS inherently involves language use (Lee, Quinn, & Valdés, 2013). Using language in the context of doing specific things differs greatly from the conventional perspective that focuses on learning vocabulary and grammar before they are put to use. Contemporary thinking recognizes that language learning occurs not as a precursor but as a product of using language in social interaction (Valdés, 2015).

This new wave of standards-based reform and new conceptions of learning science and learning language coincide with rapidly changing demographics of the nation's student population, especially English learners (ELs) who represent the fastest growing subpopulation (Gándara & Hopkins, 2010). According to the 2010 U.S. Census, 21% of school-age children spoke a language other than English at home (U.S. Census Bureau, 2012). ELs constituted 9.3% of public school students in 2013-2014, or an estimated 4.5 million students (National Center for Education Statistics, 2016).

Conceptual Framework

Our collaborative research team between New York University and Stanford University is developing instructional materials to support science learning and language learning with elementary students, including ELs, in fifth grade (NSF Grant DRL-1503330). We have developed our conceptual framework for science and language integration with ELs, which is based on how science instructional shifts and language instructional shifts support each other with ELs. Our conceptual framework consists of (1) our perspective, which provides the framing of science and language integration with ELs, and (2) design principles, which describe specific guidelines for developing our instructional materials to promote science and language integration with ELs.

Perspective

In recent years, there have been fundamental shifts in thinking about both science and language learning. These shifts are mutually supportive, as they promote a more socially-situated and practice-oriented view of learning in both fields. Science instructional shifts promote language learning with ELs, while language instructional shifts promote science learning with ELs. Recognizing science and language instructional shifts as mutually supportive can lead to better and more coherent instructional materials that promote both science and language learning for with all students, especially ELs. The mutually supportive nature of these shifts underlies our perspective on science and language integration with ELs:

ELs participate in a classroom community of practice that offers continuous opportunities to "do" science. Science classroom communities of practice provide rich environments for both science and language learning with ELs. In the science classroom, students are mutually engaged in making sense of the natural and designed world. As they build on each other's ideas and co-construct scientific understanding, they engage in interactions that promote language learning.

ELs use language for purposeful communication, as they "do" science. In classroom communities of practice, teachers generate opportunities for learners to *do specific things with language* in pursuit of a common goal. The role of the teacher is to provide opportunities for purposeful communication that are supportive of both science and language learning. The NGSS science classroom offers fertile ground for generating such opportunities.

All ELs participate meaningfully in rigorous science learning, regardless of their English proficiency levels. In the NGSS science classroom, ELs carry out sophisticated science and engineering practices, such as constructing explanations and arguing from evidence, through their emerging English. They also bring with them to the science classroom a vast array of cultural and community resources that help them make sense of the natural and designed world. Their contributions are valued for their meaning rather than their linguistic accuracy.

Science (NGSS) Design Principles

Science design principles, which are seamlessly intertwined and based on the vision of the Framework and NGSS, promote language learning for all students and ELs in particular.

ELs explain phenomena in the natural world or design solutions to problems in the designed world. We advocate for local phenomena or problems that involve ELs' everyday experience and language in their homes and neighborhoods. Local phenomena or problems combine place-based learning and project-based learning (Lee & Miller, 2016). From an equity perspective, through place-based learning, students apply science and engineering to their daily lives in local contexts (Avery, 2013). From a science perspective, through project-based learning, students integrate science disciplines as they investigate a driving question to explain a phenomenon (Krajcik, McNeil, & Reiser, 2008) and apply engineering to local contexts as they design solutions to problems and participate in citizen science (Bonney et al., 2009).

ELs engage in three-dimensional learning by blending science and engineering practices (SEPs), crosscutting concepts (CCCs), and disciplinary core ideas (DCIs). In particular, SEPs are critical for ELs. Because engagement in SEPs is language-intensive, it calls for a high level of classroom language (Lee et al., 2013). While engaging in SEPs, ELs comprehend (receptive language functions) and express (productive language functions) science ideas using less-than-perfect English. As a result of this emphasis on SEPs, the NGSS science classroom promotes rigorous science learning and rich language learning.

ELs build their understanding over the course of instruction. As ELs develop deeper and more sophisticated science understanding, their language use becomes more *precise* (NRC, 2014; Quinn, Lee, & Valdés, 2012). Students learn that the level of precision needed to engage in SEPs demands a comparable level of precision in language use. This demand for precision goes beyond the meaning of technical vocabulary to the logic of connecting cause and effect and the validity of claims and evidence. In addition, their language use becomes more *explicit.* Science often involves communicating about objects and events not immediately present, and explicitness makes language use more effective with "distant" audiences.

Language Design Principles

Drawing on socially-oriented views in second language acquisition, we present three design principles that promote language learning for all students and ELs in particular. Each design principle is discussed in relation to the science design principles outlined above.

Use multiple *modalities* in increasingly strategic ways. *Modalities* refer to the multiple and diverse channels through which communication occurs (e.g., talk, text, diagrams). Multiple modalities are important from the perspectives of both academic disciplines and EL education. In disciplines such as science, multiple modalities other than oral and written language are used to communicate ideas and thus all students, including ELs, are expected to use multiple modalities specific to each discipline in strategic ways (Lemke, 1998). In EL education, multiple modalities also serve to support ELs at the early stages of English language proficiency, as they engage in language-intensive practices such as arguing from evidence. Thus, multiple modalities are both essential to engagement in SEPs and beneficial to ELs.

Use increasingly specialized/disciplinary *register* of talk and text. *Registers* refer to the language used in talk and text that is associated with particular contexts of use (Biber & Conrad, 2009). Registers can range from everyday or colloquial to specialized and disciplinary. Differences in register, rather than being absolute, are a matter of degree. For this reason, we refer to registers as more or less everyday or specialized. As ELs build science understanding over the course of instruction, their language use becomes increasingly specialized/disciplinary.

Use multiple modalities and registers to meet communicative demands of different types of *interactions*. Whether a particular combination of modalities and registers is appropriate or effective may vary as a function of the characteristics of *interactions*, including the purpose and interlocutors involved. Which registers and modalities are used is determined, in part, by whether interactions are one-to-one (e.g., one student communicating with a partner), one-to-small group (e.g., one student communicating with a small group), one-to-many (e.g., one student communicating with the whole class or a broader audience), or small group-to-many (e.g., small groups making class presentations). For example, in communicating with broader audiences, students can rely less on a shared frame of reference and, instead, require the precision and explicitness that a specialized register affords.

Figure 1, which is adapted from Lee et al. (2013), displays modalities, registers, and interactions that are typical of the science classroom. In the NGSS classroom, students draw on multiple modalities, use a range of registers, and move fluidly across modalities and registers in response to the communicative demands of different interactions, as they use language to "do" science.

<table>
<tr><th>Modalities</th><th colspan="2">Registers</th><th>Interactions</th></tr>
<tr><td>Talk
Text
Diagram
➢ Drawing
➢ Table
➢ Graph
➢ Chart</td><td>Colloquial/
everyday
talk and text
⟵</td><td>Specialized/
disciplinary
talk and text
⟶</td><td>One-to-one
One-to-small group
One-to-many
Small group-to-many</td></tr>
<tr><td></td><td colspan="2">Precision: Is the language exact enough to communicate discipline-specific ideas (e.g., using discipline-specific terms)?
Explicitness: Can someone who is not in the classroom understand?</td><td></td></tr>
</table>

Figure 1. Modalities, registers, and interactions typical of the NGSS science classroom.

Opportunities and Challenges

Developing instructional materials based on our conceptual framework has exposed opportunities and challenges for integrating science and language with ELs. These challenges and opportunities can be attributed to a number of a potential sources:

- NGSS and language integration presents inherent opportunities and challenges;
- Increased collaboration between science and EL educators is needed;
- Curriculum writers need to know how to capitalize on opportunities and address challenges;
- Teachers and students need to go through learning progressions; and/or
- The capacity of the education system needs to be considered.

Even after we successfully address the above issues, there are practical constraints that have equity implications:

- Science instructional time,
- Science supplies and expense, and
- Teachers' content knowledge.

Our work highlights the need for increased collaboration between content areas, such as science, and the field of EL education in order to ensure all students, and ELs in particular, are supported in meeting rigorous content standards while developing proficiency in English.

Note: This paper is based on Lee, O., Grapin, S., & Haas, A. (in press). How science instructional shifts and language instructional shifts support each other for English learners: Talk in the science classroom. In A. Bailey, C. Maher, & L. Wilkinson (Eds.),

Language, literacy and learning in the STEM disciplines: How language counts for English learners. New York, NY: Routledge.

References

Avery, L. M. (2013). Rural science education: Valuing local knowledge. *Theory Into Practice, 52*(1), 28-35.

Biber, D., & Conrad, S. (2009). *Register, genre, and style.* Cambridge, England: Cambridge University.

Bonney, R., Cooper, C. B., Dickinson, J., Kelling, S., Phillips, T., Rosenberg, K. V., & Shirk, J. (2009). Citizen science: Developing a tool for expanding science knowledge and scientific literacy. *BioScience, 59*, 977-984.

Gándara, P., & Hopkins, M. (2010). *Forbidden language: English learners and restrictive language policies*. New York, NY: Teachers College Press.

Krajcik, J., McNeil, K. L. & Reiser, B. (2008). Learning-goals-driven design model: Developing curriculum materials that align with national standards and incorporate project-based pedagogy. *Science Education*, 92(1), 1-32.

Lee, O., Quinn, H., & Valdés, G. (2013). Science and language for English language learners in relation to Next Generation Science Standards and with implications for Common Core State Standards for English language arts and mathematics. *Educational Researcher, 42*(4), 223-233.

Lemke, J. (1998). Multiplying meaning: Visual and verbal semiotics in scientific text. In J. Martin & R. Veel (Eds.), *Reading Science*. London, England: Routledge.

National Center for Education Statistics. (2016). *The condition of education 2016* (NCES 2016-144). Washington, DC: U.S. Department of Education.

National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas.* Washington, DC: National Academies Press.

National Research Council. (2014). *Literacy for science: Exploring the intersection of the Next Generation Science Standards and Common Core for ELA Standards: A workshop summary.* Washington, DC: National Academies Press.

Next Generation Science Standards Lead States. (2013b). *Appendix D – "All standards, all students": Making Next Generation Science Standards accessible to all students.* Washington, DC: National Academies Press.

Quinn, H., Lee, O., & Valdés, G. (2012). *Language demands and opportunities in relation to Next Generation Science Standards for English language learners: What teachers need to know.* Stanford, CA: Stanford University, Understanding Language Initiative (ell.stanford.edu).

U.S. Census Bureau. (2012). *Statistical abstract of the United States, 2012.* Washington, DC: Government Printing Office. Retrieved from http://www.census.gov/compendia/statab/cats/education.html

Valdés, G. (2015). Latin@s and the intergenerational continuity of Spanish: The challenges of curricularizing language. *International Multilingual Research Journal, 9*(4), 253-273.