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Fostering Multilingual Learners' Discourse Through Cognitively Demanding Tasks

Dr. Walter Aminger Ph.D
Assistant Professor
Department of Science Education
Nevada State University
Email: Walter.Aminger@nevadastate.edu
ORCID iD: https://orcid.org/0000-0003-3232-0132
USA

ABSTRACT

Students designated as Multilingual learners (MLs) are the fastest-growing group of students in K-12 public schools across the United States. Therefore, preparing preservice secondary science teachers to adequately support their students' learning of science, as envisioned in these reform documents, should be a priority for all teacher education programs. This work examined ten preservice secondary science teachers' understanding of academic language and the types of instructional supports they implemented to scaffold MLs' academic language use during cognitively demanding tasks in their secondary science classrooms. In addition, this study showed that participants were willing to take responsibility for supporting the academic language demands of the cognitively demanding tasks they implemented and were able to draw on a robust range of strategies. As such, teacher education programs will need to provide preservice teachers with an even deeper understanding of how to scaffold the complex linguistic demands of discourse.

Keywords: Multilingual Learners (MLs), equity, science education, reform-based instruction, pre-service teacher, secondary teacher education

Introduction

Students designated as Multilingual learners (MLs) are the fastest-growing group of students in K-12 public schools across the United States (NGSS Lead States, 2013). Multilingual learners account for more than nine percent of students currently enrolled in K-12 classrooms in the U.S. (National Center for Education Statistics, 2016). This has prompted teacher education programs to focus more intently on preparing preservice science and mathematics teachers to integrate science content and practices with English language and literacy development effectively. These preservice teachers must move beyond general strategies to disciplinary-specific principles and practices (Lyon et. al., 2016) aligned with the *Next Generation Science Standards* (*NGSS*, NGSS Lead States, 2013) and the *Common Core State Standards in Mathematics* (*CCSS-M*, National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). They must also be able to use the diverse cultures, languages, and experiences of MLs as resources for disciplinary learning.

While the interconnected nature of scientific discourse and scientific sense-making has long been recognized (Lemke, 1990; Windschitl et. al., 2018), ambitious new *Next Generation Science Standards* (*NGSS;* NGSS Lead States, 2013) and increasing numbers of linguistically diverse students underscore the importance of preparing science teachers who can support both language and content learning in the United States. Further, despite this long-standing interest, science educators have much to learn about how teachers can best support language-intensive science and engineering practices, particularly in secondary science classrooms (Lee et. al., 2013). Thus, students are expected to engage in these practices to help reason about and make sense of phenomena as well as to develop greater proficiency in the language of science. In conclusion, preparing preservice secondary science teachers to adequately support their students' learning of science, as envisioned in these reform documents, should be a priority for all teacher education programs.

In this study, the author investigated how preservice secondary science teachers support the discourse demands of tasks implemented as part of their edTPA lesson cycle (a national performance-based assessment for preservice teachers). More specifically, this work examined ten preservice secondary science teachers' understanding of academic language, and the types of instructional supports they implemented to scaffold MLs' academic language use during cognitively demanding tasks in their secondary science classrooms. The following two sets of questions guided this research: (1) What *NGSS* science and engineering practices aligned with cognitively demanding tasks were implemented in the classroom by science preservice teachers? (2) How did preservice science teacher participants effectively support their Multilingual learners' academic language while implementing language-rich (intensive) *NGSS* science and engineering practices? Therefore, the purpose was to contribute evidence-based research to improve science teacher education and help prepare PSTs to teach their discipline in reform-based ways to MLs.

Theoretical Framework

This theoretical framework is composed of three parts. The first dimension addresses the need for teachers to adopt a principle-based approach to supporting MLs. The framework employed in this study consists of four principles. One principle, *providing students with cognitively demanding work* (Windschitl et. al., 2018), insists that MLs routinely engage in the types of reform-minded, academically rigorous tasks that are often reserved for non-ML students (Iddings, 2005). A second principle, *providing students opportunities for rich language and literacy exposure and practice* (Lee et. al., 2013), holds that MLs must be given extensive opportunities to engage in the discourse of science and mathematics. A third principle, *identifying academic language demands and supports for MLs* (Aguirre & Bunch, 2012), emphasizes that

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teachers must scaffold the academic language demands of their classrooms. Finally, the fourth principle, *building on and using students' funds of knowledge and resources* (Moll et. al., 1992), asks teachers to use MLs' languages, experiences, and community connections as resources for learning.

A second dimension of this conceptual framework addresses the cognitive demand of a task, characterized by the degree of thinking and reasoning essential for students to carry it out (Tekkumru-Kisa et al., 2017). The *TAGS* (Task Analysis Guide in Science) framework proposed by Tekkumru-Kisa and colleagues (2015) enables researchers to track the *NGSS* science and engineering practices and science content included in tasks so as to evaluate both the kind (i.e., integrated or isolated) and level (i.e., cognitive demand) of student reasoning and sensemaking required. The first dimension examines whether the task is integrated or isolated across the practices and content of the discipline; the second determines the extent to which a task promotes authentic disciplinary thinking.

The third dimension is a situated theory of teacher learning. A situated theory considers all learning to occur in a context and for that context, associated activity, and tools to contribute to what is learned (Brown et. al., 1989; Greeno, 2006). It also understands learning to be developed through social interactions: Learning is conceptualized as increased participation in a community's practices as well as an individual's development as a result of this participation (Lave & Wenger, 1991). Because teacher learning is situated in communities, colleagues can either help each other to develop a more profound understanding of content and instructional practices or constrain efforts to enact equity-minded and reform-based instruction (Putnam & Borko, 2000).

Methodology

This study is part of a larger ongoing research project focused on assessing the impact of undergraduate and graduate teacher preparation programs on preservice science and mathematics teachers. At three California research universities included in this study, participants were enrolled in small, 13-month, post-baccalaureate teacher education programs that intentionally integrated instruction about MLs across courses. Data were collected and analyzed for ten PSTs (n=10) participants' edTPA portfolios, which focus on a three-to-four-day lesson series and consist of three sections: planning, instruction, and assessment. Preservice teachers also submit written lesson plans, two video excerpts of instruction, and three student work samples. Table 1 shows the distribution of participants across the three campuses, while Table 2 presents demographic information.

Table 1
Distribution of PST Participants Across Three Campuses

	Year 1	Year 2	Total
University 1	1	3	4
University 2	1	2	3
University 3	1	2	3
			10

Table 2
Participant Demographics

Discipline	
Science	100%
Gender	
Female	55%
Male	45%
Race/Ethnicity	
White/European American	70%
Asian/Asian American	15%
Other	10%
Multiracial	2%
Latinx	3%
First Language	
English	80%
Language(s) other than or in addition to English	20%
***Note.* All demographic data are self-reported.**	

To answer these two research questions, the author began by transcribing the video clips of instruction. Later, written commentaries and video transcripts were qualitatively analyzed, using three cycles of analysis and a different set of *a priori* or emergent codes for each (Saldaña, 2016). More specifically, for this first cycle of analysis, four a priori codes constructed from the principles of effective teaching of MLs (theoretical framework) were used, especially focusing on cognitively demanding tasks and

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academic language supports for further tier 2 coding. During this second cycle of analysis, in order to answer the second research question related to preservice teachers' understanding and implementation of cognitively demanding tasks, the author coded for each of the eight NGSS science and engineering practices (e.g., engaging in argument). Moreover, the goal was to determine when and in the context of which other science practices teachers were enacting discursive instructional academic language supports for MLs while implementing those specific language-intensive practices (e.g., constructing an explanation). Finally, in this third cycle of analysis, to further explore the scientific cognitive demand and types of support preservice teachers implemented, the author used the previous two tiers of codes to make two sets of judgements: (1) The level (i.e., high/low cognitive demand) of student reasoning and sensemaking required during instructional tasks was determined. (2) The level of academic language/linguistic demand (i.e., lexical, syntactic, and discursive) and type of instructional support (e.g., word walls, sentence frames, and peer collaboration) were determined. In particular, the author focused on the most common (implemented by a majority of preservice teacher participants) types of support preservice teacher participants used to scaffold academic language demands at the discursive level given its importance in the current NGSS reform-based instruction (Table 3).

Table 3: Types of Academic Language Support

Type of Support	**Description**
Chunking task	Teacher breaks down activity into smaller, more manageable phases.
Differentiation	Teacher provides different options or activities for students with different needs.
Facilitating small group discussion	Teacher uses questions or discourse moves (e.g. probing, pressing) when working with small groups.
Facilitating whole class discussion	Teacher uses questions or discourse moves (e.g. probing, pressing) during whole-class discussions or brainstorming sessions.
Home language	Teacher uses students' home languages to support understanding.
Individual instruction	Teacher provides a student with targeted instruction not provided to the entire class.
Learner as teacher	Teacher positions students as more capable peer who can help other students to understand the material or complete tasks.
Low floor, high ceiling	Teacher structures a task so that it is initially easily accessible to all students but ultimately allows students to challenge themselves.
Modeling	Teacher models task or AL for students.
Opportunities to practice AL	Teacher provides students opportunities to practice using academic language, e.g. by asking them to explain their reasoning.
Peer collaboration	Teacher has students work in pairs or small groups and/or intentionally groups students with complementary strengths.
Providing context	Teacher either provides context (e.g., a demonstration or a lab) before asking students to use AL, or teacher makes a connection between science content and everyday life.
Questions and suggestions	Teacher poses questions to guide student reasoning and revisions or explicitly suggests a student do or change something; this code is used when such questions or suggestions are not part of facilitating small group or whole class discussions.
Revise and resubmit	Teacher asks student to revise and resubmit an assignment.
Revoicing	Teacher restates what a student says using a more scientific register.
Rubrics	Teacher provides students with a rubric that outlines performance expectations.
Sentence frames	Teacher provides students with sentence frames or starters.
Speaking more clearly or providing clear directions	Teacher makes speech more comprehensible by speaking more slowly, clearly, concisely; attends to clarity of written directions; or provides directions in multiple modalities (e.g. spoken and written).
Step-by-step	Teacher provides step-by-step prompts to guide students through reasoning.
Structured reading	Teacher uses strategies such as popcorn reading, reading guides, highlighting/annotating, or CSR (Collaborative Strategic Reading).
Visuals and hands-on	Teacher uses pictures, videos, physical objects/realia, or hands-on activities.
Learner as teacher	Teacher positions students as more capable peer who can help other students to understand the material or complete tasks.
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Results

Preliminary findings by research question as stated in the introduction section are presented next.

RQ 1: What NGSS science and engineering practices aligned with cognitively demanding tasks were implemented in the classroom by science preservice teachers?

This study examined how participants integrated the *NGSS* science and engineering practices and content. The author found that all six participants engaged their students in five to seven other practices (e.g., *using mathematics and computational thinking).* In addition, all participants used the three *NGSS* practices SEP2, *developing and using models*, SEP3, *planning and carrying out investigations*, and SEP7, *engaging in argument from evidence*, along with SEP5, *using mathematics and computational thinking*, in their work with models. However, for Haylee, Lucas, and Thatcher, the use of mathematics in intersection with these other three practices was an integral part of the science models their respective students developed. The other three participants did not place a similar emphasis in their lessons on using mathematics to create and argue about models.

As one example, Thatcher, as a second example, explicitly identified SEP2, *developing and using models*, and SEP5, *using mathematics and computational thinking*, as two of the practices his students would engage in when using charts and simulations to build a model of collision phenomena:

By creating MVP [Mass, Velocity and Momentum] charts and using computer simulations, they will apply the scientific practice of developing and using models and computational and mathematical thinking to build a model that explains and predicts

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collision phenomena and explains and predicts the conservation of momentum.[Thatcher, Planning Commentary]

RQ 2: How did preservice science teachers effectively support their Multilingual learners' academic language while implementing language-rich (intensive) NGSS science and engineering practices?

As was the case for all participants, Adam provided a meaningful context for language use. He grounded his lesson cycle in a discrepant evolutionary phenomenon and strategically grouped students, creating a need for students to talk science as they collaboratively analyzed data and constructed explanations. Like the other participants, he relied on peer collaboration and discourse moves such as probing, pressing, and re-voicing (Windschitl et. al., 2018) to scaffold students' oral discourse. Preservice teacher participants' relative confidence in supporting oral discourse may stem from the exploratory and contextualized nature of talking science during an investigation, which does not impose the same language demands as written discourse meant to communicate more stable scientific understandings. Notably, participants supported their students' ability to construct evidence-based explanations or to justify claims by embedding scaffolds in the assessment tasks, in their feedback, and in follow-up activities.

Introducing another illustrative case, Molly grounded her instructional task in an observable event or "contextualized phenomenon" (Windschitl et. al., 2018), asking her students to explain the pattern of pea color inheritance observed during their simulation of Mendel's pea crosses. To scaffold this task, she provided students with guiding questions; a word bank of six relevant unit vocabulary words; and two sentence frames to prompt students to make a causal claim about the underlying mechanism. Many PSTs suggested that such supports could help MLs communicate their content understanding independent of language constraints, but they were less likely to suggest these supports could help MLs produce the complex language characteristic of science discourse.

Conclusion

In closing, this study seeks to understand how preservice science teachers can contribute to educational equity by ensuring that all students, including ML students, have substantive opportunities to engage in rigorous content learning as they are supported to use scientific discourse. This study indicated that participants were willing to take responsibility for supporting the academic language demands of the cognitively demanding tasks they implemented, and that they were able to draw on a robust range of strategies. While such attention to language is both understandable and important, this current principle-based framework argues that teachers must do more. As such, these findings suggest that teacher education programs must carefully attend to the balance between supporting academic language and supporting rigorous content learning for MLs. Finally, this study also indicates that if secondary science teachers are expected to help their students successfully engage in scientific discourse, teacher education programs will need to provide preservice teachers with an even deeper understanding of how to scaffold the complex linguistic demands of discourse.

References

Aguirre, J. M., & Bunch, G. C. (2012). What's language got to do with it? Identifying language demands in mathematics instruction for English language learners. In S. Celedón- Pattichis & N. Ramirez (Eds.), *Beyond good teaching: Advancing mathematics education for ELLs* (pp. 183-194). Reston, VA: National Council of Teachers of Mathematics.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, *18*(1), 32-42. doi:10.3102/0013189X018001032

Greeno, J. G. (2006). Learning in activity. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 79-96). New York, NY: Cambridge University Press.

Iddings, A. C. D. (2005). Linguistic access and participation: English language learners in an English-dominant community of practice. *Bilingual Research Journal*, *29*(1), 165-183. http://dx.doi.org/10.1080/15235882.2005.10162829

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation.* New York, NY: Cambridge University Press.

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. doi:10.3102/0013189X13480524

Lemke, J. L. (1990). *Talking Science: Language, Learning and Values*. Norwood, NJ:

Ablex. Lyon, E. G., Tolbert, S., Stoddart, P., Solis, J., & Bunch, G. C. (2016). *Secondary science teaching for English learners: Developing supportive and responsive learning contexts for sense-making and language development*. New York, NY: Rowman & Littlefield.

Moll, L. C., Amanti, C., Neff, D., & Gonzalez, N. (1992). Funds of knowledge for teaching: Using a qualitative approach to connect homes and schools. *Theory into Practice*, *31*(2), 132-141.

National Center for Education Statistics. (2016). *English language learners in public schools*. Retrieved from https://nces.ed.gov/programs/coe/indicator_cgf.asp

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National Governors Association Center for Best Practices, & Council of Chief State School Officers. (2010). *Common Core State Standards for mathematics*. Washington, D.C.: Author.

NGSS Lead States. (2013). *Next generation science standards: For states, by states*. Retrieved from http://www.nextgenscience.org/next-generation-science-standards

Putnam, R. T., & Borko, H. (2000). What do new views of knowledge and thinking have to say about research on teacher learning? *Educational Researcher*, *29* (1), 4-15. doi:10.3102/0013189X029001004

Saldaña, J. (2016). *The coding manual for qualitative researchers* (3rd ed.). Thousand Oaks, CA: Sage.

Tekkumru-Kisa, M., Schunn, C., Stein, M. K., & Reynolds, B. (2017). Change in thinking demands for students across the phases of a science task: An exploratory study. *Research in Science Education*, 1-25. doi:10.1007/s11165-017-9645-z

Tekkumru-Kisa, M., Stein, M. K., & Schunn, C. (2015). A framework for analyzing cognitive demand and content-practices integration: Task analysis guide in science. *Journal of Research in Science Teaching*, *52*(5), 659-685. doi:10.1002/tea.21208

Windschitl, M., Thompson, J., & Braaten, M. (2018). *Ambitious science teaching*. Cambridge, MA: Harvard University.