An Asset-Based Approach to Support Multilingual Learners in Science Classrooms

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UCSB Land Acknowledgement
The University of California, Santa Barbara campus is located on Indigenous land, and it is important that staff, students, and faculty understand the significance of observing protocols in recognizing the traditional custodians of the land at university events and ceremonies. It demonstrates the respect the university has for the Chumash people, the history and culture of the community, and all Native Americans as America’s First Peoples.

We acknowledge the Chumash people, who are the traditional custodians of this land. We also pay respect to Elders both past and present, as well as other Indigenous people present. We are proud to continue their tradition today of coming together and growing as a community.
Multilingual Learners
Starting Points

- Learning science means learning both disciplinary content and language (Lee et al., 2013).

- Use of the term multilingual learners describes students from an asset-based rather than a deficit-based frame (Gonzalez-Howard & Suarez, 2021).

- Multilingual learners bring rich knowledge and resources to the science classroom (Rosebery & Warren, 2008).

- Multilingual learners must be both supported and challenged in learning science (de Araujo et al., 2016).
Who Are Multilingual Learners?

Multilingual learners are diverse.

• They include
  • students who recently immigrated to the US;
  • students born in the US who speak a home language other than or in addition to English; and
  • students who are transnational.

• They vary by
  • language and literacy backgrounds, including home language and number of and proficiency in languages spoken;
  • country of origin, ethnicity, and culture;
  • levels and quality of their prior schooling;
  • personal history;
  • gender identity and sexual orientation; and
  • socioeconomic status.

(National Academies of Sciences, Engineering, & Medicine, 2017)
Who Are Multilingual Learners?

- The population of multilingual learners continues to increase in US K-12 schools.
- In California, over 19% of public school students are multilingual learners.

(National Center for Education Statistics, 2020)
Research makes clear that multilingual learners have not been well served in science classrooms (National Academies of Sciences, Engineering, & Medicine, 2018).

• Multilingual learners are often systematically excluded from rigorous or advanced coursework in science due to the misconception that they must be proficient in English before they can be successful (Callahan, 2017).

• Research has shown a persistent, negative relationship between multilingual learner status and science achievement (Maerten-Rivera et al., 2010).
Goals for Science Education

• We must transform science education so that all multilingual learners have access to, explore, and excel in learning reform-based science ideas, concepts, and practices.

• My focus is on improving science teacher education so beginning teachers learn how to better support and challenge multilingual learners.
A preservice teacher reflected on what she had learned about teaching multilingual learners:

“I, myself, was an EL [multilingual learner] student growing up. I feel like that gives me a little bit of an insight as to what they [multilingual learners] are going through. I know, of course, case by case, it's different. But from everything I've read, the most important part is being able to scaffold the instruction so that even if, say, they're not completely fluent in English, they can still obtain the different concepts and ideas despite the language. They don't need to have ’dumbed down’ curriculum. They can achieve at the same level as everyone else. And actually, I think having multiple languages or having a culture that's slightly different from your neighbor’s is a benefit. You are able to see things from a different point of view.” (Lacey, University 2)
An Asset-Based Framework for Multilingual Learners
Five Principles for Effective Multilingual Learner Instruction

(Meier et al., 2020; Roberts & Bianchini, 2019; Graphic from Santa Barbara Unified School District)
Principle 1: A Safe Classroom

Create a community of learners where all students, including multilingual learners:

- Contribute to sensemaking, regardless of language status, race/ethnicity, gender, disability status, or social class.
- Collaborate.
- Take intellectual risks, including asking questions and respecting different ideas.
- Possess an equity mindset.
- Participate and learn free of fear and stereotypes.
Principle 1: A Safe Classroom

Examples of teacher moves include:

- Know, pronounce correctly, and use students’ preferred names.
- Create student-driven norms and shared beliefs.
- Explore and celebrate students’ identities.
- Create and maintain classroom traditions.
- Select texts that offer windows, mirrors, and sliding doors for all students.
- Implement sensemaking activities and productive discussions so that all students share their reasoning and listen to others’ ideas.
Principle 2: Student Funds of Knowledge

Discover, build on, and amplify student funds of knowledge:

• Learn about students’ interests, life and school experiences, family and cultural resources, and community resources.

• Intentionally integrate students’ knowledge into planning, implementing, and assessing lessons to make content relevant and meaningful.

• Understand and communicate an appreciation for multilingual learners’ ability to speak multiple languages and use different dialects.
Principle 2: Student Funds of Knowledge

Examples of teacher moves include:

• Seek information proactively about students’ histories, families, and communities.

• Draw on students’ knowledge and resources to situate phenomena, questions, and solutions in local contexts.

• Use information about students to plan lessons and (re)design instruction.

• Promote use of multiple languages and non-linguistic resources (e.g., visual representations, gestures, and facial expressions) in the classroom.

• Include families and community members in projects.

• Encourage students to critically evaluate information and enact change connected to their lives and communities.
Principle 3: Disciplinary Language

Attend to disciplinary language demands and provide appropriate supports for all students, particularly multilingual learners:

- Address multiple levels of language, including vocabulary (word), syntax (sentence), and discourse.

- Identify different types of texts, ways to engage students, and opportunities for demonstrating understanding.

- Support comprehension and production of language through speaking, reading, writing, listening, and using non-linguistic resources (e.g., visual representations, gestures, and facial expressions).
Principle 3: Disciplinary Language

Examples of teacher moves include:

• Explain how language functions within science disciplines.

• Model target language.

• Use gestures, models, graphic organizers, physical objects, and visuals to communicate ideas.

• Provide sentence frames and starters that encourage reasoning and diverse ideas.

• Encourage students to use multiple languages and dialects as well as multiple registers within science.
Principle 4: Cognitively Demanding Tasks

Prioritize cognitively demanding tasks for all students, including multilingual learners:

• Create opportunities to engage students in work that allows for multiple perspectives, procedures, and/or products and that is not tightly scripted.

• Implement activities and projects aligned with the Next Generation Science Standards.
  • Include practices like developing and using models, analyzing and interpreting data, engaging in argument, and constructing explanations.
  • Include crosscutting concepts like identifying patterns, determining cause and effect, and connecting structure to function.
Principle 4: Cognitively Demanding Tasks

Examples of teacher moves include:

• Deemphasize rote memorization and “Googleable” facts.

• Contextualize units in relevant, local phenomena.

• Provide opportunities for student choice and peer teaching.

• Support students in reasoning with evidence, justifying their ideas, explaining phenomena, and designing solutions.

• Help students critically evaluate information and enact change connected to their lives and communities.
Principle 5: Rich Language Opportunities

Provide opportunities for rich language and literacy exposure and practice so that all students, including multilingual learners:

- Comprehend disciplinary language.
- Negotiate meaning using texts and with peers.
- Produce disciplinary language.
- Advance both their science understanding and their language development.
Principle 5: Rich Language Opportunities

Examples of teacher moves include:

• Choose texts that model rich disciplinary language.

• Provide daily opportunities for communicating verbally, in writing, through visual representations, and using gestures.

• Plan regular opportunities for turn and talks, partner work, and group discussions.

• Strategically plan for multilingual learners’ participation in small group and whole class discussions.

• Offer opportunities for rehearsal before communicating or presenting ideas.

• Facilitate critical evaluation of information, ideas, and perspectives.
Transforming Science Teacher Education: A Study Across Universities
Overview: Science & Mathematics Teacher Research Initiative (SMTRI)

- Investigated 6 teacher education programs (TEPs).
- TEPs were small in size and housed at research-intensive universities in California.
- Focused on preservice secondary science and mathematics teachers.
- Examined knowledge, beliefs, and practices related to reform (i.e., NGSS, CCSSM) and equity (i.e., multilingual learners).
- Collected data over 4 years (2016 to 2020).
Conceptual Framework: The Five Principles

(Meier et al., 2020; Roberts & Bianchini, 2019; Graphic from Santa Barbara Unified School District)
The small study reported here focused on preservice secondary science and mathematics teachers from 4 TEPs across 2 years:

• How prepared did preservice teachers think they were to teach multilingual learners? What sources did they identify as contributing to their preparation?

• How did preservice teachers understand the five principles of effective multilingual learner instruction?

• Within this principle-based framework, how did preservice teachers understand disciplinary language?
# Preservice Teacher Participants

<table>
<thead>
<tr>
<th>TEP</th>
<th>Type</th>
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<th>Year 2</th>
<th>Total</th>
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<tr>
<td>University 2</td>
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<tr>
<td>University 3</td>
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<td>20</td>
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<tr>
<td>University 4</td>
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<td>24</td>
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<td></td>
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<tr>
<td>66 Female</td>
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<td>78 English</td>
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<td>5 Other</td>
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<td></td>
<td>1 Pacific Islander</td>
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Note: One participant did not answer the race/ethnicity question.
Data Collection and Analysis

- Conducted semi-structured pre and post interviews.
- Created verbatim interview transcripts.
- Qualitatively coded interview data across multiple cycles of analysis to answer each research question:
  - Perceived level (i.e., high, medium, low) and sources of preparation;
  - Understanding of the five principles in general; and
  - Understanding of the disciplinary language principle.
RQ 1: How prepared did PSTs think they were to teach multilingual learners?

A large majority of preservice teachers reported medium to high levels of preparation, but percentages varied by university.
RQ 1: How prepared did PSTs think they were to teach multilingual learners?

The most common source of preparation (or lack of preparation) was the same across universities: field experiences.

- Participants who reported high levels of preparation noted the importance of having opportunities to teach linguistically and culturally diverse students in their classrooms.

- Conversely, participants who reported medium to low levels of preparation noted few such opportunities.
RQ 1: How prepared did PSTs think they were to teach multilingual learners?

The second most common source of preparation (or lack of preparation) was also the same: coursework.

- Participants who reported high and medium levels of preparation saw their courses as helpful in learning how to effectively teach multilingual learners.

- Some who reported medium to low levels of preparation noted their methods courses did not examine this topic in enough detail.

- Others who reported medium to low levels of preparation noted they were unable to practice what they learned in their courses because they did not teach multilingual learners in the field.
RQ 1: How prepared did PSTs think they were to teach multilingual learners?

Examples of preservice teachers who discussed limitations to field placements and coursework:

• “Somewhat [prepared]. Not as much as I could be. I have zero English learners [multilingual learners] right now. So, this is my longest placement, and I'm doing a long placement without any English language learners. Everything that I'm doing with English language learners at this point is theoretical [in courses], as opposed to practical.” (Alexander, University 1)

• “I wish we had spent more time on those topics. There was one week in the methods class that was spent on ELs [multilingual learners], students with diverse language backgrounds. And then there was another week spent on just differentiated instruction in general. I think both of those could have easily been expanded to two weeks, three weeks if time had allowed for it.” (Brandon, University 3)
RQ 2: How did PSTs understand effective instruction for multilingual learners?

Participants discussed the principle of disciplinary language the most often.

- Across universities, every participant discussed this principle.
- Disciplinary language accounted for almost 50% of codes for principles.
RQ 2: How did PSTs understand effective instruction for multilingual learners?

Participants discussed the principles of providing students with rich language opportunities and building on student funds of knowledge at moderate rates.

• Across universities, more than 75% of participants discussed each of these two principles.

• Each accounted for just under 20% of codes for principles.
RQ 2: How did PSTs understand effective instruction for multilingual learners?

• Many participants described language production opportunities in the form of peer collaboration:

  “So my support for ELLs [multilingual learners] was pretty much throughout the lesson series. For one, I had students sit in student groups, heterogeneous groups, so they were purposefully engineered...so that they can bounce ideas off each other and bring various aspects into their group product.” (Kevin, University 4)

• Many described using their multilingual learners’ everyday experiences or prior content knowledge to tap into their funds of knowledge:

  “I feel that my focus on authentic teaching sort of lends itself to teaching diverse populations because it's about finding about what interests them and what experiences they've had.... A diverse population can really increase the effectiveness of science instruction if you use that diversity as a strength.... And maybe you can explain this one phenomenon like surfing that is around here experienced, but maybe there's somebody who has lived in a snowy region...and they have a completely different take on the phenomenon.” (Shane, University 2)
RQ 2: How did PSTs understand effective instruction for multilingual learners?

Overall, participants discussed the principles of cognitively demanding tasks and safe classrooms at low rates.

- Each accounted for less than 10% of codes for principles.

- There were some differences among universities:
  - While 50% to 75% of preservice teachers from Universities 1, 2, and 3 discussed cognitively demanding tasks, less than half from University 4 did so.
  - While 75% of preservice teachers from University 1 discussed a safe classroom, less than 50% from Universities 2, 3, or 4 did so.
RQ 3: How did PSTs understand disciplinary language support for multilingual learners?

Participants across universities focused on two of five types of disciplinary language supports.

• Helping students interpret language: Using visuals or multiple representations, graphic organizers, modified language in directions or text, and/or simplified layout of texts

• Helping students produce language: Using sentence frames and starters, word walls, modeling and examples, and/or alternative ways to express understandings
RQ 3: How did PSTs understand disciplinary language support for multilingual learners?

• Tessa described how she helped multilingual learners access texts:

  “[I tell them,] ‘Okay, you're only going to read these two lines. Then you're going to talk with your partner about what you read. Now someone summarize it for the class. Okay, now let's move on.’ That way, I make sure that all my students, especially my ELLs [multilingual learners], are catching up and not getting bogged down by the language.” (University 1)

• Jasmine explained how she modified a writing task so multilingual learners could more easily produce language:

  “Instead of saying, ‘You have to just write me a claim, evidence, reasoning,’ there's usually a little clause in there like, ‘You can draw a diagram and explain the diagram.’... Because often times it's easier for them to draw what they see, draw what's going on, and then explain it.” (University 2)
RQ 3: How did PSTs understand disciplinary language support for multilingual learners?

Participants across universities focused less on the following three types of supports:

- **Organizing instruction:** Differentiating, adjusting instruction for students’ needs/language proficiency levels, providing individual or extra instruction, chunking a project or lesson, and/or using a formative assessment.

- **Validating students’ home languages and dialects:** Using translations, encouraging multiple languages and dialects, and/or regularly moving across multiple registers for science learning.

- **Creating a meaningful context for language use:** Starting with a phenomenon; connecting to home, communities, or everyday life; addressing a socioscientific issue; and/or taking students’ prior knowledge into account.
Implications for Policy and Practice

Strength: Teacher education programs in California prepare preservice secondary teachers to teach multilingual learners.

- Across universities, the majority of preservice teachers reported medium to high levels of preparation in teaching multilingual learners.

- Across universities, preservice teacher participants’ understanding of effective multilingual instruction was multidimensional, including attending to disciplinary language, rich language opportunities, and student funds of knowledge.

- Across universities, preservice teacher participants identified different types of disciplinary language support, in particular, helping students interpret language and helping students produce language.
Implications for Policy and Practice

Needed Improvements: Teacher education programs should work to better align theory and practice, science and language learning.

• Programs should ensure all preservice secondary teachers teach multilingual learners in their placements.

• Programs should emphasize the principle of cognitively demanding tasks so that multilingual learners engage in language for learning science (and mathematics) – so that they are both challenged and supported.

• Programs should emphasize more types of supports, in particular, supports tied to science (and mathematics) concepts and practices like creating meaningful contexts for language use.
Making the Principle-Based Framework “Work” for Preservice Science Teachers: A Study in Progress
Overview: STEM Teachers for Multilingual Learners – Excellence and Retention (STELLER)

• We are investigating preservice secondary science and mathematics teachers at one university in California.

• We are examining their understanding of teaching multilingual learners using the five principles and instructional language routines.

• Our collection and analysis of data are ongoing (2019 to present).
Conceptual Framework: The Five Principles

(Meier et al., 2020; Roberts & Bianchini, 2019; Graphic from Santa Barbara Unified School District)
Conceptual Framework: Instructional Language Routines

• Instructional language routines provide structured ways for students to regularly and productively engage with concepts and practices (Kelemanik et al., 2016).

• They organize tasks and amplify language so multilingual learners
  • Access rigorous concepts and practices;
  • Engage in productive discussions;
  • Optimize their language production opportunities; and
  • Forge connections across content and language (Zwiers et al., 2017).

• Examples include
  • Co-Craft Questions & Problems;
  • Three Reads;
  • Stronger & Clearer; and
  • Clarify, Critique & Correct (see Roberts et al., 2021).
Research Questions

• How did preservice teachers use different instructional language routines to highlight one or more of the five principles of effective multilingual learner instruction?

• What did preservice teachers learn about how to support and challenge their multilingual learner students? What questions or struggles remain?
# Preservice Teacher Participants

<table>
<thead>
<tr>
<th>Year</th>
<th>Gender</th>
<th>Race/Ethnicity</th>
<th>First Language</th>
<th>Total</th>
</tr>
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<tbody>
<tr>
<td>Year 1</td>
<td>7 females 6 males</td>
<td>9 European American 2 Asian American 2 Latinx</td>
<td>12 English 1 Spanish</td>
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<td>Year 2</td>
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<td>11 European American 3 Asian American 1 Latinx</td>
<td>13 English 1 French 1 Japanese</td>
<td>15</td>
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</tbody>
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Data Collection and Analysis

- We are collecting the following types of data:
  - Lesson plans that include principles and instructional language routines;
  - Weekly written reflections on understanding and use of principles and routines;
  - For a subset of participants, video recorded rehearsals of routines; and
  - For a subset of participants, individual interviews.

- We are qualitatively coding data across multiple cycles of analysis to answer our two research questions.
Context of Study

• During a science methods course, we engage preservice teachers in a unit on School Water Pathways (see Warnock et al., 2012).

• The unit’s purpose is to understand the complexities of the water cycle by exploring relationships among multiple processes, pathways, driving forces, and constraining factors.

• The phenomenon investigated is rain falling and then pools of water “disappearing” from their school grounds.

• The driving question is: Where does the water that falls on our school campus go?

• We emphasize supporting and using language for learning science – helping students to learn to talk about and make sense of water pathways.
Moving Towards Principle-Based, Science-Specific Supports: One Example

**Stronger & Clearer Routine**

1. **Individual prewrite**
2. **Think time to decide and rehearse what they will say about the water pathways to their peers**
3. **Pair share with a partner**
4. **Switch partners one to three more times**
5. **Post-write, where they return to their seats and revise their Pathways Tool**

Pathways Tool
Moving Towards Principle-Based, Science-Specific Supports: A Second Example

Clarify, Critique, & Correct Routine

1. Students first clarify the reasoning of the initial response. They are given sentence starters to help frame their discussion if needed.

2. In critique, students analyze the response in light of their own understanding of the scientific principles that govern where water moves and why.

3. In correct, students work collaboratively to write an improved response.

4. The routine concludes with pairs or groups sharing out their improved Drivers and Constraints Tool responses.
Implications for Policy and Practice

In this ongoing research project, we are working to determine the following:

• What principle-based, science-specific supports can beginning teachers learn to use in their instruction with multilingual learners.

• How do these principle-based, science-specific supports help multilingual learners to develop both deep content understanding and fluency in disciplinary language – help to both support and challenge multilingual learners.
Wrapping Up
References

Callahan, R. (2017, July 26). Equity & access: High school EL students’ STEM course-taking. Presentation to the National Research Council’s Committee on STEM Education for English Learners, Washington, D.C., United States.


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