Intensive Intervention Practice Guide:

Mathematics-Language Instruction for Emergent Bilingual Students With Mathematics Difficulty

Danielle O. Lariviere, University of Texas at Austin
Vishakha Agrawal, Vanderbilt University
Jiaxin Jessie Wang, Vanderbilt University

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What Is It?

Mathematics language is the avenue through which students access mathematics information and concepts. Language plays a central role in students' development of mathematics knowledge, beginning with early numeracy skills (Purpura & Reid, 2016). As students advance through grade levels, they encounter new mathematics language across domains, including the number system, data and measurement, and algebraic thinking (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). Across these domains, students are exposed to a wide range of mathematics language (Monroe & Panchyshyn, 1995). Some mathematics terms are entirely unique to the context of mathematics, such as *integer* and *quadrilateral*. Other terms have both mathematics-specific and generalized meanings, such as *volume* and *degrees*. In this practice guide, we consider mathematics language to include all terminology with mathematics-specific definitions, including those that also have alternative meanings.

Given the complex language demands embedded in learning mathematics, it is essential to provide students with high-quality mathematics-language instruction. Several student populations may require targeted support in building mathematical language comprehension, including those with oral language and reading difficulties (Adlof & Hogan, 2019; Powell et al., 2019). Emergent bilingual (EB) students, particularly those who exhibit mathematics difficulty (MD), may also benefit from tailored mathematics-language instruction (Doabler et al., 2016). In this practice guide, we focus specifically on EB students with MD as we outline evidence and research gaps on mathematics-language instruction. This practice guide can serve as an extension to Zagata et al.'s (2021) guide by offering additional insight into the specific needs of EB students.

Specifically, we describe how to support mathematics-language development in the context of word-problem solving. Word-problem solving is a primary element of overall mathematics proficiency, and it relies heavily on mathematics-language knowledge (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010; Powell et al., 2019). Fuchs et al. (2015) outlined that word-problem solving requires a unique form of language comprehension focused on mathematics-specific language. This content-specific language comprehension includes both mathematics-vocabulary knowledge and understanding of the syntax (sentence structure) of mathematics word problems. In this practice guide we focus our review to the best practices in mathematics-language development within the context of word-problem instruction.

For Whom Is It Intended?

Upon entering the public school system, families complete a home language survey. If the family identifies a primary home language other than English, students are classified as having a non-English language background (NELB). NELB students complete an English proficiency assessment and may receive English language services depending on their performance. Many terms have been used to describe students from NELB who require English language services. Students who require services have been, throughout the literature, described as "Limited English Proficiency," "English Language Learners," and "English Learners" to name a few examples. Recently, there has been a push to describe the students as EBs to combat a deficit perspective of NELB students who require English services. For the purpose of this guide, we use the term EB to identify NELB students who are actively receiving English language services (Garcia, 2008).

In the fall of 2019, EB students accounted for 5.1 million students, or 10.4% of all students, in the public education system (National Center for Education Statistics, 2022). Of all EB students, 14.4% were also identified as having a disability. With the increasing percentage of EB students in the United States, it is critical to identify the most effective interventions for this student population. In particular, given EB students' risk of experiencing MD (Doabler et al., 2016), development and accessibility of effective mathematics interventions specific to EB students' development is needed.

In this practice guide, we define students with MD as those with or without a disability who exhibit below-grade-level mathematics performance (Nelson & Powell, 2018). Researchers identify this level of performance in multiple ways, including (a) teacher nomination, (b) placement in a mathematics resource classroom, and (c) cutoff scores on research-based screening tests (Bottge et al., 2001; Nelson & Powell, 2018). Cutoff scores on research-based screening tests often range from the 10th percentile to the 40th percentile (Jitendra et al., 2021; Nelson & Powell, 2018). To make this practice guide as widely applicable as possible, we rely on literature from researchers who determine MD status across each of these modes of identification.

How Does It Work?

Mathematics language can either be taught in isolation or by embedding its instruction into existing interventions for other skills that require mathematics-language knowledge. For EB students, a growing research base (see Arizmendi et al., 2021 for review) on the efficacy of mathematics-language interventions supports a variety of interventions over business-as-usual instruction, with the largest effect sizes for kindergarten students compared to older students in late elementary or middle school, especially for students with MD. This underscores the importance of early detection and early intervention. Recommendations for teaching mathematics language in isolation draw heavily on evidence-based instructional practices for non-mathematical English language. This research includes repeated exposure to target words in different contexts (across multiple texts) and modalities (discussion, videos, writing), and using explicit instruction practices (Powell et al., 2020; Truckenmiller et al., 2019). In studies where mathematics-language instruction is embedded in a larger intervention, EB students with MD have shown improvement in skills such as addition (Powell & Driver, 2015) and numeracy (Doabler et al., 2019). In addition, the most relevant findings come from studies examining word-problem solving (Driver & Powell, 2017; Orosco & Abdulrahim, 2018). Culturally responsive mathematics-language instruction was intentionally woven into the preexisting evidence-based word-problem solving interventions for students with MD to tailor them to the unique needs of EBs (Doabler et al., 2016).

While these studies did not isolate the contribution of mathematics-language improvement in overall gains in word-problem solving, they did outline the emerging best practices for EB students with MD. From reviewing the abovementioned studies, commonalities in instructional practices across studies are listed below. It is not statistically feasible to disaggregate the impact of each of these practices, but these are the most research-informed recommendations that can be made from the available literature specific to mathematics language and EB students with MD. Incorporating them will bolster Tier-2 instruction by fostering a more inclusive classroom environment.

1. Explicit Instruction and Modeling: Guided and independent practice with corrective feedback and frequent opportunities to respond for students, preferably in small, homogenous groups
2. Schema or Strategy-Based Word-Problem Instruction: Scripted lessons where students are taught different word-problem types, with an emphasis on recognizing the underlying structure of the problem and distinguishing when to use which strategy
3. Scaffolding Instruction with Culturally Responsive Practices: Explicitly stating measurable goals of instruction, incorporating student experiences or references to their cultural heritage in instructional examples, and encouraging peer discussion in English or students' own native language

Additionally, teachers can rely on school and district-level supports such as their ESOL counselor, multicultural coaches, and language facilitators who are trained in adapting curricula to cater to the needs of EB students. Further, resources from the WIDA consortium (World-Class Instructional Design and Assessment) can also be helpful in planning lessons involving complex language and content-area instruction for EB students with learning difficulties. Consider the following scenario:

"Mx. Taylor is a fourth-grade teacher with most students in their class struggling with reading and/or mathematics to varying degrees. They recently had a new student, Sam, join their class. Sam is an EB who receives language supports from a district community language facilitator, but Mx. Taylor does not have a specialization in teaching students from linguistically diverse backgrounds. They are about to start a unit on using the four operations to solve word problems with fractions and decimals that involves heavy mathematics-vocabulary knowledge, which Mx. Taylor recognizes might be more difficult for Sam than other non-EB students in the class.

Mx. Taylor knows that schema-based instruction is the best practice for teaching word-problem solving to students, and upon further review, finds that this applies to both EBs and non-EBs. Further, Mx. Taylor thinks back to a recent training at the school district on supporting students from linguistically diverse backgrounds in academic classes where the trainer emphasized using explicit systematic instruction. Mx. Taylor has experience with explicit systematic instruction for reading-related skills but not for mathematics skills and so they seek input from others on how to incorporate it in their upcoming mathematics lesson.

Before beginning the unit, Mx. Taylor reviews their lesson plans to check that their lessons are consistently scripted so that their students will be able to easily identify the structure of the word problem in line with schema-based instruction. Using an "I do, we do, you do" structure, they walk the students through identifying the relevant mathematics vocabulary. They have students identify the operation, the relevant numbers, and the units before setting up an equation to solve the problem. This is good instructional practice for all students who struggle with mathematics regardless of language status.

Additionally, Mx. Taylor makes sure to set up a data collection tracking sheet to track Sam's progress. They build in check points to track Sam's understanding. When working in small groups, Mx. Taylor reinforces Sam's understanding of the word problem by stopping to do vocabulary checks and building vocabulary repetition into the instruction. Mx. Taylor also provides Sam with a glossary with key words in English and their primary language. When Sam codeswitches during a lesson and answers in their primary language, Mx. Taylor reinforces Sam's mathematics vocabulary by having them repeat the word and identify the English equivalent using their glossary. By doing so, Mx. Taylor recognizes Sam's primary language answers as correct while also continuing to build their mathematics vocabulary in English."

How Can Families Help?

Families can support mathematics-language development by continuing to encourage general language and vocabulary development in both languages. At home, families should continue to converse with their child in their native language. Families may find their children switching between both languages as they are learning English. This development is normal, and this codeswitching is NOT indicative of delayed development nor intelligence (Moschkovich, 2019).

In addition to supporting their child's native-language development, families can provide structured literacy opportunities for their children in English even if they do not regularly converse in English at home. For example, families can reach out to their child's teacher or ESOL coordinator for mathematics texts that align with their child's interests. If the school is limited on texts, families can reach out to local library systems or community organizations for assistance in identifying mathematics or non-mathematics related texts. In general, reading builds vocabulary development which in turn supports mathematics-vocabulary development. Families should aim to read aloud to their students or have their students read aloud in both languages, if possible.

Additionally, families may consider reaching out to local libraries or community organizations for online resources or activities to help support their child's development and interest in mathematics. They can also incorporate mathematics into everyday activities such as counting the number of steps it takes to walk across a room, telling time, or measuring ingredients when cooking. Day-to-day activities provide children opportunities to practice mathematics skills and vocabulary in a low-stakes, comfortable, naturalistic setting. Consider the following scenario:

"Ms. Santana's daughter, Sara, is entering kindergarten. Ms. Santana is most comfortable communicating in Spanish, and at home she speaks Spanish with her daughter. Ms. Santana expressed concern that Sara will fall behind in school since she is still learning English. Thankfully, Sara's homeroom teacher, Mr. Mary, has many years of experience working with children from linguistically diverse backgrounds. Mr. Mary works with the school's translator to communicate to Ms. Santana some activities at home that can help Sara's mathematics-language development. Mr. Mary recommends Ms. Santana continue to speak and read with Sara in Spanish. He lets Ms. Santana know that for EB students, development of their primary language helps strengthen the development of their second language! He also provides some independent reading books from the class library for Ms. Santana to take home and have Sara read. He encourages reviewing daily vocabulary by having Sara 'teach mom' what they learned in class that day."

How Adequate Is the Research Knowledge Base?

Research on improving mathematics language in EBs with MD is in a nascent stage; the few published studies examine interventionist- or researcher-led instruction in pull-out or small group settings, with minimal teacher involvement. Given the variability in interventions, type of research designs, effect sizes of the interventions, and limited disaggregation of results by MD or EB status, currently there is insufficient research to make evidence-based practice recommendations for improving mathematics language specifically for EB students with MD. However, commonalities across the available studies as presented above represent the most promising directions for what soon may become evidence-based practices in both interventionist-led and teacher-led contexts.

How Practical Is It?

The research-recommended instructional practices have low to moderate barriers of implementation. Teachers with more experience may be able to adapt their own lesson plans to include schema or strategy-based instruction, and explicit instruction (I do, we do, you do) can be incorporated across subject areas.

Teachers who want or require additional training can consider reaching out to their school or district-level coaches for support in delivering explicit instruction. For instance, coaches can help teachers through modeling explicit instruction, practicing with the teachers, observing classroom instruction, and providing feedback on how to improve. School districts may also have content area or certified curriculum coaches provide assistance with specific interventions or approaches, including schema instruction.

Additionally, teachers can consider creating an in-school professional learning community (PLC) to collaboratively lesson plan or practice instructional techniques. If teachers are already organized into PLC teams, they can suggest to their PLC leader to lead a unit on explicit instruction. For example, the PLC leader may be familiar with the Institute of Educational Sciences practice guides structure, as listed in Table 1, and be able to lead the group with mathematics language content. The PLC leader may specifically choose to print out the documents on systematic instruction and mathematics language to target both the content area and teaching strategies their team should focus on. There are many video resources that the PLC team leader may choose to incorporate in their explicit instruction training unit.

If resources are not available within the district, state department of education websites can also contain resources. Additionally, listed at the end of this guide is a collection of online resources that instructors can consult for more information on mathematics-language instruction for EB students.

How Effective Is It?

At present, most evidence for effective mathematics-language instruction is embedded within the context of word-problem solving. Instructional approaches such as schema instruction have accumulated evidence of efficacy (Peltier et al., 2018). However, there is currently limited evidence for mathematics-language instruction taught in isolation. Moreover, the effectiveness of research-recommended instructional practices, such as schema or strategy-based explicit instruction, is better known for native speakers of English and students with MD in general; relatively few studies focus specifically on the effectiveness of these practices for EB students with MD.

What Questions Remain?

Given the limited research base on mathematics-language instruction for EB students with MD, multiple questions remain. Because mathematics-language development supports overall mathematics performance (Lin, 2021; Purpura & Reid, 2016), further research on mathematics-specific language instruction is warranted. This includes instruction in both mathematics vocabulary and the syntax of mathematics problems, both of which contribute to mathematics-language development (Fuchs et al., 2015).

Although research on mathematics-language instruction for EBs with MD is limited, promising research directions exist in academic-language development across other content areas. Effective approaches include but are not limited to explicit instruction on specific words, repeated exposures, morpheme analysis, and visualization strategies (Powell et al., 2020; Truckenmiller et al., 2019). In future research studies, it will be important to determine if the positive effects are also positive for EBs with MD in developing their mathematics-language knowledge.

Questions also remain regarding how to most effectively leverage the assets of teachers and family members to support the mathematics-language development of EB students with MD. This is primarily due to most intervention research in this field being researcher-delivered. In the future, researchers may consider prioritizing intervention studies that incorporate teachers and family members as implementation agents. In this way, forthcoming research will provide additional insight into how teachers and families can best support the mathematics-language development of EB students with MD.

Where Can I Learn More?

Table 1
Additional Resources

Resource	Link
Teaching Academic Content and Literacy to English Learners in Elementary and Middle School	https://ies.ed.gov/ncee/wwc/practiceguide/19
Assisting Students Struggling with Mathematics: Intervention in the Elementary Grades	https://ies.ed.gov/ncee/wwc/PracticeGuide/26
Math Instruction for English Language Learners	https://www.colorincolorado.org/article/math-instruction-english-language-learners?theme=print
Intensive Intervention in Mathematics Course	https://intensiveintervention.org/training/course-content/intensive-intervention-mathematics
Providing ELLs with Disabilities with Access to Complex Language	https://wida.wisc.edu/sites/default/files/resource/FocusOn-Providing-ELLs-with-Disabilities-Access-to-Complex-Language.pdf
Dual Language Learners with Disabilities: Supporting Young Children in the Classroom	https://iris.peabody.vanderbilt.edu/module/dll/

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