Math Instruction for English Language Learners

By Kristina Robertson

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My dad gave me one dollar bill
'Cause I'm his smartest son,
And I swapped it for two shiny quarters
'Cause two is more than one!

— Excerpt from "Smart," by Shel Silverstein

As a student, I struggled with math. I didn't understand why it came so naturally to some students, but not to me. Looking back, however, I realize that I had an advantage that I wasn't even aware of — I understood the language in which the problems were written, even if I didn't understand how to solve them! Although it is easy to assume that many English language learners (ELLs) will excel in math because math is a "universal language" and students may have had prior educational experience that included mathematical instruction, that assumption can lead educators astray.

As I spoke with teachers and did research for this article, it became very clear that making sure that students understand math vocabulary and have ample opportunities to use it are very important. Solving word problems, following instructions, understanding and using mathematical vocabulary correctly — all of these skills require a language proficiency that sometimes exceeds our expectations. We tend to think of mathematics as a subject that does not require a strong command of language. In reality, however, mathematical reasoning and problem solving are closely linked to language and rely upon a firm understanding of basic math vocabulary (Dale & Cuevas, 1992; Jarret, 1999).

For many educators, the challenge of bringing language and math instruction together is a
relatively new one. ELL teachers who hadn't taught content areas previously are now being asked to lead or support instruction in the math classroom, and many math teachers who don’t see themselves as language instructors are now responsible for providing effective math instruction to ELLs.

High school math teacher Hillary Hansen learned just how big a role language plays in math instruction when she taught her first Basic Math course for ELLs last year. She wanted so much to provide the students with the good foundation they needed, but she felt unable to reach the students or engage them in her lessons, and by the end of the year she was exhausted and frustrated.

That summer she had an opportunity to join a district Sheltered Instruction Observation Protocol (SIOP) cohort to receive professional development and support to meet the needs of ELLs in content classes. She learned about the importance of language acquisition, building background knowledge, increasing student language production, and explicitly teaching academic language. She began this school year with a new set of tools and a deeper understanding of the instructional scaffolding ELLs need in order to learn the content while also learning English. I am happy to report that while Hillary still feels challenged and is working very hard, this year has been much more successful for her and her students.

As a result of more effective instruction, her students:

- understand the content better and are working together to find creative ways to learn
- discuss math more and know how to use the instructional supports their teacher has in place
- are comfortable with math and asking questions to get the help they need.

Hillary feels that she is providing them with the foundation they need not only to understand the mathematical concepts, but also to successfully interact within a math classroom in order to continue learning more advanced concepts.

Following are some strategies that Hillary and some of the other teachers I spoke with found helpful this year, and that they recommend as best practices when teaching math to ELLs.

**The importance of teaching academic vocabulary**

Vocabulary instruction is essential to effective math instruction. Not only does it include teaching math-specific terms such as "percent" or "decimal," but it also includes understanding the difference between the mathematical definition of a word and other definitions of that word.

The following example, used in a presentation by Dr. Judit Moschkovich of the University of California at Santa Cruz, underscores why vocabulary must be introduced within the context of the content (Moschkovich, 2008):

In this problem, the student is instructed to "find x." The student obviously knew the meaning of the word "find" because he/she "found" it on the page and circled it. The student even put a note on the page to help the teacher in locating the lost "x". The student understood the meaning of "find" in one context, but not in the appropriate mathematical context.

I recently helped a math teacher create a Sheltered Lesson, and I was surprised to find that there were some vocabulary words that I didn't understand. My lack of familiarity with the words hindered my ability to do the math problem and gave me a deeper empathy for ELLs who struggle in the same way with vocabulary and comprehending math assignments.
Following is a list of tips for explicitly teaching mathematical academic vocabulary:

- **Demonstrate that vocabulary can have multiple meanings.** Help students understand the different meanings of words such as "table" and "quarter," as well as how to use them correctly in a mathematical context.

- **Encourage students to offer bilingual support to each other.** Students will understand material better if they explain it to another student, and the new student will benefit from hearing the explanation in their first language. (Check the hotlinks for a list of bilingual translations of math vocabulary in multiple languages).

- **Provide visual cues, graphic representations, gestures, realia, and pictures.** Offer students the chance to work with objects and images in order to master vocabulary. If there aren't enough items for each student, use manipulatives on the overhead or posted throughout the classroom, and demonstrate the vocabulary in front of the students. For example, Hillary created a Math Word Wall that has three parts: key vocabulary, "in your own words" definitions, and a variety of ways to portray a function. For example, multiplication is portrayed by the following symbols: $\times$, $\ast$, and $( )$.

- **Identify key phrases or new vocabulary to pre-teach.** This strategy will help students decide which math function they should apply. Example: "more than" means "add." (See hotlinks for more references about math vocabulary.)

The importance of reading and understanding written math problems

Written word problems present a unique challenge to ELL students and teachers alike. In *Reading and Understanding Written Math Problems*, Brenda Krick-Morales writes, "Word problems in mathematics often pose a challenge because they require that students read and comprehend the text of the problem, identify the question that needs to be answered, and finally create and solve a numerical equation — ELLs who have had formal education in their home countries generally do not have mathematical difficulties; hence, their struggles begin when they encounter word problems in a second language that they have not yet mastered" (Bernardo, 2005).

Teacher Xiao-lin Yin-Croft has encountered this pattern in her classroom of bilingual Chinese students in San Francisco. She has developed a very creative way to use her students' background knowledge of math as a stepping stone for other language learning. She does this by accelerating math instruction at the beginning of the school year and then building on what students have learned in math in reading and other content areas. In *Building Bridges for the Future*, a Colorín Colorado "From the Heart" article, Xiao-lin explains her strategy:

First, we read math word problems; I demonstrate the logical thinking process while translating words into pictures and, finally, into number sentences. Soon, they start to explain their own thinking after reading complicated word problems that involve several steps. They correct each other, and argue about which number sentences they should use to arrive at the correct final results. As they sharpen their math skills, I capitalize on their enthusiasm to teach them how to extract the most important information from texts, and move them toward the oral and reading fluency they need to understand and discuss more challenging texts.

Even if you aren't accelerating math instruction, however, there are a number of ways to help students master word problems. Krick-Morales offers suggestions in the previously mentioned article, such as explicit instruction of key vocabulary, daily practice of problem solving, repeated readings of the word problem together as a class, and hands-on activities such as movement, experiments, or drawing to help students comprehend the problem. As students become more familiar with math vocabulary, they will be able to solve problems more easily.

The importance of building background knowledge

As the opening quote from the Shel Silverstein poem reminds us, background knowledge plays a critical role in math class! My colleague Hillary found that sometimes her students would get "lost" in a problem simply because they didn't understand the context. Following are some tips to help in building background knowledge of students.
• **Modify the linguistic complexity of language and rephrase math problems.** Students will understand the problem better if it is stated in shorter sentences and in language they understand.

• **Guide students to cross out the unnecessary vocabulary in word problems.** Doing so allows students to focus on the math function required. For example, one problem Hillary’s students came across referred to a “school assembly.” Even though the meaning of that phrase wasn’t important in the solving of the math problem, students didn’t know it wasn’t important, and the lack of understanding contributed to their confusion.

• **Build knowledge from real world examples.** Try to reinforce concepts with examples that students can picture and talk students through the situation. For example, if you need to paint a room, you need to know how much area will be covered so that you know how much paint to buy. Look for familiar ideas or props that can be used to engage students such as recipes, news stories about the economy, or discussion of personal spending habits.

• **Use manipulatives purposefully.** This is important at all grade levels. Hillary has found math cubes to be very useful in having students represent the numbers in the problems and then manipulate the cubes to get the answer. She used the cubes and the terms “hot” and “cold” numbers when teaching with the concept of negative numbers. Students would use the red cubes as “hot” or positive numbers and the blue cubes as “cold” or negative numbers. As students laid out the number of hot cubes and cold cubes represented, they could easily see if the answer would be a positive or negative number by which color had the most cubes. A problem such as \(-2 + 1 = -1\) would look like this:

  ![Cube Representation Image]

  e student then removed pairs of cubes — one red, one blue — until they could no longer remove any blocks. The remaining blocks represent the answer.

**The importance of increasing student language production in the content area**

As I've worked with content area teachers in my district to develop Sheltered Instruction lessons and activities to enhance ELL learning, I've told them, "If a student doesn't say it in your class, they're never going to say it." This is a bit dramatic, but it's true to some extent. When students learn new vocabulary, the opportunity to use it must be presented in class, because students are unlikely to try it out on their own — especially academic words like “parallelogram” or “function”!

Here are some tips to increase student-to-student interaction with academic language in the math classroom:

• **Have students translate symbols into words, and write the sentence out.** Hillary used this strategy to check students' comprehension of problems before they solved them. For example, \(3x + 4 = 16\) would be written out, “Three times \(x\) plus four equals sixteen.” This helps students process the operations involved in the question and gives them an opportunity to think through how to solve it. It also gives students a chance to familiarize themselves with important vocabulary words.

• **Create a “sentence frame” and post it on the board.** Write the format of the sentence you would like students to use in discussion and then hold them accountable for using it. For example, “The answer is _______ degrees because it is a ________ triangle.

• **Have students share problem-solving strategies.** This involves asking a simple question such as, “Did anyone else get the answer in a different way?” Then allow enough wait time so students can think through how their problem-solving process was similar or different to the one offered.

• **Allow students to discuss how they are thinking about math.** This is a way of redirecting the lesson from teacher-to-student to student-to-student. For example a student might ask a question, “How do you know what kind of triangle it is?” Instead of the teacher answering and going to the board and pointing out the names and different triangles, the teacher can simply ask, “Does someone have an answer? Or “Would someone like to offer help to Mario?” Allow students to share how they think about the math concept and any tips they have for remembering the information.
• **Incorporate writing activities like math journals.** This is an excellent way for students to process what they've learned and what questions they still have. The journal could start with simple prompts such as, “One thing I learned today…” “One thing I still don't understand…” “One way I can get the help I need…” “The answer to this problem is…” Writing out the answer to a problem is a very important skill to develop because many state math tests require a constructed response to questions.

• **Challenge students to create their own math problems.** This can be a fun activity if students create a problem similar to the ones you have used in class and they exchange problems with a partner. By creating the problem and checking the answer they are reinforcing their own learning.

### Using technology

Technology can also be a powerful tool in math instruction for ELLs. Here are some ideas ways you can play with technology in a math lesson:

• **Teach students how to use a calculator.** Based on background and prior educational experience, students might not be familiar with how to use a calculator nor some of the more sophisticated models, such as the graphing calculator. Give students a chance to practice solving problems with their calculators once you have reviewed different functions. [Texas Instruments](http://www.ti.com) offers numerous activities and product tutorials in their educational materials.

• **Look for educational resources that accompany your school’s technology tools and programs.** For teachers who have an electronic whiteboard in the classroom, there are many resources available on links that can be easily accessed and brought into the classroom. One in particular comes from SMARTTech, and features [SMART Notebook lesson activities](http://www.smarttech.com).

• **Look for interactive games that offer students a chance to practice their mathematical skills.** Nintendo DS has an educational game called Brain Age, which is not language specific. The game provides excellent mathematical training for numbers and tracks results, showing student improvement over time.

• **Find out what’s available online.** [Vital NY](http://www.vitalny.org) (Video Teaching and Learning for NYS Educators) on Teachers’ Domain offers an online library of free media resources from the best in public television. Teachers’ Domain resources include video and audio segments, Flash interactives, images, documents, lesson plans for teachers, and student-oriented activities. (Free registration required.)

Even if it doesn't come easily at first, there are ways to get ELLs excited about math. By keeping their language skills and needs in mind when planning mathematical instruction (and by helping your colleagues do the same), you will be taking important steps in helping students master mathematical concepts and skills — and who knows? Your students may be the next generation of economists, rocket scientists, and math teachers just waiting for the tools they need!

Note: I’d like to thank my Minnesota colleagues, Hillary Hansen at Burnsville Senior High School and Kim Olson at Hidden Valley Elementary, as well as Xiao-lin Yin-Croft from San Francisco, for providing many of the helpful math teaching tips in this article. It is inspiring to know that there are talented, creative teachers who are always finding better ways to teach and are willing to share the knowledge.

### Hot links

**Common Core Math and ELLs: Blog Posts**

These posts from our Common Core blog highlight resources that can be used in Common Core math instruction for ELLs.

**EngageNY: Common Core and Math**

The EngageNY website provides materials focused on curricular examples, standards for mathematical practice, and other materials for professional development.

**Discovery Education: Puzzlemaker**
Puzzlemaker is a free puzzle generation tool for teachers, students and parents where users can create and print customized word search, criss-cross, math puzzles, and more using their own word lists.

Catherine Snow: Word Generation

Catherine Snow's new website provides information and resources for educators who would like to learn more about Word Generation and how it is implemented. Includes links to comprehensive academic word list that students need to master to comprehend academic content.

Dave's Math Tables: English/Spanish Dictionary

List of English math vocabulary words with the Spanish equivalent.

PBS Teachers: Math Lessons

PBS Teachers offers a database of multimedia math lessons and activities that can be searched by grade or topic.

SMART Notebook Lesson Activities

Browse lesson activities and materials for classrooms using SMART notebook software. Choose the country or region, and search by curriculum standards, subject and grade level.

"Smart" by Shel Silverstein: Complete poem and activity

This worksheet offers the complete poem cited in the article, as well as some fun related activities and questions.

Colorín Colorado Webcast: English Language Learners in Middle and High School

This webcast features Dr. Deborah Short and discusses effective instructional strategies for teaching English language learner students in middle and high school, such as the SIOP model.

Translating Word Problems

This is a great site for teachers in the elementary levels, as it provides a list of keywords you can teach your ELLs to look for as they read word problems. Also included are useful ideas and tricks to better prepare students to understand written math problems.

References


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20 Strategies for School Leaders
Accessing Students' Background Knowledge in the ELL Classroom
Addressing ELLs' Language Learning and Special Education Needs: Questions and Considerations
An ELL Teacher's Back-to-School Checklist
Bilingual Family Night for ELL Families
Communicating Important Information with ELL Families: Strategies for Success
Connect Students' Background Knowledge to Content in the ELL Classroom
Connecting with ELL Families: Strategies for Success
Creating a Plan of Action for ELL Family Engagement
Eight English Learner Myths for Administrators
ELLs in Early Childhood Education: Recruiting Immigrant Families
Encouraging and Sustaining ELL Parent Engagement
Engaging ELL Families Through Community Partnerships
Engaging ELL Parents as Leaders
Essential Actions: 15 Research-based Practices to Increase ELL Student Achievement
Final Thoughts
Finding Answers for Our Immigrant Students and Families: An ELL District Leader's Perspective
Five Things Teachers Can Do to Improve Learning for ELLs in the New Year
Gear Up for a New School Year!
Getting Ready for College: What ELL Students Need to Know
How to Support ELL Students with Interrupted Formal Education (SIFEs)
How to Support Refugee Students in the ELL Classroom
Improving Writing Skills: ELLs and the Joy of Writing
Increase Student Interaction with "Think-Pair-Shares" and "Circle Chats"
Increasing Academic Language Knowledge for English Language Learner Success
Increasing ELL Student Reading Comprehension with Non-fiction Text
Introducing and Reading Poetry with English Language Learners
Introduction: Strategies for Engaging ELL Families
Language Acquisition: An Overview
Motivating ELL Student Readers
Music and Language Learning
No Child Left Behind and the Assessment of English Language Learners
Phonics Instruction for Middle and High School ELLs
Preparing an Engaging Social Studies Lesson for English Language Learners
Preparing ELLs to be 21st-Century Learners
Reader's Theater: Oral Language Enrichment and Literacy Development for ELLs
Reading 101 for English Language Learners
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Comments

Deborah Ortiz replied on Tue, 2010-10-19 12:48
Wow! This is an awesome site with many practical instructional ideas to help our English Language Learners. Thanks!

Carlos Malcon replied on Wed, 2011-04-06 16:18
Awesome!!! There is no doubts that there are a lot of researches behind these great advices and point of view of teaching math. I am a Honduran teacher conducting an Extensive Reading program. Thank you!!!

Maestra en Mexico replied on Thu, 2012-02-23 21:05
Thanks so much for sharing your knowledge. This is one of the best articles I've read with ideas for teaching math to ELLs. We'll be putting these ideas into practice in our bilingual school in Mexico.

Mercy replied on Sun, 2012-07-08 01:35
Thanks a lot for these words on how to tackle questions in reading math. I have similar problems understanding the principle of math 12! I feel like dropping out of the course, but now, these words of advice, which I refer to as “teaching knowledge,” have fully encouraged me to continue and complete my course. I hope to do better from reading these words and encourage the writer to keep doing a very good job.

Linda Witas replied on Wed, 2012-12-26 23:47 Permalink
good information

Natalia Ferrell replied on Tue, 2013-04-16 16:46 Permalink
Thanks a lot!

WONDERFUL!

llooll replied on Wed, 2013-06-12 14:11 Permalink
Thank you very much, this information and advice were really good. Now I can sleep better!

Sukaina replied on Tue, 2013-08-20 18:47 Permalink
Thanks for sharing, it’s really informative and interesting

Tarry replied on Fri, 2013-09-27 05:14 Permalink
Thank you for sharing. I am working on a research paper and your post has given me a good structure for helping me crystallize my ideas.

Jane M replied on Wed, 2014-04-02 18:35 Permalink
Wow, thank you so much for this article! I’m doing my teaching practicum in a school with a large percentage of ESOL students at all levels and this is extremely helpful... I’m going to put these suggestions to use immediately!

khosraw replied on Thu, 2015-01-08 12:41 Permalink
good work

Ruchira Modi replied on Thu, 2015-02-05 15:10 Permalink
Thanks! We are building math animations for ELLs and your article was very helpful.

Add new comment

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Workbook The workbook provides a wealth of information about this important topic, including research foundations and principles of instruction for teaching math and science to English language learners, the language of math and science, Common Core State Standards for Mathematics, making math and science comprehensible, developing higher-order thinking in math and science, and a complete lesson plan from one teacher’s perspective. Video New authentic classroom video clips illustrate the principles and practices presented in the workbook, with Video Observation Guides and activities that reinf
This is a myth buster for any language teacher, but should not surprise a math teacher. The semiotic systems that are involved in mathematical discourse are natural language, mathematics symbol systems, and visual displays. Instruction should recognize and strategically support EL students’ opportunity to engage with this linguistic complexity. Rather than debating whether an utterance, lesson or discussion is or is not mathematical discourse, teachers should instead explore what practices, inscriptions, and talk mean to the participants and how they these to accomplish their goals. The new Scaffolding Instruction for English Language Learners Resource Guides for ELA and Mathematics provide guidance to educators on how to take the curriculum materials on EngageNY and provide additional scaffolds for ELL students according to their level of English language proficiency. The resource guides are aligned to the levels in New Language Arts Progressions and provide examples of how to apply the Progressions to the EngageNY curriculum. The resource guides were developed by national experts in ELL instruction, Diane August and Diane Staehr Fenner, who have developed these ELL scaf