Strategies for modifying word problems

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Introduction

Best practices for instruction of English Learners (ELs) in content areas are paramount in elementary schools to set the foundation for future learning. Culturally responsive teaching (CRT) (Gay, 2002, 2018) and thematically integrating literacy with mathematics through problem solving are some of these best practices. Word problems can serve as vehicles for teaching mathematical concepts (Stanic & Kilpatrick, 1989) and a bridge in which both the learning of mathematics and English literacy occur (Owles & Herman, 2013) as students read, listen, discuss, explain, write, and represent real-life contexts. In this article, we propose applying CRT principles to connect literacy with mathematics and provide strategies with several examples for using word problems to facilitate ELs’ understanding and learning of both literacy and mathematics in kindergarten through 5th-grade classrooms.

This article is timely considering that the EL student population continues to grow in American schools. Projection data indicate that ethnically, culturally, and linguistically minority children will become the majority in 2045 (Vespa et al., 2020). However, ELs have often performed below grade level when compared to English native speakers. In the last decade, the achievement gap between ELs and non-ELs reported by the National Assessment for Educational Progress (NAEP) ranged between 33 to 37 average points for 4th-grade reading and 43 to 45 for 8th grade (National Center for Education Statistics [NCES], 2020b). Regarding mathematics, the achievement gap ranged between 23 to 26 average points for 4th-grade mathematics and 38 to 42 for 8th grade (NCES, 2020a).

Effective teaching practices can help diminish this gap, although practices or strategies are not an end in themselves but a means to an end. Finally, for teaching practices to work, they must be implemented in classrooms where ELs are welcomed and their diverse backgrounds, or funds of knowledge (González et al., 2005), are viewed as resources for learning rather than as liabilities (Echevarría et al., 2017; TESOL International Association, 2018).

Culturally Responsive Teaching

Gay (2002) defines CRT as “using the cultural characteristics, experiences, and perspectives of ethnically diverse students as conduits for teaching them more effectively” (p. 106). The CRT approach includes students’ “ways of knowing, understanding, and representing various ethnic and cultural groups in teaching academic subjects, processes, and skills” (Gay, 2018, p. 52). CRT, as well as other equity and culture-based pedagogical approaches (e.g., González et al., 2005; Ladson-Billings, 1995, 2014; Paris & Alim, 2017), highlights the wealth of non-traditional (or non-school-related) resources of minority students and families. CRT applied to teaching and learning in the content areas can increase ELs’ motivation and engagement, facilitate comprehension, and enhance academic achievement. This is important because school curriculum typically represents white students’ experiences, presenting difficulties for those who come from culturally and linguistically
diverse backgrounds (Hawkins, 2014; TESOL International Association, 2018).

In this article, we use CRT foundational tenets (Gay, 2002) to present what effective and equitable teaching is, particularly for disenfranchised minority students. The following are the main tenets: (1) developing a knowledge base about cultural diversity, (2) including ethnic and cultural diversity content in the curriculum, (3) demonstrating caring and building learning communities, (4) communicating with ethnically diverse students, and (5) responding to ethnic diversity in the delivery of instruction. We will focus on the first, second, and fifth principles as applied to connecting literacy with mathematics through problem solving.

**Teaching Mathematics to English Learners: Mathematics CCSS and Literacy Processes**

The Mathematics Common Core State Standards (Math-CCSS) are classified in two types: (1) the content standards and (2) the standards of mathematical practices (National Governors Association Center for Best Practices & Council of Chief State School Officers [NGA Center for Best Practices & CCSSO], 2010b). The content standards are a set of mathematical concepts students should learn, and the standards of mathematical practices (MP) describe eight processes and proficiencies educators at all levels should encourage in their students. As educators, we should use the MP as a guide for using a CRT approach for teaching ELs. Specifically, three MP standards are key for facilitating the connection between mathematics content-area literacy and students’ diverse cultural backgrounds:

- **MP1 Standard: Make Sense of Problems and Persevere in Solving Them** – Students make sense of mathematics through multiple representations and strategies. Young ELs need concrete objects to make sense of word problems. A CRT connection is to use objects familiar to students—for example, teachers can use beans as counters or other cultural artifacts as manipulatives. This provides opportunities for including cultural diversity content and tools in the curriculum. Multiple representations of concepts also align with the literacy processes of viewing and representing through the use of multisensory resources for teaching and learning.

- **MP3 Standard: Construct Viable Arguments and Critique Reasoning** – Through this standard, students develop efficient communication skills. Research supports that arguing and critiquing arguments are beneficial for developing mathematical thinking. ELs are capable of participating in math discussions as they learn English and use different literacy processes such as listening and speaking. The use of word problems is important for providing the context students need to develop these arguments. By communicating their reasoning, this standard supports students’ development of mathematical knowledge by leveraging their diverse cultural repertoires. Higher-order thinking skills are also relevant for literacy development since literacy involves more than reading texts. Literacy development requires analysis and critique of oral and written discourse.

- **MP4 Standard: Model with Mathematics** – Students apply mathematics to solve problems connected to their everyday life. CRT is an important framework for making these connections by using students’ diverse experiences and perspectives as conduits and contexts for learning mathematics. In this way, the teaching of mathematics responds to students’ diversity in the delivery of instruction.

The CCSS also provide additional resources for teaching. The Addendum for ELs provides a guide for teaching mathematics specifically
to ELs (NGA Center for Best Practices & CCSSO, 2010a). This document highlights that it is critical for ELs to actively participate in the mathematics classroom by reading, listening, discussing, explaining, writing, representing, and presenting (which are all different literacy processes) as they learn English.

The CRT framework, the standards of mathematical practices, and the Addendum for ELs are three key tools for teachers to promote these students’ development of expertise in mathematics and content-area literacy. By using relevant contexts, students will have the knowledge and experience to contribute to discussions. These relevant contexts could also bring opportunities for students to use their native language and cultural representations as resources for learning mathematics and making sense of word problems (NGA Center for Best Practices & CCSSO, 2010a).

Providing a Relevant Context for Mathematics Learning Through CRT

Teachers may struggle finding contexts relevant to ELs in textbooks since curriculum often reflects the experiences and backgrounds of white students (TESOL International Association, 2018). However, relevant contexts will motivate ELs to actively engage in problem-solving activities (Nivens et al., 2014; Owles & Herman, 2013; Tomaz & David, 2015; Zullo et al., 2013) such as reading, discussing, justifying, and explaining (which are literacy processes as well), supporting both their English and mathematics learning. How can we ensure ELs experience mathematics learning connected to their life? The answer to this question requires two actions: (1) know your students and (2) connect mathematics to their life experiences, which align with the first, second and fifth CRT principles, respectively (Gay, 2002).

There are several ways for teachers to learn about their ELs such as through informal school conversations, parent meetings, and community walks. Informal school conversations with students are non-school-related small talk that can happen in the classroom or in the hallways. Knowing students’ parents can also provide background on family activities and hobbies. Furthermore, community walks can be done by actively participating in community activities where your students live such as shopping or attending sports events. All these activities use CRT as a frame and can provide examples of real-life connections to mathematics. After you know your students’ experiences, you can select several mathematical concepts that may fit their real-life experiences. In the next section, we focus on strategies to modify word problems in ways relevant to elementary school students.

Strategies to Write Mathematics Word Problems: CRT Connected to Literacy and Math

We present three strategies aligned with CRT for teachers to write, or modify, mathematics word problems to facilitate ELs’ understanding and learning of both literacy and mathematics:

- **Strategy 1: Mimic Mathematics from the Real Life of ELs** – The purpose of this strategy is to acknowledge the mathematical thinking processes of your students’ culture. Some ways of making the mathematical task more realistic are to include students in the process by not providing all the information that is needed to solve the problem. You can address this by adding a homework component of gathering information at home. You can also encourage students to share their insights about the problems to solve. In this manner, students will use different literacy processes such as asking family members questions, summarizing, and taking notes.

- **Strategy 2: Connect to the Culture of your ELs** – This is a complex challenge because every student is different. ELs come from different
communities and have different cultural experiences. If you give all students the same problem, it will not likely be relevant to all of them. However, you may alternate contexts to make them relevant for specific students in each class. Another approach is selecting problems that can be adapted to diverse cultural experiences (e.g., places familiar to them, sports familiar to them). These adaptations can be done with the collaboration of your students. This will help them engage in mathematical discourse by providing their expertise in a context familiar to them.

- **Strategy 3: Make Problem Solving Accessible to ELs** – There are several strategies to make problems accessible to ELs. You want to make sure they understand the word problems they will work on in class to allow them to participate in the mathematical discourse or math content-area literacy. You can support them by carefully explaining the word problem vocabulary and academic language relevant for that task. As an illustration of academic language, consider the term grouping used when teaching place value. In this case, it refers to making groups of numbers (e.g., ten units make one ten), but students could think you are asking them to work in groups. In addition, you may support ELs’ understanding of the word problems by visually representing the problem with concrete models (Aguirre et al., 2013). This can be done by assigning tasks to students such as reading and representing the problem with manipulatives or role playing the situation. These are opportunities for ELs to experience learning in an active way through which different literacy processes are deployed (Echevarría et al., 2017; TESOL International Association, 2018).

**Practical Examples for Teachers Working with ELs**

To illustrate these strategies, we adapted the context presented in the “Abuela’s Shopping List” lesson plan (Aguirre et al., 2013) and in the “Cultural Food: Measurements and Fractions” analysis of a small town (Harding-DeKam, 2014). First, we explain some cultural experiences of the ELs and then use the strategies to write word problems connected to those cultural experiences.

**Example 1 – “Abuela’s Shopping List”**

The context for “Abuela’s Shopping List” (Aguirre et al., 2013) is that there is a neighborhood food market called “El Güero” and that some of your Latinx students visit this market with their families. While they are visiting this market, you notice they are talking about their shopping list and the cost of different items. They are also estimating the money needed to buy groceries. A potential math problem is to ask students to calculate the cost of the items on abuela’s (grandma’s) shopping list and determine whether a given amount of money will be enough.

In the “Abuela’s Shopping List” problem, the cultural actions performed by students include going to the market and talking about the shopping list with their grandmother. This action provides several themes you may consider such as the selection of a market relevant to your students and the selection of ingredients that are also relevant to your students. It is assumed that the ingredients can be found in the store in which they are shopping.

To match the real-life experiences of students and differentiate instruction, you may ask them for information they will gather at home. Each student will have different lists, which could promote discussions about their cultures and family knowledge—for example, (1) create a grocery shopping list with the help of their family as homework or (2) ask for a family recipe, write down the ingredients, go
to the market, and list the price of each ingredient on the list. In this manner, connections with literacy are also made through listening, speaking, reading, and writing within the math content-area-based learning activity.

To connect to students’ cultures, you can change the name of the store to one relevant to other ELs’ cultures (e.g., Chinese, Pakistani, Israeli) and provide a list of ingredients relevant to a specific country’s meal recipe (e.g., egg-drop soup, hummus, falafel). You can also change the Spanish word *abuela* to its equivalent in another language (e.g., *nonna*, *bibi*, *maman bozorg*).

To make the problem more accessible, you can use role play—for example, a student going to the market with their grandma, with the grandma speaking Spanish and the student speaking English (Aguirre et al., 2013). In this role-play scenario, students may read the items on the list in Spanish, or in their primary language, but explain their definitions in English. This will assist ELs in both building vocabulary knowledge and visualizing the requirements of the mathematical word problem, which also overlap with important literacy processes and skills.

**Example 2 – “Cultural Food: Measurements and Fractions”**

The context for “Cultural Food: Measurements and Fractions” (Harding-DeKam, 2014) includes a small-town elementary school with approximately half of the students white and half second-generation Latinx students. Through informal conversations with the students, the teacher learned that the latter group of students frequently visit their families in Central or South America. From their visits, they highlight cultural actions such as making traditional dishes with their families and discussing family recipes and quantities. Some of them mentioned that their families use a scale to weigh some ingredients. One idea for a math problem is to ask students to use appropriate units and fractions to measure and estimate ingredients used in a recipe.

In the “Cultural Food: Measurements and Fractions” math problem, the cultural actions performed by students provide several themes you may consider such as the selection of the ingredients and appropriate measures that are relevant to your students. You can mimic the real-life experiences of your students by asking them to explain their experiences selecting the ingredients for a recipe and how they can measure each of those ingredients. A good approach for this context is the use of an ingredient typically used in all cultures such as sugar or salt. As all students are familiar with the use of sugar, this can lead to rich conversations about the way different cultures measure sugar for recipes. This is a learning opportunity to understand the different attributes that one can measure (e.g., volume, mass) and the units that one can use to measure (e.g., cups, tablespoons, grams). This can also develop different perspectives about the importance of *estimation* when measuring to know if there is enough sugar to make the recipe. These specific terms also refer to math content-area literacy. Thus, these learning activities strengthen the ELs’ literacy–math connection.

A way to connect to the culture of your students is to ask for recipes of a traditional dish in their culture. Students can also demonstrate in a video or in the classroom the way they measure ingredients to make these traditional dishes. These demonstrations can include family participation and the use of vocabulary in both English and their native language. In this manner, the activity also connects with literacy skills and elicits translanguaging (García, 2009), allowing the ELs to take advantage of their multiple linguistic resources.

Having previous demonstrations of measurements in class can also make the problem more accessible for ELs and ensure that they understand what is required from them. A specific emphasis in reading measurements and
abbreviations should also be discussed such as including units and using precise vocabulary, which is part of math content-area literacy and connects with their home experiences. For example, if the recipe asks for “1/3 c of flour,” a student should refer to this as one-third cup of flour instead of reading it as one over three cups of flour.

Conclusion

In this article, we have presented strategies for connecting literacy with mathematics to support ELs’ learning of both literacy and mathematics through problem solving and CRT. The strategies consist of considering mathematics in the students’ real lives, connecting their culture, and making the problems more accessible. We analyzed two types of math word problems.

We connected literacy with math by explaining how students engage in distinct literacy and higher-order thinking processes (e.g., listening, speaking, discussing, reading, writing, and providing arguments for tentative solutions to word problems). We also considered different contexts to ensure that math word problems can be accessible for ELs and connected to their real-life mathematical and diverse cultural experiences.

The approach we present is one of many ways to support ELs’ learning and to help bridge the mathematics and reading achievement gaps these children show when compared with white middle-class students (NCES, 2020a, 2020b). While this is not the only or ultimate solution to the achievement gap, these strategies, based on effective teaching practices (i.e., CRT, thematic integration between literacy and mathematics, CCSS’s Addendum for ELs), can help diminish this gap by valuing and using ELs’ cultural experiences and rich diverse backgrounds as resources for teaching and learning.

References


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