

Passion for Equity: An Asian-American Mathematics Educator's Journey

Carol A. Edwards

Abstract

The recipient of the 2011 TODOS Iris M. Carl Leadership and Equity Award gives a first-person account of the life experiences that shaped her passion for equity, especially in education.

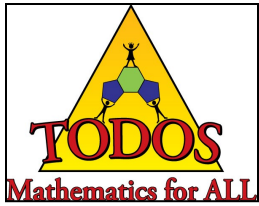
Discussion And Reflection Enhancement (DARE) Pre-Reading Questions

1. What experiences influenced your attitude and beliefs regarding equitable education for all of your students?
2. What experiences influenced the manner and extent to which you work for equity beyond your classroom?



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As a 73-year-old mathematics educator, I have lived long enough to have encountered and observed instances of prejudice, racism and discrimination during successive phases of my life. But I have also seen and experienced many changes in our society which give all of us hope for the future.

Hawai'i Beginnings and Influences

I am a third-generation American of Japanese ancestry, and my family subscribed to the American Dream. When the Empire of Japan attacked and bombed Pearl Harbor on December 7, 1941, I was 3 years old. Although I did not know it then, my family and many of our friends were subjected to what is now referred to as *racial profiling*. It was a confusing time for a child who knew only a few words of the Japanese language.

I was born and raised in the town of Hilo on the Big Island of Hawai'i in the days when the islands were a Territory of the United States. My paternal grandfather came to the islands from Japan in the late 1800s as a contract laborer for a sugar plantation. The Hawai'ian Islands were agricultural then, and Sugar was King, with plantations owned and managed by White American planters, and with field workers imported from Asian and Pacific Rim nations.

On the plantations, White managers segregated workers' housing into separate camps for Chinese, Japanese, Filipino, and other ethnicities to keep them from forming interracial bonds and cohesive labor unions. In addition, there were separate pay scales for workers of different races and ethnicities. The Japanese got \$18 per month, while Portuguese and Puerto Ricans got \$21-23 for the same work (Daws, 1968).

Immediately after the Pearl Harbor bombing, America lashed out at fellow citizens who had no part in the attack, as President Roosevelt issued Executive Order 9066 in February 1942 which authorized the internment of Americans of Japanese ancestry from the West

Coast into camps in remote and desolate locations in the interior states. About 110,000 Japanese-Americans and legal immigrants of Japanese ancestry were forcibly evacuated from their homes and communities with little notice. They lost almost all property that belonged to them, except for what they could carry with them to camp (Conrat & Conrat, 1972). This order against Japanese-Americans remained in effect until it was revoked in 1976 by President Ford (Ford, 1976).

We in Hawai'i were mostly not interned, except for community, business, and political leaders. But we lived under close scrutiny by the government, as our civilian governor of the territory was replaced by a military commander who imposed martial law throughout the islands. That meant many civil liberties were suspended, and replaced by the often arbitrary rule of military officers in charge (Daws, 1968). It was a hard time to be a Japanese-American. My mother's relatives in California were sent to camps, which were in desolate places in California, Idaho, Utah, Arizona, Wyoming, Colorado and Arkansas. There were even small camps in Hawai'i which housed not only local Japanese, but also German and Italian community leaders.

In many camps, Japanese-Americans were housed in tarpaper-covered, unpartitioned barracks without plumbing or cooking facilities, and which were overcrowded and offered little privacy. They were initially provided only army cots and blankets and in many camps, the winter and summer weather was brutal (Wilson & Hosokawa, 1980). When the war ended and the camps were closed, many internees had nowhere to go. They had lost almost everything at the start of the War, and many of the younger Japanese-Americans fought their battles through state and federal courts and U.S. Congress to gain a measure of recompense (Wilson & Hosokawa, 1980).

Restitution was hard won and token. In 1988, the U.S. Congress passed legislation which awarded formal payments of \$20,000 to each surviving internee. This vic-

tory, 40 years after the closing of the camps, came too late for many, as less than half were still alive to collect on Uncle Sam's apology (Maki, Kitano, & Berthold, 1999). Today, some surviving former internees have opposed racial profiling because they recall their own personal hardships during World War II. Following the horrific events of 9/11, then U.S. Secretary of Transportation Norman Mineta, who was interned during World War II, sent a letter to all U.S. airlines forbidding them from racial profiling (Martin, 2008).

Social Class, Ethnicity, and Language

While Hawai'i was (and remains) a multicultural society with housing and public schools integrated, there were subtle and explicit racial prejudices. The sugar and pineapple plantations were owned and run by wealthy White families. This class difference was prevalent while I was growing up. Many of the teachers were from the Midwest and tended to look down on us because we were English Language Learners. For many of us, our first language was Island pidgin, and we entered school reading at a three-year-old's level according to tests which were normed on the general U.S. school population (Daws, 1968).

As I entered public elementary school in Hilo in 1943, I knew that there was also a special public school in town, set up by the Territorial Department of Public Instruction. It was called Riverside School, and was an "English Standard School." It was supposed to be an upper tier public school for which entry was based upon passing an oral English Standard and general knowledge test. The oral English test was a pretext for admitting Caucasian (*haole*) students as they all spoke standard English, while Asians and native Hawaiians had much smaller passing rates. Riverside School, along with other English Standard Schools in Hawai'i, was disbanded in the early 1950s (Wright, 1972).

The advancement of non-White races and ethnic groups in Hawai'i can largely be seen in the elections of top executives in state and county governments. For example, we have advanced from the early 20th-century during the days when Hawai'i was a territory of the U.S. and where the governors were exclusively *haole* (White) and male, to our days after statehood when we elected a Japanese-American (George Ariyoshi), a part Hawai'ian (John Waihe'e), a Filipino-American (Ben Cayetano), and a Caucasian woman (Linda Lingle) to

lead our state (Abercrombie, 2011). Hawai'i's crowning achievement is that our current President of the U.S., Barack Obama, who is of mixed race, was born and educated there.

We have in Hawai'i, like most places in the U.S., come a long way in accepting each other. During recent reunions of my high school class, our differences did not get in the way of our friendships or enjoying each other's company as adults.

High School and University Years

Some of the best science and mathematics students in our Hilo High School graduating class were both Asian and female. Our valedictorian, who was strong in mathematics, was Asian and female and was featured in *Life Magazine* for being in the first group of National Merit Scholars. Like me, she went on to achieve a doctorate in mathematics and teach in college. And to highlight further the achievements of females in my high school, there were 30 females among the 37 students elected at the end of our senior year to the Honor Society for academic achievement (Sueyoshi, 1956).

As a University of California at Berkeley undergraduate, I became friends with women from my dormitory who were mostly White from California, and one was from Argentina. I felt no racial pressures there, but I lived with being a stereotype. I was told repeatedly that, because I was Asian, I had to be good at mathematics and science. I tried not to disappoint them. It had never occurred to me that women fared worse than men in mathematics and science at that time. I was one of three women in a physics class of 600, and two of us lived in the same dormitory. The male teaching assistant who graded our papers stopped by one day. I think he wanted to be sure that we knew our stuff and that we were not copying each other's work because we were outscoring most of the men.

During my graduate school years at the University of Illinois in Urbana-Champaign, my husband-to-be was arriving for the summer to enroll in classes. I called to make an appointment to see an apartment for him. The woman was very welcoming over the phone. When I showed up at her door, she would not let me in to see the apartment. As I turned to leave, a White couple came to the door, and she let them in to see the

apartment. This experience happened before the landmark passage of the Civil Rights Act of 1964.

“Mixed Marriage”

My husband is a *haole* (Caucasian) and our marriage is a reminder of how far we have come. When my husband and I married in central Illinois in 1962, we could not have married in Tennessee, just a few hours’ drive to the south. When we married, my parents were initially upset that I did not marry within my race; however, when our son was born, my parents could not have been more supportive and loving of our family. My late mother-in-law was wonderful and accepting, not only of our racial differences but also of our differences in religion (I am a Buddhist, and she was a devout Methodist).

In the summer of 1964 when my husband and I drove around the continental U.S., we were fearful of stopping in some states where marriages of mixed races were illegal. When we stopped at a hotel in such a state, he would go in to ask first if we could stay there. This was not a comfortable situation. One hotel clerk in Louisiana grudgingly took us in late one night but had to say “only because Asians are almost as clean as white people.”

St. Louis Struggles and Successes

Before retiring and moving to Arizona, I taught mathematics and then served as Associate Dean at one of the campuses of St. Louis Community College in Missouri. During my 24 years there, this campus experienced an increasing number of Black students because of changing neighborhood demographics and enrollment patterns. The student population was one-third Black when I retired 12 years ago. Some of my colleagues had difficulty accepting this change. For example, they would lock the doors at the beginning of class to prevent late students from entering class. This was very upsetting. I asked my colleagues how they got to campus—of course, they drove there in their automobiles. Many of the students from the city came to campus by bus, sometimes making at least one transfer and then walking to buildings from the bus stop. If the bus was late, the student was late. I used to tell my students that they should come to class no matter how late; being late was better than not being there.

There are bright spots in the St. Louis part of my story. The number of students from underserved populations and the number of women enrolled in science, technology, engineering, and mathematics (STEM) courses were increasing. One of my former students from St. Louis Community College is Debra Dickerson, award-winning essayist whose work has appeared in *The New Republic*, *The Washington Post*, *Talk*, *Slate*, *Salon*, *Essence* and *Vibe*. She has won the New York Association of Black Journalists’ first-place award for personal commentary. Her critically-acclaimed first book *An American Story* reveals her struggles to achieve an education in a way that is inspiring for students and teachers of all races.

Concluding Thoughts

I am also optimistic about the future of racial and gender equity, but feel we are not making progress fast enough. It was only in 2000 that the decennial U.S. Census began allowing respondents to identify as more than one race. We have had some recent major setbacks in our country, but our grandson and many of our great nieces and nephews are of mixed races and are living in a world more accepting of differences. Their world has a U.S. president of mixed race who was born and raised in Hawai’i where concepts and practices of equity got an early start even before required by law. This is quite a contrast to the days of my youth when no woman or African-American would have been a front-runner for her/his party’s nomination for President of the United States.

My life journey has led me to volunteer for national and local organizations. I first began formally addressing multiculturalism and gender in mathematics education when, at the conclusion of my term as Program Chair for the 1994 NCTM Annual Meeting, NCTM asked me to serve on the editorial panel for the six-volume *Changing the Faces of Mathematics* series and as editor of the particular volume *Perspectives on Asian Americans and Pacific Islanders* (NCTM, 1999). This experience expanded my knowledge beyond my personal observations as I became more aware of “the roles of language and culture in the classroom.... rich traditions and contributions of Asians and Pacific Islanders to mathematics.... [and] cultural differences that influence classroom dynamics, classroom behavior and environment” (NCTM, 1999, p. v). This NCTM series

came somewhat late for my generation but began to address some of the challenges we still face in mathematics education today.

Since retiring in 1999, I served 10 years on the Board of the National Council of Supervisors of Mathematics (NCSM), on a number of committees of the National Council of Teachers of Mathematics (NCTM), and on the Board of TODOS: Mathematics for ALL. They all advocate for equitable and high-quality mathematics education for all students, so my retirement is really a rededication of my life's passion. I volunteer for these organizations, especially TODOS, because the mission is so important and close to my heart.

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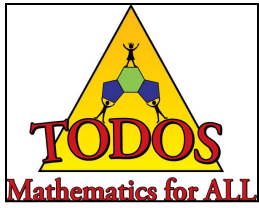
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Discussion And Reflection Enhancement (DARE) Post-Reading Questions

1. What are some of the ways in which racial profiling still exists today?
(see online resources such as <http://www.racialprofilinganalysis.neu.edu/>)
2. How has the U.S. used statistics against minority populations, and what safeguards are now in place to avoid this?
(see the work of Margo Anderson and/or William Seltzer)
3. What are some ways in which salary inequities still exist? What websites offer data on this?
4. How can the "Asians are good at math" stereotype be harmful as a gross generalization? How does this stereotype relate to the Chval and Pinnow article in the fall 2010 issue of *TEEM*?
5. What are ways you can make a difference in issues of equity as an individual teacher?
6. How can being active in national organizations such as TODOS, NCTM, or NCSM have an impact on issues that are important to you?

"DARE to Reach ALL Students!"





Developing Mathematics Literacy for Bilingual Learners: A Framework for Effective Learning

Zulmaris Diaz, J. Joy Esquierdo, Olga Ramirez, and Isela Almaguer

Abstract

A framework is proposed for how bilingual learners develop knowledge, language, and mathematics literacy. The framework centers on principles of learning, effective pedagogy, and second language acquisition theories, and these elements are incorporated in a mathematics lesson depicted in this article.

Discussion And Reflection Enhancement (DARE) Pre-Reading Questions

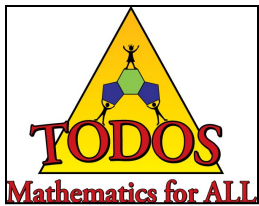
1. Does the term *bilingual learners* seem different from *English Language Learners*? Explain your reasoning and any possible influences from your experiences in teaching.
2. How do you define *mathematics literacy*?
3. What challenges might bilingual learners face when developing mathematics literacy?
4. Discuss any experience or knowledge that comes to mind connected to the components in Figure 1, page 12.

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Developing Mathematics Literacy for Bilingual Learners: A Framework for Effective Learning

Zulmaris Diaz, J. Joy Esquierdo, Olga Ramirez, and Isela Almaguer

The belief that mathematics is an easier subject than others to teach to students who are English Language Learners (ELLs) has misconceptions. While some view mathematics as a subject with minimum linguistic requirements that involves only numbers, many mathematics teachers would disagree. Mathematics involves specialized vocabulary, oral and written language, multiple representations of concepts, and same terminology for different concepts (Echevarria, Vogt, & Short, 2001). Moreover, research indicates that knowing how to complete computational problems and repeat definitions verbatim is insufficient for mathematical literacy.

Martin (2007) defines *mathematics literacy* as the ability to “reason, analyze, formulate and solve problems in a real-world setting” (p. 28). For students learning English and mathematics concurrently, becoming mathematically literate presents certain challenges. They need to learn not only English, but also the language of mathematics to construct meaning in mathematics (Ron, 2005); further, they need to communicate orally and in writing so as to explain solutions, provide conclusions, or present arguments (Moschkovich, 2002).

Another challenge faced by ELLs as they develop math literacy is the achievement of the Communication Standard outlined by the National Council of Teachers of Mathematics (2000), which suggest “instructional programs from prekindergarten through grade 12 should enable all students to-

- organize and consolidate their mathematical thinking through communication;
- communicate their mathematical thinking coherently and clearly to peers, teachers, and others;
- analyze and evaluate the mathematical thinking and strategies of others;
- use the language of mathematics to express mathematical ideas precisely” (p. 59).

For these reasons, we present a framework designed to support the development of mathematics literacy for

ELLs. The framework will be complemented with an experimental activity that examines a lesson in a mathematics classroom through the lens of our framework.

Bilingual Learners

Throughout the general literature, students who are learning English are referred to as English Language Learners (ELLs), yet in this article we will use a more encompassing term. We refer to such students as Bilingual Learners (BLs) to emphasize that they are learning content at the same time they are developing two languages, English and their mother tongue. It is crucial when teaching BLs to keep in mind that the main focus needs to be on the cognitive development of the students and, as they are exposed to English, their linguistic abilities will develop concurrently. Teachers may sometimes become so focused on increasing language proficiency in the students’ second language -- in most cases, English -- that the development of mathematics literacy can lose priority.

Framework for Teaching BLs New Content Literacy

The proposed mathematics lesson framework (in Figure 1) resulted from an extensive review of the literature on how BLs best develop content knowledge and skills. It centers on three fundamental elements: three principles of learning, effective pedagogy, and second language acquisition theories, all of which will result in a learner-centered classroom environment that supports the development of grade-level content literacy (Baker, 2006; Cook, 1992, 2002; Cummins, 1981, 1984; Krashen, 1982; Padrón & Waxman, 1999; National Research Council, 2000).

Three Key Principles of Learning

When developing the proposed mathematics lesson framework, we focused on three major principles of learning presented by the National Research Council (2000):

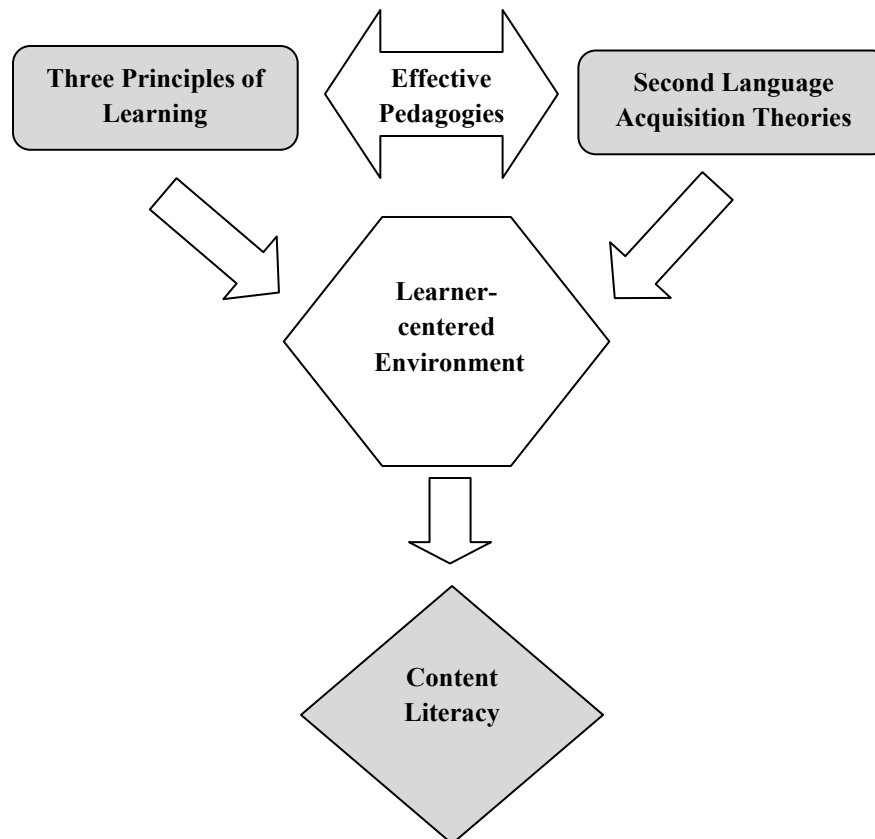


Figure 1. Framework for teaching Bilingual Learners new content literacy (modified from Diaz et al., 2010)

Principle of Learning #1: All students start school with preconceived concepts of how the world functions. They bring experiences from home and from their surrounding community, which help them construct new knowledge in the classroom.

Principle of Learning #2: In order for students to develop the ability to make inquiries, they must have developed basic factual knowledge and the ability to manipulate that knowledge (see Figure 2 to the right for an illustration).

Principle of Learning #3: For bilingual learners to become lifelong learners, they need to take a metacognitive approach to their learning. Metacognition occurs when a student makes a conscious effort to control and monitor his/her learning through the use of various learning strategies (Brown, Bransford, Ferrara, & Campione, 1983).

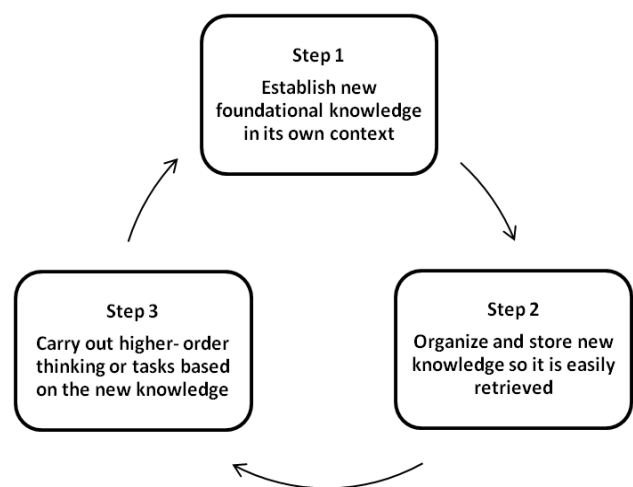


Figure 2. Learning principle #2 (Esquierdo, 2010)

Pedagogy Supportive of Language Acquisition and a Learner-Centered Classroom

When providing content instruction, mathematics teachers must be sure to employ solid pedagogy that upholds the theoretical views of language acquisition. Padrón and Waxman (1999) propose five research-based instructional practices (explained in Table 1 below) that support language acquisition, development, and knowledge for BLs: (1) Culturally Responsive Teaching; (2) Cooperative Learning; (3) Instructional Conversation; (4) Cognitively Guided Instruction; and (5) Technology-Enriched Instruction.

These instructional approaches are just a few of the research-supported strategies used to provide meaningful and effective instruction to BLs. They focus on a *learner-centered* environment, where “the students’ own desire to know, to discuss, to problem solve, and to explore individually and with others” serves as the foundation of instruction rather than imparting “learning that is dictated, determined, and answered by the teacher” (Glickman, 1998, p. 52).

Table 1. Instructional practices that can support language acquisition

Pedagogy	Description
Culturally Responsive Teaching	Instruction that builds on the languages and cultures that children bring from their home and community (Slavin & Cheung, 2005).
Cooperative Learning	Instruction that involves the use of small groups as a means to optimize students’ own and each other’s learning. Some benefits: (1) enhances instructional conversations; (2) develops social, academic, and communication skills; and (3) develops proficiency in English (Calderón, 1991; Christian, 1995; Johnson & Johnson, 1991; Rivera & Zehler, 1991).
Instructional Conversation	Extended instructional discourse between the teacher and students (Duran, Dugan, & Weffer, 1997). Provides opportunities for extended academic conversations and allows BLs to reformulate previous concepts and attach new vocabulary to them (Christian, 1995).
Cognitively Guided Instruction (CGI)	Instruction allowing students to articulate their thinking which in turn provides teachers with a better understanding of how children learn mathematics (Carpenter, Fennema, & Franke, 1996).
Technology-Enriched Instruction	Instruction utilizing technology to help connect learning in the classroom to real-life situations (Means & Olsen, 1994) and allows students to access information in their native language as well as in their second language. Examples include the use of virtual manipulatives, web-based picture libraries, multimedia, calculators, etc.

Second Language Acquisition Theories

Teachers ought to be cognizant of students' acquisition of a second language. We will examine some principles of second-language acquisition with the intention to help teachers plan mathematics instruction for BLs. These principles take into consideration the learner as the center of his or her language and learning development and how all he/she brings into the classroom promotes language proficiency and academic achievement, specifically mathematics literacy.

Baker (2006) suggests that it is imperative that the education community stop viewing BLs as "two monolinguals in one person" (p. 10), so there is a need for a paradigm shift such that individuals are viewed as having *multi-competence* (Cook, 1992, 2002) in both languages. It is well known that language comprises four domains: listening, speaking, reading, and writing. Within these domains, there is much variation in language development and ability, spanning these stages (Baker, 2006; Krashen & Terrell, 1983):

- (a) simple or what second language acquisition scholars will call pre- and early- production stage: the person has limited comprehension of the language and uses short phrases to communicate;
- (b) basic or speech emergent stage: the person has an increased comprehension of the language, is less hesitant to speak and uses simple sentences to convey meaning;
- (c) fluent or intermediate fluency stage: speech is at greater length with the use of more complex sentence structures; and
- (d) accomplished or advanced proficiency: the person uses complex grammar and specialized academic vocabulary.

For BLs, the level of fluency within each of the language domain will depend largely on the need and use of a language (Grosjean, 1998). In fact, it is almost impossible for a bilingual person to be equally competent in both languages (Fishman, 1971). For example, some BLs might have a fluent or intermediate level of proficiency in speaking English when it is used in a social context (e.g., shopping, interactions with family, etc.), but demonstrate basic or speech emergent skills in reading and writing when used in formal contexts (e.g., academic lectures, work, etc.). Students might have an

accomplished or advanced level of proficiency in speaking and listening to Spanish in formal context, but demonstrate fluent or intermediate skills when reading and writing Spanish in formal context.

Consequently, BLs need to be given opportunities and access to rich language environments in order to develop multi-competence in both languages at the social and formal context, or what Cummins (1984) identifies as the two key dimensions of language proficiency: (1) basic interpersonal communicative skills (BICS), language skills that are acquired easily through daily living; and (2) cognitive academic language proficiency (CALP), the language proficiency learned in an academic setting (Cummins, 1981).

It is important for teachers not to be deceived by BLs' language fluency in the social context since they might not have the same language proficiency in the academic or formal context. If bilingual learners are not exposed to the language of the classroom, the "vocabulary and the rhetoric style that make up the academic" language (Gandara & Contreras, 2009), specifically in our case the language of mathematics, they will encounter difficulties when having to read and analyze mathematical texts, including having to support, explain, and articulate their results and ways of thinking mathematics.

Under the premises that language is acquired through social interaction in different contexts, Krashen (1982) has concluded that the key to second-language acquisition is not the quantity of exposure to the second language, but the quality of instruction in the second language. That is, when a teacher is aware of the bilingual learner's second-language development, the focus goes from a *more coverage* approach to a *more appropriate* experience. The acquisition of language competency and content literacy in the second language is a result of comprehensible input, the spoken or written message that is delivered at the student's level of comprehension, and an accommodating affective environment, where the students' level of anxiety is low.

Learner-centered Environment

The main focus of a learner-centered environment is learning with understanding, while taking into consideration the needs, abilities, and interests of the learner. A learner-centered classroom promotes active exploration

tion and construction of meaning, while moving away from the passivity of listening to the teacher’s lecture and reading the textbook. It builds on the idea that the learner is responsible for his/her own learning.

The proposed framework serves as a catalyst for the creation of a learner-centered environment. Two of the main elements of the framework ask teachers to take into consideration the learner – specifically, how BLs learn based on the three principles of learning – and understand how they acquire the second language and develop language proficiency. Moreover, using effective pedagogies in the classroom help bilingual students become motivated about their own learning. Each of these elements contributes to the evolution of mathematics literacy collectively; they do not work in isolation. In other words, a teacher cannot simply assume that, for example, using the principles of learning component of the framework will guarantee that bilingual learners develop mathematics literacy. All three components of the framework need to be considered when planning and delivering instruction to BLs so that content literacy can be acquired.

A Closer Look in a Mathematics Classroom

The following scenario is a hypothetical sixth-grade classroom applying ratios through a real-world experience. The teacher, Mr. Cruz, starts his lesson asking the students about their homework. For homework, the students had to go to the store to choose a liquid product (e.g., juices, cleaning products, milk) and record the different size containers of the chosen product and their respective prices (e.g., a gallon of milk is \$4.00; a ½ gallon is \$2.50, a quart is \$1.40, and a pint is \$0.75).

Mr. Cruz asks the students, “So what did you find out?” “I found out that the bigger the container, the higher the price,” offers Michael. María raises her hand and says, “I recorded the prices for milk and noticed that one gallon of milk costs \$4.00, and ½ a gallon costs \$2.50, and a quart costs \$1.40.” Mr. Cruz adds, “That’s right. The prices will vary according to the container sizes. Today we will compare how prices of milk vary depending on their container size by using ratios. Ratios are used in our everyday life. Let’s look for example at the different size containers of milk and let’s use the prices María recorded.” The teacher then places on the board a picture of a gallon, ½ gallon, and a quart of milk and writes down the prices María wrote down as

homework. He then asks “which one do you believe is a better buy and why?”

Mario answers, “I think the quart is a better buy because it’s cheaper.” “No but you get less fluid ounces. I think it is the gallon,” responds Jesús. Lucia adds, “Yo creo que el medio-galón tiene el mejor precio porque tiene más cantidad pero solo cuesta \$2.50” [*I believe that the half-gallon is the better price since it has more milk and it only costs \$2.50*]. Mr. Cruz continues with the lesson by commenting, “Okay, let’s see which one is a better buy. To find out, we need to calculate the price per ounce. To do this, we need to take into consideration the ratio between the price and the fluid ounces of the container.” Using an organized table, Mr. Cruz guides the students on how to study and calculate ratios (see Table 2).

Table 2: Price for one gallon of milk

Capacity of Container	Equivalent Fluid Ounces	Price of Container	Price per Ounce
<i>Capacidad del envase</i>	<i>Equivalencia en onzas líquidas</i>	<i>Precio del envase</i>	<i>Precio por onza</i>
1 gallon <i>1 galón</i>	128 fluid ounces <i>128 onzas líquidas</i>	\$4.00	$\$4.00 \div 128 =$ \$0.03125

Mr. Cruz continues, “Now get with your partner and find out what the price per ounce would be if the gallon would cost \$4.50. As students work in partners to respond to Mr. Cruz’ subsequent question, he walks around guiding them when needed and asking them to explain how they solved the problem. In the background, you can hear the students using English and Spanish to solve the problems and also discussing the different steps they take when calculating division operations with and without the use of a calculator. Mr. Cruz takes advantage of the moment and asks Lucia, who recently emigrated from México, to explain to the class how she divides since she solves the problems differently.

After the students have completed the problems he posed, Mr. Cruz asks them “What did you find out?”

Marco responds, “if the gallon costs \$4.00, the price per ounce is \$0.03125, but if the price per gallon costs \$4.50, the price per ounce is \$0.03516.” “Very well, now let’s use the calculators and see what the price per ounce is when the ½ gallon costs \$2.50,” says Mr. Cruz. The class continues with the same study format and the teacher guides the students by showing them how to link what they know about determining the price per ounce of milk when given the price per gallon to finding the price per ounce of milk when a half-gallon costs \$2.50 such as in Table 3. As the students work together they use both languages to complete the assignment and to help each other.

Table 3: Price for half-gallon of milk

Capacity Container Capacidad del envase	Equivalent Fluid Ounces Equivalencia en onzas líquidas	Price of Container Precio del envase	Price per Ounce Precio por onza
$\frac{1}{2}$ gallon	64 fluid ounces	\$2.50	$\$2.50 \div 64 = \0.03906
$\frac{1}{2}$ galón	64 onzas líquidas		

After the students have completed the work given, Mr. Cruz asks them “What did you find out?” Angela responds that “if half-gallon costs \$2.50, the price per ounce is \$0.039063.” “So then, which one do you think is the better buy?” asks Mr. Cruz. All students shout “the gallon!” Mr. Cruz continues, “So far, the gallon of milk is our better buy, but we cannot make assumptions. We need to calculate all the ratios. Continue working with your partner and find out the price per ounce when the quart of milk is sold for \$1.40.” After the students complete all the calculations, Mr. Cruz asks them, “Which one is the better buy and why?” The students answer in unison “the gallon of milk, because the price per ounce is \$0.03125.” Subsequently, Mr. Cruz asks the students to summarize how the price per fluid ounce is determined. As the students explain their thinking, he encourages them to notice that the price of the container must be divided by the number of fluid ounces in the container. Then Mr. Cruz asks

the students to write in their journals a “word square” (Winsor, 2007) for the term “ratio” (see Table 4 below).

Table 4: Word square for the word “ratio”

Ratio	Razón
A ratio is a relationship or comparison between two numbers	Ratio = <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 5px auto;"> $\frac{\text{PricePerContainer}}{\text{NumberofFluidOunces}}$ </div>
Razón es una relación o comparación entre dos números semejantes.	Razón = $\frac{\text{Precio del envase}}{\text{onzas líquidas}}$

After having students write in their journals, Mr. Cruz asks the students to work in pairs and use the findings from their homework to calculate the ratio of the prices of each of their recorded liquid products and to decide which size container is a better buy. Then, they are to write a small paragraph explaining which size container is a better buy and why, and they are to present the findings to the class. At the end of the lesson, Mr. Cruz reminds the students that for homework they will have to compare three different brands of cereal and decide which one is the best buy.

Connection of Lesson with Framework

Three Principles of Learning

At the beginning of this lesson, Mr. Cruz makes use of his understanding of the first Principle of Learning when he asks the students to share what they found out from their homework and when he makes connections to their prior experiences and knowledge. When Mr. Cruz asks the students to work with partners to use the findings from their homework to calculate the ratio of the price per ounce for each of the liquid containers and cereal brands and to decide which container or brand is the best buy, this demonstrates how this teacher makes use of the second Principle of Learning. The students will also be required to apply the same knowledge to a different context when they will have to compare three different brands of cereal. Moreover, Mr. Cruz makes use of Learning Principle #3 when he helps the students understand the new concept by orga-

nizing the new information into a table both in English and Spanish. He also makes the connection between English and the students' native language when he asks the students to create a word square for the new term. These two approaches are cognitive strategies which help promote the development of metacognitive strategies for BLs.

Pedagogy

Throughout the lesson, the students are working cooperatively. They are working in pairs instead of larger groups because students who are not proficient in English, females, and minority students tend to participate less in cooperative learning activities when groups are larger (Webb, 1984). Therefore, in Mr. Cruz's classroom, by working in pairs, all students contribute equally and are provided with opportunities for mathematical discourse, which allows BLs to process the new information further and develop language as they discuss findings with each other. As the teacher explains the concepts and walks around when students are working in pairs, he is making use of instructional conversations to promote language development and mathematical literacy. Likewise, there are hints of CGI when the students explain how they got their answers for finding ratios and when Lucia describes the method she learned in México of solving division problems. Teachers need to understand mathematical cultural differences, accept them, and allow students to use their own strategies (Midobuche, 2001). Moreover, students had ample opportunities to participate in academic conversations with their partners, the whole class, and the teacher. They also had the opportunity to use technology – in this case, calculators – to solve problems.

Second Language Pedagogical Strategies

In this particular lesson, the teacher works under the premise that language is acquired through social interaction, with comprehensible input in an accommodating affective environment. The students are acquiring the English language as they experience and discuss the mathematics content in this lesson. They are not learning English rigidly through the review of rules and grammatical structures, but are learning and applying their English and Spanish skills as they attain the new vocabulary and knowledge introduced in the lesson and modeled by the teacher. Additionally, Mr. Cruz uses Krashen's (1982) notion of comprehensible input by providing visuals, and modeling allowing for language

and concept transfer through the use of word squares (Winsor, 2007). All of these strategies provide support to the BLs' comprehension of the mathematical content and the development of the second language. Most importantly, the lesson is designed to lower the affective filter and allow BLs to feel comfortable taking academic and linguistic risks.

Learner-centered environment

The setting of a learner-centered classroom environment is created by employing the three key Principles of Learning (NRC, 2000), effective pedagogy, and second language acquisition theories. One fundamental trend among these three major areas is that providing a learning-safe, risk-free classroom helps the development of mathematics literacy skills in BLs to flourish. In the learning framework espoused in this paper, it is clear that permitting BLs to discuss the mathematics requirements of the lesson in both English and Spanish is empowering and fundamentally important in supporting a learner-centered environment.

Conclusion

This article proposes a framework that encompasses how BLs develop knowledge, language, and mathematics literacy. It provides a functional structure for teachers on how three principles of learning, effective pedagogy, and second language acquisition theories, collectively, can lead to the development of mathematics literacy for BLs. It is based on the premise that teachers must view bilingualism as a strength and not as an obstacle to teaching and learning.

It is crucial that teachers keep aiming for BLs to perform higher-order thinking skills and tasks. We posit that when BLs have the opportunity to explore actively and construct meaning by engaging in higher-order thinking projects in a learner-centered environment, they expand their understanding of the language (first and second language), content literacy, and most importantly, transfer knowledge from one language to another. They also gain the ability to apply the information to an assortment of contexts and use language as a tool. Thus, this article provides an important message to teachers of BLs that promotes exploring, inquiring, and applying new mathematics knowledge in and out of school contexts with opportunities to use both English and their mother tongue to “communicate their mathe-

mathematical thinking coherently and clearly to peers, teachers, and others” (NCTM, 2000, p. 59).

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Discussion And Reflection Enhancement (DARE) Post-Reading Questions

1. Looking back at Figure 1, what did you learn about each component of the framework?
2. Which of the three Principles of Learning most resonates with your approach to teaching? Explain.
3. Review a mathematics lesson you have previously designed and/or delivered to BLs. Does it encompass any components of the framework? What modifications can you make to the lesson plan so that it can utilize the major components of this framework?
4. Create a mathematics lesson for BLs that takes into consideration the framework in this article.
5. Analyze a video lesson through the lens of the proposed framework. For example (from <http://www.learner.org/catalog/browse.html?discipline=5>), suggested Annenberg/CPB Mathematics Videos are “Ladybugs” or “Marshmallows” (from Teaching Math: A video library, K-4) or “The Largest Container” (from Teaching Math: A video library, 5-8).
6. How can teachers optimize mathematics learning for BLs?