In the Shoes of English Language Learners: Using Baseball to Help Pre-service Teachers Understand Some Complexities of Language in Mathematics Instruction

Eugenia Vomvoridi-Ivanović and Aria Razfar

Abstract

This article discusses qualitative data collected from elementary pre-service teachers (PSTs) who participated in an activity that uses the context of baseball to highlight some of the complexities of language in mathematics instruction. Through this activity, PSTs moved from a more discrete vocabulary orientation for teaching mathematics towards an embedded discourse approach, broadened their views on whom they classify as an English language learner (ELL), and developed empathy for the meaning-making struggles of ELLs in mathematics classrooms.

Discussion And Reflection Enhancement (DARE) Pre-Reading Questions

1. Who do you consider as an ELL? What are the characteristics of an ELL?
2. Imagine a student who speaks English fluently and does not have a "foreign" accent. Could this student be an ELL?

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Pre-service teachers (PSTs) enter the profession with little knowledge about the needs, resources, and support required to teach mathematics effectively to English Language Learners (ELLs) (Chval & Pinnow, 2010). They often have very simplistic notions about the language demands that are present in mathematics classrooms (Vomvoridi-Ivanović & Khisty, 2007). Their notion of mathematical language is reduced to mathematical terminology and they assume that simply providing their students with a vocabulary list or definitions of mathematical terminology will suffice. In addition, many of the PSTs and in-service teachers we have encountered tend to think of ELLs as students who have difficulty speaking in English or speak with a "foreign" accent. They would not view as an ELL a child who speaks English fluently or has a native-like American-English accent.

Activities that are often used with (monolingual) PSTs or inservice teachers to have them experience what ELLs experience in the classroom, and to perhaps model strategies that can be used to accommodate ELLs, are in a language that none of the PSTs speak (see Anhalt, Ondrus, & Horak, 2007). Such an activity, for example, is a mathematics problem written in a language the pre-service teachers are not familiar with, or a health video giving instructions in Farsi language (e.g., Harding-DeKam, 2007). While these activities can be useful to have pre-service teachers experience what it feels like to be an ELL who has recently moved to the US and speaks no English, the majority of the ELLs that pre-service teachers will be teaching will not fall into that category. In fact, most ELLs have some level of conversational fluency in English, and many of them might not have an easily detectable foreign accent, which makes it tricky for teachers who, mistakenly, do not classify them as ELLs. According to Cummins (1981), conversational fluency in English is acquired within 2 years, while it takes 5-7 years to acquire academic (including mathematical) fluency in English. This is an important distinction that teachers need to be aware of and understand its implications for teaching mathematics to ELLs. Pre-service teachers are often taught this distinction in their coursework but do not necessarily make connections with what this means for teaching mathematics to ELLs (Vomvoridi-Ivanović & Khisty, 2007).

This article discusses an activity intended to help PSTs and other educators understand some of the complexities of language in mathematics instruction and experience what many ELLs who have conversational fluency in English may experience in the mathematics classroom.

The importance of distinguishing "language" from "discourse" is central to teacher education, including professional development activities. Typically, the notion of language refers to the structural aspects of language (i.e., code) and/or the use of national languages (e.g., Spanish, English). In contrast, "discourse" refers to the specialized and situated language of mathematics that is generally more quantitative and symbolic.

In addition, the concept of discourse more explicitly includes performative, semiotic, and critical dimensions of language use (Gee & Green, 1998; Razfar, 2012). These dimensions account for language use in real communicative situations, focus on actual meaning-making, and how people draw on contextual cues and relationships when they purposefully use language to solve problems. Performative aspects of language use consist of paralinguistic and non-verbal dimensions of language like tone, intonation, loudness, pitch, gestures, facial expressions, and rhythm. Semiotic and critical dimensions of language use focus our attention on the less apparent aspects of communication, namely intentionality, meaning, values, histories, world-views, power relations, and *language ideologies.*

These aspects require in-depth ethnographic relationships in order to gain closer approximation of how people make sense of the complex web of interpersonal, institutional, and ideological relations that inform their lives. While consideration of semiotic and critical dimensions of discourse complicate our understanding of language use, they constitute a more complete view of language that is essential for understanding how language mediates mathematical problem-solving (Razfar, 2012).

As part of this activity, PSTs discuss and solve a mathematics problem in the context of baseball. The mathematical skills required to solve the problem are at elementary level. However, for someone who is not familiar with baseball and/or baseball discourse it is impossible for him/her to make sense of the problem. The purpose of the activity was to move PSTs from a *discrete vocabulary orientation* for the language used in teaching mathematics towards an *embedded discourse approach*.

An embedded discourse approach frames mathematical terminology as nested within activity systems mediated by cultural rules and concrete goals. In contrast, a discrete vocabulary orientation treats mathematical terminology as decontextualized entities abstracted from cultural practices and activity systems. In this orientation, mathematical terms are provided with absolute, fixed, and universal definitions often in the form of flash cards, word lists, and skill-based worksheets. Data collected from PSTs participating in this activity suggest that PSTs moved from a discrete vocabulary orientation for the language used in teaching mathematics towards an embedded discourse approach, developed a greater empathy for the meaning-making efforts of ELLs in a mathematics classroom, and broadened their views on ELLs to include those who have conversational (but not academic) fluency in English.

The Baseball Activity

The baseball activity is an adaptation of a version the authors created and used at a week-long seminar for the Center of Mathematics Education for Latinas/os (CEMELA) and also at the middle of the first author's mathematics methods course, after students completed relevant readings: Bresser (2003), Coggins, Kravin, Coates, and Carroll (2007), and Moschkovich (1999). At the beginning of the activity, the PSTs are asked to imagine an ELL and write a description of that ELL on a piece of paper. Then they are prompted to describe what the ELL they imagined looks like, sounds like, etc. The instructor then provides additional experiences that distinguish between language and discourse to foster empathy for the challenges of doing mathematics not only as a language learner, but also as a discourse learner.

First, PSTs are informed that they will solve a baseball problem working with peers who have similar knowledge about baseball. PSTs are asked to self-identify as being a member of one of three groups, the latter two of which are labeled as "Baseball Language Learners" (BLLs):

- Group 1: Baseball experts, PSTs who are very knowledgeable about baseball and can fluently talk about the sport.
- Group 2: Baseball novices, PSTs who have only basic knowledge about baseball.
- Group 3: Foreign to baseball, PSTs with no or almost no knowledge of baseball, other than that it is a sport. They could not explain how the game is played.

Second, PSTs work in their groups to define the following baseball terms: slug, bat, batting three hundred, ball, strike, diamond, base, steal, stealing home, hit and run, Triple Crown, run, out, balk, and save. Groups are asked to share their definitions with the rest of the class starting with Group 3, then Group 2, and then Group 1. As might be expected, the baseball experts are easily able to define all these terms. However, the BLLs, struggle to accurately make sense of the terms within a baseball context. The point of the activity becomes clear as many of the BLLs express that they experience what it is like to be an ELL since, although they all speak English, they do not speak baseball.

As a result, the word 'bat' conjures a flying mammal rather than a stick and is viewed only as a noun as opposed to both noun and verb. 'Ball' represents a spherical object instead of a pitch that is not good to hit. To 'strike' something is equivalent to hitting it whereas in baseball, a batter that swings the bat and completely misses the ball gets charged with a strike. Once the class reaches consensus on each definition, the definitions are displayed on poster boards.

Third, PSTs are informed that they are to collaborate with their group members to solve the following baseball problem (see Appendix for a solution) that includes some of the baseball terms they previously defined:

> *Barry Bonds, one of the most prolific home run hitters of the modern era, slugged over "eight-hundred" in one season. If he had six hundred at bats, how many total bases did he get?*

As each group attempts to solve the problem, the "BLLs" are asked to monitor the process of trying to understand the problem and to note the resources that they draw from to make sense and solve the problem. At the same time, the "baseball experts" are asked to think about how they would help the BLL groups make sense of the problem and its solution.

Fourth, BLLs are asked to share their solutions and the processes they went through as they tried to make sense of and solve the problem. Members from the BLL groups become increasingly frustrated as they go back and forth from the definitions to the problem text and still fail to make meaning of the text. Some BLLs make parallels between what they experience through this process and trying to make sense of a text written in a foreign language that they do not understand with the aid of a dictionary. All agree that it is almost impossible to understand a foreign text this way. This is perhaps the first time that many of them realize that discrete dictionary definitions of words do not provide sufficient context to engage in embodied meaning making. This leads to a whole class discussion on *register* (Halliday, 1978) and on why it did not suffice simply to go over key baseball terms (vocabulary) at the beginning of the activity.

Fifth, the groups are rearranged so that there is at least one "baseball expert" in each new group. The "baseball experts" are asked to assist the BLLs in understanding and solving the problem. Typically, "baseball experts" try to explain the problem using various visual aids and/or physical representations, such as drawings, diagrams, and acting out aspects of a baseball game. Despite the experts' efforts, the BLLs, especially those in Group 3, typically do not fully understand the problem and its solution and express that they would not be able to solve another similar baseball problem. A whole class discussion follows as various groups share their solutions and the methods the "experts" employ to assist the BLLs.

Sixth, baseball experts are asked to "talk baseball" and to argue about a baseball related issue. After listening to the experts "talk baseball" the BLLs quickly feel at a loss and experience what it is like not to be a member of a particular discourse community.

Finally, "lessons learned" are discussed from this experience, particularly as they relate to ELLs. In this discussion, PSTs are expected to make connections with relevant readings. These prompts generate very rich discussions around language, context, mathematics, and ELLs. BLLs, for example, may interpret a slugging average of "eight hundred" as '800' rather than 0.800, which is what it means within baseball. Others interpret the slugging average as a percentage, thus, they set up the slugging percentage as 800%, which is incorrect also. This brings up the point that mathematical meaning is situated in the context and common language is shared and understood by a community, such as this case, a baseball community. BLLs often use the two numbers 800 (given in the problem) and 4 (the number of bases implied by a homerun) and perform some mathematical operation such as total bases equals 4×800 or $800/4$. This is characteristic of how students generally approach a problem: if they can't make sense of the problem, they focus instead on key words and numbers.

PSTs' Post-Activity Reflections

As a course assignment, PSTs write a reflection with the following prompt: "What kinds of insights have you gained from this experience that relate to the teaching and learning of mathematics for ELLs?" A total of 129 PSTs' reflections were collected: 105 from the three undergraduate level sections and 24 from the one master's level section that the first author taught. These reflections were completed by all the PSTs who participated in this activity and, since they were a course assignment, were graded. To protect PST's identities, the first author removed all identifying information from the reflections prior to data analysis. A grounded theory methodology (Strauss & Corbin, 1990) was used to identify recurring themes in the PSTs' reflections. Our coding scheme aimed to characterize the nature and content of the PSTs' written comments so as to identify patterns in the insights that PSTs gained through the baseball activity. From the analysis across all 129 PSTs' reflections, three major insights (discussed in the following three subsections) emerged with respect to teaching mathematics to ELLs.

From Vocabulary to Discourse

The vast majority of PSTs (123 out of 129, or 95%) realized that knowing vocabulary and having definitions of terms available were not sufficient for understanding text. Many of the comments suggest a change from a more discrete vocabulary orientation to an embedded discourse approach, such as this PST's reflection:

I used to think that just having a dictionary with all the math terms along with the math book would be enough for an ELL to understand what the book says. When we did the activity in class and we went over the terms of baseball before being given the problem, I still was not able to understand exactly what the question was asking even though it was in English.

Another PST noted:

> Before this activity, I assumed that providing an ELL with a list of vocabulary and definitions, giving a lot of visuals, and sitting them with a more fluent English speaker would be enough to help them understand conceptually. Now I see there is more to it and I need to make sure my ELLs have opportunities to develop the language of mathematics in English.

In their reflections, many baseball experts expressed how difficult it was to modify their talk in order to explain the problem to the BLLs who did not "talk baseball" and were not competent members of the baseball discourse community. One PST, for example, wrote:

It was so hard to explain to BLLs how this problem is solved without using baseball language. I think it is the same way when teaching math to ELLs, we need to be conscientious of the language we are using and modify it so that they understand what we are teaching them and at the same time learn the new language.

Baseball experts also shared how they became so knowledgeable about baseball and how they came to be members of the baseball discourse community by playing baseball, watching baseball games, interacting with "baseball experts," forming and expressing opinions about baseball, discussing baseball-related issues, etc. They noted that just as one does not become a member of the baseball discourse community simply by learning definitions of baseball terms, the same is true with mathematics. As one "baseball expert" commented, "Why don't we learn math just how we learned baseball… watching, playing, listening, and talking about baseball? With math it's mostly watching and listening to the teacher." Baseball experts expressed that showing BLLs how to solve the problem did not lead to BLLs understanding the language of baseball, especially to those who were not familiar with baseball. For example, one "baseball expert" wrote:

It would have been very easy to give BLLs the formula and assume they understand the problem because they can solve it using the formula. But that doesn't mean they know baseball or understand the language used in baseball or can solve a related problem. Mathematically they might be able to do the problem, but they may (will) not understand it because of the language, even if they have a mathematics dictionary available.

Along the same lines, a BLL wrote:

> Just because I was shown how to solve this problem, it doesn't mean I really understand. Like if you give me the same exact problem with different numbers, sure I can solve it, but if it is worded differently or if there is another baseball math problem, I would be lost. So it's the same way with math. We can't assume that because our students solve something because they memorized a formula that they really understand it.

In the Shoes of ELLs

For 112 out of the 129 PSTs (87%), this activity provided a context to develop empathy for the meaning-making struggles of ELLs, even those who have conversational fluency in English. While the PSTs knew the mathematics content necessary to solve the problem, they had never experienced 'language barriers.' As one of the pre-service teachers commented:

> I really didn't have an insight to how ELLs personally must feel in math class until we did the baseball activity in class. I felt like I had a basic knowledge of baseball, I actually thought it was better than most people. When it came time to do the problem, though, my confidence lessened. It was remarkable to me how lost I was, particularly since math has always been a strong subject for me. The problem seemed so hard and I could not even start the problem, let alone figure it out. What made me even more surprised was when the problem's formula was written out on the board and it was such a simple algebraic problem, that I know I could have figured out.

Many of the PSTs observed that most of their methods courses, even English as a Second Language (ESL) courses, did not provide activities that engender this type of empathy for ELLs. The following comment illustrates this point:

> If you are not an ELL then it is hard for you to understand what it feels like to be one! Sure we can attend ESL classes and learn how it is best to teach them and that is helpful. But it is so hard to actually understand what it is like to have to learn in school when you cannot understand what is being said. I found the baseball activity to be a good demonstration of what it feels like to be an ELL student.

BLLs noted that they particularly felt at a loss when listening to the "baseball experts" talk and argue about baseball. As one BLL commented: "They (baseball experts) were talking and talking and I could just catch some words that I understood, and it was so hard to follow them. I guess that's what it might feel like to be an ELL in a math class during math discussions."

Rethinking Who is an ELL

This activity also helped PSTs broaden their views on whom they classify as an ELL. About three-quarters (98 out of the 129) of the PSTs expressed that although they had initially described an ELL as a student who "does not speak English very well" and/or who "has an accent," this activity changed their views to include all students who speak another language at home and whose first language is not English. Many students are not typically classified as ELLs because they are conversationally fluent in English but they are not 'discourse fluent.' This is an important realization not only for math educators of ELLs, but also for all language minority students, as exemplified by this comment:

> It also made me realize one more thing. There is a student in the class I am observing who is from Peru and has a slight accent but speaks English very well. After doing this activity I realized that maybe he is only fluent in everyday English but might feel the same way I did today during the baseball activity. I really had no clue he could be going through this in class! I need to look into it.

Of course, it will be important for teacher educators to ensure that PSTs do not fall into making "deficit assumptions" about students such as this example of a Peruvian student, or assuming that everybody who speaks another language at home or whose first language is not English is automatically an ELL.

Final Thoughts

This paper described an activity in the context of baseball in which PSTs gained insights on some of the complexities of language in mathematics teaching. Those PSTs who were baseball novices experienced what it is like to have conversational fluency and know the mathematics content but not be able to solve a problem because of lack of specialized baseball language and not being part of the baseball discourse community. Those PSTs who were very knowledgeable about baseball and its language realized how difficult it is to have the rest of the PSTs who are not part of the baseball discourse community make sense of the problem without having experience with baseball. Through this activity, PSTs broadened their views on whom they classify as an ELL and developed empathy for the meaning-making struggles of ELLs in mathematics classrooms.

Baseball has proven to be a strategic context for elementary PSTs, as only a few consider themselves baseball experts. This has allowed for the formation of both baseball expert and BLL groups. A problem in the context of soccer may yield a similar formation of groups in populations who are likely more familiar with baseball than soccer. It would be worthwhile, however, to do parts of the baseball activity even with teacher populations who are very familiar with baseball. Such a population might not experience what it is like to be an ELL but may be able to explore further how mathematical meaning and procedures are distinctively situated in a particular context. In baseball, for example, if a batter gets 1 hit in 3 at bats and then the next day gets 2 hits in 5 at bats, her overall accumulated batting average is computed as (1+2)/(3+5) = 3/8 = .375, a very different result from what is obtained from (performing the common denominator algorithm for) adding the fractions 1/3 and 2/5.

Also, statistics for how many innings a pitcher pitches are often represented as decimals in nonstandard ways. Since an inning (technically, a half-inning) has three outs, the only possible "fractions" of an inning for a pitcher to pitch are 1/3 or 2/3, but those fractions are usually represented in baseball statistical summaries as .1 and .2, respectively. Furthermore, the infield is referred to as a "diamond," which could suggest a non-square rhombus rather than the square that it is.

Although the baseball activity has been presented as a context (others might include medicine, the sport of cricket, etc.) that can help educators get 'in the shoes' of ELLs and gain insights about teaching mathematics to them, what is most important is not whether English is the language that a student started with or hears at home. The important issue is that students have had the opportunities to develop the academic language and discourse skills needed to be successful in mathematics when it is taught in English. In contrast to other aspects of language, which are very robust in society (for example, storytelling), the language for mathematics is developed mainly in school. Thus, future teachers need to realize that what this article describes also applies to native speakers of English. Just because students are native speakers does not mean they have the language and discourse skills they need to be successful in mathematics. In this sense, all children are MLLs (mathematics language learners, analogous to the Mathematics as a Second Language designation in Winsor (2007)), whether they are labeled as ELL or not. Thus, what teachers develop to help ELL students become more proficient with mathematical language may often be very beneficial for many other students as well.

In order to move towards preparing teachers to teach mathematics to ELLs, mathematics teacher education programs and professional development opportunities need to be improved so that they develop teacher knowledge related to teaching ELLs. The development of this knowledge should not be deferred to additional certification programs or professional development, but rather needs to be initiated early in the preparation process (Chval & Pinnow, 2010). It is hoped that readers will find ways to modify or expand the baseball activity discussed in this article for use in various teacher preparation and professional development contexts.

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Discussion And Reflection Enhancement (DARE) Post-Reading Questions

1. Revisit the two pre-reading DARE questions and discuss how your answers may have changed.
2. How has your thinking regarding teaching mathematics to ELLs changed after reading this article?
3. What kinds of experiences would the BLLs need to make sense of the problem? How do those experiences relate to the teaching and learning of mathematics?
4. What is the difference between conversational language and the language needed to participate in a mathematics discourse community?
5. What background information or examples from Albert (2003) or Quinn (1996) might be useful to add to the baseball activity?

Appendix

Baseball problem:

Barry Bonds, one of the most prolific home run hitters of the modern era, slugged over "eight-hundred" in one season. If he had six hundred at bats, how many total bases did he get?

Solution to Baseball problem:

First, someone with knowledge of the context of baseball recognizes that "slugged over eight-hundred" (which means .800 in baseball language spoken as a three-digit whole number) does not mean "slugged over 800 home runs" (the record for a season is well under 100), but refers to the value for his slugging average. Slugging average measures the power of a hitter by dividing the total number of bases attained by the total number of official at bats, where walks do not count as official at bats and each single, double, triple, and home run generates 1, 2, 3, and 4 bases, respectively. An ideal player who gets a home run on every at bat would attain the maximum possible slugging average of 4.00.

Bonds slugging over .800 in one season means that his slugging average over the course of that season can be computed the following way:

Slugging Average = Total Bases /At Bats

0.800 = Total Bases / 600

Total Bases = 600 * 0.800 = 480 bases

Since Barry Bonds slugged over .800, he got at least 480 bases that season from some combination of singles, doubles, triples and home runs. Readers can look up online to see that Bonds had slugging averages over .800 in two seasons: 2001 (.863) and 2004 (.812), and .863 is the highest value of any player in history.

Editor's Notes: Slugging average (the mean number of bases obtained per official at bat) is a number from 0 to 4.000, which is not consistent with a percentage. However, readers should know that these words are sometimes used in baseball as if they were interchangeable. For example, on the Major League Baseball (MLB) page *mlb.com/stats/*, hovering over the column heading SLG reveals the term "slugging percentage", while the Baseball Almanac page *http://www.baseball-almanac.com/hitting/hislug2.shtml*, uses the term "slugging average." The Baseball Almanac site remarks, "In 1920, Babe Ruth set the all time single season record when he hit fifty-four (54) home runs in four-hundred fifty-eight (458) at bats (plus his other extra base hits) giving him an unbelievable slugging average that year of .847. So unbelievable that when Barry Bonds crushed the record in 2001 he secured his place in baseball immortality."

TEEM readers should also be aware that Bonds was convicted in 2011 on obstruction of justice during the U.S. Government's investigation into the use of steroids. Additionally, keep in mind that baseball statistics sites such as the ones mentioned above can be used to create mathematics problems using any players' statistics.