

Connected Math Plus Connected Language Learners: An Algorithm for Participation

**Holly Hansen-Thomas
Texas Woman's University**

Rationale and purpose

In the U.S., research has shown that both immigrant and U.S.-born Latina/os do not perform well in math (Secada, 1992; Tate, 1997; Gutierrez, 2002). Latina/o English language learners (ELLs) are at a greater risk for failure in today's math classes as a result of not only increased linguistic and possibly cognitive demands, but likely also due to attitudes and expectations. There exists a tacit assumption among some teachers and administrators that ELLs should succeed—or at least be able to minimally participate in some classes. Math is certainly one of them. Despite its reputation as being one of the easiest courses for ELLs (Dale & Cuevas, 1992), math is nonetheless considered one of the more rigorous gate-keeping classes in which students must succeed (Tananis, 2001). In contrast to popular belief—this owed to math's reliance on numbers and symbols—math is not “culture-free” (Garrison & Mora, 1999). Math is intimately connected to aspects of language, including semantics, vocabulary, and syntax, and in fact, has its own language (Kessler, Quinn, & Hayes, 1990). This specialized academic language—also referred to as math discourse or math talk—is comprised of situated and specific forms, meanings, and usage.

Reform-oriented mathematics curricula are increasingly being used in schools throughout the nation. These curricula stress student-to-student interaction, critical thinking, and require ALL students to play more active roles. A consequence of this increased emphasis on interaction is that ELLs must produce more academic language in math class. Mathematical language is thus a central player in today's mathematics classes. In reform-oriented classrooms, students are no longer able to sit on the sidelines and quietly compute and calculate. Knowing, and being able to talk math is critical for ELLs and native speakers alike. As a result, engaged, active participation is mandatory for students to succeed in reform math classes.

This paper examines the practices by which two teachers encouraged newly mainstreamed, adolescent English as a second language (ESL) students, or ELLs, as well as recent exit bilinguals from Spanish-speaking backgrounds, to participate in class interactions. The study examines, in particular, students in math classes that use CMP, the Connected Math Project, a reform curriculum implemented throughout the U.S. CMP, based on the National Council of Teachers of Mathematics (NCTM) math standards, specifically addresses today's diverse school population by taking into account special needs of learners such as ELLs. CMP promotes the use of group work, strategies, manipulatives, and discovery learning and strives to make content meaningful and relevant to students' lives by framing math problems within interesting and motivating scenarios (Lappan, Fey, Fitzgerald, Friel, & Phillips, 1996). These scenarios attempt to make connections to adolescent culture and interest, thereby inspiring them to talk about, and ultimately, to learn math.

Research questions

The principal question that guides the present research asks: What do teachers do to encourage ELLs from Spanish-speaking backgrounds to participate in class interactions and discussions in math classes that use CMP? Two additional questions help to uncover a rich, descriptive, and multifaceted answer to this query:

- Which practices used by teachers (and that are embedded in the curriculum) work to invite ELLs into the mathematical community?
- What role does language and culture play in teaching reform math to ELLs?

Theoretical orientation

With a socioculturally-influenced theoretical orientation drawing from the community of practice (CoP) model, and in particular, highlighting the notion of participation, the study examines what teachers do to help ELLs become central members of a mathematical community. In effect, this paper explores the ways in which ELLs connect (and are connected with) the content they are learning in math. In the CoP, learning is seen as participation in shared practices, while participation is defined as engagement and individual accountability within a social practice and a group goal or task (Lave & Wenger, 1991). As group members work cooperatively, they engage in shared practices while working towards a group goal. The group goal referred to here is talk in and about mathematics.

As defined within the CoP, the three characteristics that define a community are mutual engagement, a joint enterprise such as a

task or activity, and a shared repertoire of negotiable resources (Wenger, 1998, pp. 72-73). These criteria must be met in order for participants to engage in learning. In the math classrooms that were involved in the study, the criteria were met.

In the reform-oriented mathematics classroom, students (member participants) work cooperatively (mutual engagement) on a task (joint enterprise) using mathematical discourse and the typical mathematical tools they are familiar with such as the text and manipulatives like graphing calculators, rulers, colored blocks or spinners (shared repertoire of negotiable resources). In the participating math classrooms that value interaction and problem solving as the backdrop for this research, the critical notion of participation is highlighted to understand how ELLs work together to construct knowledge in reform-oriented mathematics classes.

Talking math

Language constructed and produced during social interaction in school, such as that employed in math class, is a crucial element in understanding how and what ELLs learn with regard to mathematics, and how they come to see themselves as math “knowers.” Hicks holds that education standards such as those implemented by NCTM “invoke the notion that... children need to be able to ‘talk math’ in order to participate fully in the intellectual and social practices that characterize... (the) discipline” (1995, p. 51). It is therefore of vital importance to learn how teachers create the mechanism for making students feel entitled and inclined to engage in math talk within the classroom community.

While mathematical language is often considered precise and specific, with respect to vocabulary and linguistic constructions, it

is also thought to be a very situationally constituted discourse which develops through patterns of interaction in class (Brilliant-Mills, 1994, p. 302). Thus, the math discourse students must know is comprised of both grammatical and lexical competence, as well as the communicative competences needed to understand and negotiate math problems with others.

Methodology

The case study, qualitative in nature, was designed with an ethnographic perspective. Data were collected in two demographically similar middle schools, Hot Springs and Ritter², in Springvale Independent School District (SISD), a small, inner city school district in a Spanish/English bilingual community in the Southwest. These two schools were located in an urban area less than two miles apart and both enrolled just over 700 students. Latina/o students formed the majority of students, comprising 89% of the student population at Ritter, and 93% at Hot Springs (Greatschools.net). The student population of all of Hot Spring's students included 7.1% who were labeled as limited English proficient (LEP), and 5.4% of Ritter's were classified as such. Despite the relative proximity of the schools, over 95% of Ritter's students were considered economically challenged while 76% of Hot Springs' students fell into that category (Greatschools.net).

Within the two schools, two sixth grade math teachers who used CMP in their classes were chosen as participants. The schools and teachers were chosen as a result of both criteria and convenience sampling: of the schools in the district that were recommended by other researchers, the two that were selected

²As is common in educational research, these and all other names are pseudonyms.

were the ones that both used CMP and that allowed entry. Although the district mandated that the teachers use CMP, not all teachers used it to the same degree. The teachers' training and personal preferences contributed to their degree of use of the reform curriculum.

Of the two teachers, only Mr. Martinez (from Hot Springs) was bilingual and a member of the same urban community from which his students came. He was open about his dislike of CMP, and not surprisingly, he did not often use it. Mr. Martinez preferred a more traditional classroom environment where students practiced math individually or as a whole class. In interviews with him, he indicated that he felt the students in his classes learned better using a traditional approach. He also believed that CMP was not rigorous and did not promote the teaching of important math concepts the students needed to be successful. Ms. Koch (from Ritter) was recognized in the school district as an effective mathematics teacher. Active in the math community, she had presented at state and national conferences and had led seminars in the district. Of the two, Ms. Koch was better trained in CMP and consequently utilized more CMP in her classes. Both teachers, however, indicated the importance of connecting to their students and requiring some kind of participation from the learners.

In Mr. Martinez' second period class of 19 students, 3 were currently enrolled in language support classes (ESL), and 3 had recently exited from language support (ESL or bilingual education). Of the 3 in ESL, 2 were Spanish monolingual newcomers, having just that year entered an American school for the first time. The others had been in the U.S. for at least three years. In Ms. Koch's second period class of 22 students, 2 were currently enrolled in ESL classes and at least 2 others reported

speaking Spanish at home. The 2 in ESL had been in the U.S. for at least two years and had some degree of English proficiency.

Data for this project were collected during the regular school year. Data sources considered in this project include audio and video-recorded classroom interactions, observation notes, classroom artifacts including student produced work and tests, and student records such as grades and standardized test results, and formal and informal interviews with teachers addressing their use of and attitudes toward reform math.

Methods of analysis

Teacher practices were analyzed to determine how the teachers attempted to connect the content with the students and increase student participation in class. In order to do this, transcripts of classroom interaction collected over a school year, interviews with teachers, and curricular guides from the CMP manual were all examined. In determining which practices were used by the teachers, a comparison was made from what emerged in the data to known best practices such as sheltered instruction, an ESL methodology used in content classes, and from reform mathematics literature such as CMP guides and NCTM *Principles and Standards* (2000). From these data, categories were developed that represented the most common teacher practices that engaged students within lessons. Determination of student participation and engagement was based on active student involvement in the lesson and on-task behavior (as evidenced by use of math talk).

Findings

Four teacher practices were most successful in engaging ELLs

to discursively participate in class. To varying degrees, these practices worked to connect content to students' lives as well as to promote student participation in class. The four practices included the incorporation of frames of play, in which popular topics and themes such as basketball, pizza, and McDonald's were used to invite students into the discourse; an explicit, and almost daily emphasis on both modeling and eliciting language from students by defining and explaining critical terms, operations, and expressions in math through oral, and sometimes choral, teacher-led mini-reviews, as well as questioning, and revoicing student language; the use of the first language (L1) (Spanish); and the use of varied grouping structures. Table 1 outlines the practices.

Table 1. *Four Practices Used to Connect ELLs with Content, Discourse, and Community*

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| <ul style="list-style-type: none"> • Frames of Play (scenarios from CMP or teacher experience) • Emphasis on Academic Language (modeling/eliciting) • L1 Use (by teacher or students) • Varied Grouping (pairs/small groups/whole class) |
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The teachers and their classrooms

Ms. Koch

Ms. Koch is an innovative, enthusiastic teacher, well-versed in mathematical pedagogy and highly trained in CMP. She is European American and does not speak Spanish. At the time this research was conducted, she had taught for over 17 years and prior to her tenure as a teacher, was in the military. Although her teaching was characterized by regular group work (all students were seated at tables of 4-5 students) and almost daily use of

manipulatives and hands-on activities, Ms. Koch's class was extremely orderly and intensely rule-governed. Students weren't allowed to leave their seats without permission, nor were they permitted to speak unless they were instructed to do so by the teacher. As a result, some of her students considered her to be strict and even mean.

Mr. Martinez

Mr. Martinez was a friend to his students. The environment in his classroom was relaxed, jocular, and bustling with movement: students were constantly coming and going, sharpening pencils, and walking to the teacher's desk to ask questions. When the class was engaged in a lesson, it was almost always teacher-directed and teacher-centered. He can be considered traditional, as he organized his classes in straight rows, eschewed much of the innovation and reform in reform math, and preferred to assign seatwork to his students from the (not-CMP) state-adopted textbook. Mr. Martinez shared the students' L1 and ethnicity—he is Latino and Spanish-speaking and often used Spanish in his classes. Since he lived in the same neighborhood as his students, he made regular reference to community landmarks and institutions, for their utility in elucidating mathematical concepts. Prior to teaching, Mr. Martinez was a contractor. He was a veteran teacher, having spent over 17 years in the classroom. Teacher practices used by both Mr. Martinez and Ms. Koch will be discussed in the following section.

Teacher practices

Frames of play

Both teachers used frames of play³ to some extent to motivate

³ See Chapter 4, Hansen-Thomas (2009a) for an extensive discussion of frames of play.

the students and promote participation. Frames of play are defined as interesting and motivating, but imaginary, or play scenarios used to help learners understand and engage expansively in math⁴. To be sure, not every example used in class can be called a frame of play. In some cases, the example scenarios included in the texts or in the teacher's own discourse are just that: examples used to illustrate the mathematical concepts presented in the lesson. Using slices of pizza to demonstrate fractions does not automatically count as a play frame, but when a scenario or example piques the interest and motivation of learners to encourage them to produce academic language characterized by in-depth and higher order thinking, it can be termed, or utilized as a frame. Frames work within CMP lessons to provoke discussion, interaction, interest, motivation, and problem solving in math.

The units that were covered in the spring term were those which encompassed fractions and probability in the sixth grade CMP textbook series (Lappan, Fey, Fitzgerald, Friel, & Phillips, 1998, 2002a, 2002b). These included *Bits and Pieces I* (Lappan et al., 2002a), *How Likely Is It?* (Lappan et al., 1998) and *Bits and Pieces II* (Lappan et al., 2002b). Within these units, learners engaged in a number of roles which framed the fraction or probability lesson presented by the teacher. Those roles dictated by the curriculum included the following: builder, cat specialist, basketball/sports analyst, gambler/scratch-off card player, restaurant customer, breakfast cereal analyst, mathematician (one who measures and calculates), researcher (who conducts experiments and knows critical information like the outcome of an

⁴ From *English Language Learners and Math*, by H. Hansen-Thomas, 2009, Charlotte, NC: Information Age Publishing. Copyright 2009 by Information Age Publishing, Inc. Reprinted with permission.

experiment in probability will be facilitated by an increased number of trials), team player (who works well in a group), and problem solver.⁵ Table 2 shows the frames roles used in CMP-framed lessons throughout the spring semester.

Table 2. *Frames in CMP Fraction Units*

Mr. Martinez	Ms. Koch
<i>Bits and Pieces I</i>	<i>How Likely Is It?</i> <i>Bits and Pieces II</i>
Sports/basketball analyst Mathematician	Researcher Basketball/football analyst Gambler/guesser of odds Restaurant customer Breakfast cereal analyst Mathematician

Note. Adapted from *English Language Learners and Math*, by H. Hansen-Thomas, 2009, Charlotte, NC: Information Age Publishing. Copyright 2009 by Information Age Publishing, Inc. Reprinted with permission.

The frames included in the sixth grade CMP texts are used to encourage and motivate students to think about mathematical concepts in ways they might not have before. For example, the CMP text on probability (*How likely is it?*) introduces a boy named Calvin. Throughout the several weeks-long probability lesson, students learn how this eighth grader uses his knowledge of math, and in particular, chance, prediction, and theoretical probability, to

⁵ From *English Language Learners and Math*, by H. Hansen-Thomas, 2009, Charlotte, NC: Information Age Publishing. Copyright 2009 by Information Age Publishing, Inc. Reprinted with permission.

negotiate not only better (more sugar-laden) breakfast cereal, but also an even later bedtime.

By virtue of the CMP curriculum's theme-based lesson presentation, a variety of frames were used in class. In addition to the frames of play anchored in the texts, frames of money, food, building, and playing a variety of games were also often used in class. Some of these other frames were introduced along with the lesson in the CMP text, such as playing roller derby, calculating the bill at a restaurant (after having the opportunity to order one's own meal and dessert selections), or being able to buy desired goods and calculating the additional money one needs to save to purchase the item(s). When the scenarios from the texts were not appropriate or interesting to the students (e.g., calculating the effectiveness of a cat's mouthwash), or in the case that the teachers did not utilize the texts, the teachers drew from their own experience to connect to the students' interest and encourage participation. Overall, both teachers used a number of frames to help the students understand fractions.

Table 3: *Teacher Produced Frames in Fraction Units*

Mr. Martinez	Ms. Koch
Teacher/peer tutor	Game player
Problem solver	Problem solver
Pizza eater	Team member
Engineer/carpenter	Money manager

Note. Adapted from *English Language Learners and Math*, by H. Hansen-Thomas, 2009, Charlotte, NC: Information Age Publishing. Copyright 2009 by Information Age Publishing, Inc. Reprinted with permission.

Grouping and use of LI

The most common grouping structure in Mr. Martinez' class was that of whole class grouping. Since the students in his class were arranged in rows, they all faced the front and the overhead projector. During direct teaching, Mr. Martinez would conduct lessons sitting front and center in the room and work out problems at the projector, eliciting assistance from students, or read from a text, involving those students who were engaged in the lesson. Very rarely were students instructed to work in pairs or small groups. However, if time allowed for homework to be completed in class, Mr. Martinez would permit students to work together.

Much of the Spanish that was used in Mr. Martinez' class was used by the teacher himself when directly teaching whole class lessons. In those cases in which time allowed for students to work together to clarify problems or questions, they would. Thomas, the most outgoing and verbal bilingual student who was also very strong in math, would help others on the rare day that the teacher allowed the students to work in groups. Although Thomas indicated he spoke only Spanish at home, he would almost never use Spanish when assisting other bilinguals and ELLs.

Grouping played an important part in facilitating student participation and connection to content and academic mathematical language in Ms. Koch's class. She employed a wide range of grouping configurations, including whole class, small groups, and pairs. In this class, the students would interact in several different arrangements throughout the course of a period. As they entered class, the students usually worked on a warm-up activity in small groups, then Ms. Koch would conduct a whole class lesson to introduce them to the day's lesson and task. After the students had been given their instructions for the task, they would return to their

small groups to work cooperatively.

Ms. Koch did not speak the same L1 as her students, but she allowed and encouraged use of Spanish in small group interactions. She made a conscious effort to seat bilinguals at the same table as ELLs so they could help each other comprehend the content and language. She also kept Spanish language resources such as dictionaries and math texts in her classroom as a tool for the limited ELLs and monolingual Spanish speakers. However, it was during small group interactions when most of the L1 use was employed in her class.

Discussion

Both teachers utilized practices that were effective in engaging and connecting their ELLs to the mathematical content and language they needed to know to be successful as sixth graders. Some of the practices were built in to the reform-oriented CMP curriculum, including the use of varied grouping structures, as employed in Ms. Koch's class, and the frames of play that contextualized the fraction and probability lessons in both Ms. Koch and Mr. Martinez' classes. Other practices emerged through the teacher's background and experience. In general, Ms. Koch's practices hailed from her use and experience with CMP, while Mr. Martinez' practices stemmed from both his ethnolinguistic background and his long experience as a teacher.

Use of the ELLs' L1, Spanish, was incorporated in both classes, but in differing ways. By virtue of the heterogeneous small grouping in Koch's class, the ELLs had abundant opportunities to interact using Spanish as a tool to facilitate their comprehension. Spanish was also used in Martinez' class, but it was often by the

teacher only. It is quite likely that Mr. Martinez believed he was in fact meeting the linguistic needs of the ELLs and more reticent bilinguals in his class through his use of Spanish; however, many of the language learners who could have benefited from having Spanish as a learning tool weren't able to utilize the tool due to lack of discursive opportunities.

However, there exists a silent period (Krashen, 1995) in second language acquisition in which beginning learners do not say, or rather, produce much language. Second language acquisition theory suggests that in this period ELLs are actually absorbing language and linguistic rules. Mr. Martinez' lack of elicitation, or calling on students to participate and use language, might then be considered beneficial, at least for the two Spanish dominant newcomers in his class. Many of the other students in his class, some of the other ELLs and bilinguals, as well as the quiet and less mathematically strong students, likely did not benefit from not being required to be actively engaged in the classroom language and content.

In general, while both teachers used some linguistic practices, including modeling and eliciting of mathematical discourse to engage participation in the community of practice in each of the classes, their implementation of these practices resulted in differing opportunities for ELLs. In Ms. Koch's class, students were regularly encouraged to practice the discourse. This practice was manifested through oral responses to explicit, focused teacher questions posed within mini-lessons, and choral responses of mathematical vocabulary and definitions. While Mr. Martinez also interacted one-on-one with some of the ELLs and bilinguals in his class, using focused questions and recasting to elicit student input, he did not provide the majority of the language learners with many

opportunities to participate in and demonstrate their comprehension and mastery of the mathematical language.

While both teachers used particular practices that were comfortable to them with respect to their teaching style and background, more of the practices used by Ms. Koch were, in general, more effective at promoting participation of the language learners in these two classrooms. This claim is based on data triangulated through student assignments, test scores, observations, and teacher and student interviews. Not only did the ELLs in Ms. Koch's class succeed on both traditional and non-traditional measures of success including standardized and classroom test scores, homework, but they also performed well on oral classroom interactions (insofar as they successfully answered teacher questions and small group interactions). In Mr. Martinez' class, only the two most outgoing bilinguals generally interacted in class discussions, and only one succeeded on both traditional measures of success and oral interactions in the classroom. The other language learners did not demonstrate that they were connected to the content, discourse, nor were they overly enmeshed in the classroom CoP.

With respect to language and culture, it was clear that both teachers worked to include the ELLs' and bilinguals' backgrounds in their lessons; however, the role of language and culture varied depending on each of the teacher's personal backgrounds and teaching style and experience. In the case of Ms. Koch, she did not share ethnicity or a home language with the students, but her training in CMP helped to connect students' interest and ultimately produce learning. She allowed student interaction, which worked to increase connections with the content, mathematical discourse, and interactions with the CoP in the classroom. Mr. Martinez did,

on the other hand, share the students' ethnicity, home language, and even knowledge of the local community. While these shared factors were indeed very useful in connecting to some students -- especially those who were outgoing and had proficient math skills -- it was not enough to connect to the more limited ELLs and bilinguals. Those students simply did not have adequate opportunity to interact with others to utilize their knowledge of math skills and arguably, more importantly, math language. Ultimately, those students did not become central members of the community of practice in their classroom, due to a paucity of opportunity. They remained quiet, disengaged, and unable to keep up with the work in class not only in English, but often also in Spanish.

Conclusions and implications

Overall, both teachers did in fact utilize good, effective practices to connect with the ELLs in their mainstream math classes. They both used modeling of standard academic language, provided opportunities for L1 use, incorporated frames of play, and used some varied grouping structures. But because Ms. Koch worked to incorporate more students into the academic language and content, by using her entire arsenal of effective practices much of the time, she was generally more successful in connecting to students. On a daily basis, Ms. Koch arranged students in small groups and encouraged students to work in pairs, small groups, and whole class arrangements. She used frames of play from the CMP lessons as well as from popular culture, and she emphasized math language and literacy. In the end, the ELLs in Ms. Koch's class were both engaged, or connected to the mathematical content and

language, and drawn into socially-constructed interaction in class.

Mr. Martinez, on the other hand, made connections to the students' lives, used their L1 as a tool to facilitate comprehension, and even used academic language himself to invite students to use the academic discourse. The fact that he shared ethnicity, language, and even background knowledge with the majority of the students in the class was a highly valuable resource that served to incorporate some students who may otherwise have been relegated to the periphery of the classroom community. The most overt problem with respect to interaction in Mr. Martinez' class was that he often failed to provide ALL students with opportunities to use academic language and engage in interaction. A handful of capable students leading discussions, coupled with a lack of opportunities for interactive group work, resulted in fewer students participating in the community of practice, and ultimately, fewer connecting with math talk. To maximize Mr. Martinez' strengths, and to connect more ELLs, he could utilize appropriately formed groups where limited ELLs work with highly knowledgeable bilinguals on content tasks. Utilizing only this small strategy could work to incorporate those students who lacked opportunity to practice math talk and demonstrate their knowledge. In so doing, he would not have to compromise his beliefs regarding how his students best learn, but rather, simply modify his practice in a small, but meaningful way.

The literature on effective strategies and best practices in ESL education is thorough. The practices that Ms. Koch and Mr. Martinez utilized in their classes are components of, for example, sheltered instruction (Echevarria, Vogt, & Short, 2010). But it is also known that teachers cannot and should not simply eliminate those teaching practices that are less parallel with what has

previously been comfortable as part of a teaching style. Doing so can result in a loss of opportunities for students who may truly need them.

An important implication that can be drawn from this study is that while shared ethnicity, language, and culture is extremely important to engaging ELLs in content participation and situated academic language, it *alone* is not enough. Teachers must also encourage student participation by actively involving learners in the content-specific language within the classroom community. Thus, through use of appropriately constructed methodological strategies, including of frames of play and grouping *as well as* drawing on cultural and linguistic tools such as the use of L1 and the use of academic language to model and elicit student interaction, math teachers have a simple and effective algorithm with which to encourage ELLs' participation in their classes.

Recommendations for teachers to help ELLs connect in (reform-oriented) math classes:

- Incorporate the students'
 - Home culture and language (can be done even if teachers do not share it!)
 - Prior knowledge of mathematics.
 - World and local community knowledge.
- Provide opportunities for ALL students to
 - "Play" math.
 - Work together.
 - Hear standard math language.
 - Be silent (sometimes).

BUT ALSO

- Produce and use math talk.
- Understand that ELLs

- May not have the background knowledge (of math, the world, or language) to be able to work problems alone.
- Working in well-constructed, linguistically heterogeneous groups may be able to learn language and content from each other.
- Need opportunities to practice not only academic, but linguistic content.
- Who are very limited in English may not be able to produce language, but will benefit from seeing, reading, and hearing the standard forms.
- Need exposure to not just a few effective teaching practices, but many!

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