

## ACCOMMODATING THE ENGLISH LANGUAGE LEARNER IN MATHEMATICAL DISCUSSIONS

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*This study explores the communicative accommodation strategies employed by a bilingual tutor and an ELL student during the discussion of word problems involving secondary algebra and geometry concepts. Mathematics discussions are conceived as communicative events wherein ELL student comprehension is promoted through provision of simplified linguistic input. The reported findings reveal that ELL student accommodation entails multiple dimensions, taking multiple (non)verbal forms with varied degrees of orientation toward language versus ideas and relative focus on literalness versus metaphoricality.*

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There is growing interest among mathematics educators in helping English Language Learners (ELLs) overcome the complex linguistic demands of mathematics instruction and promote their participation in mathematical discussions as legitimate members of the classroom community. To help mathematics teachers attain this goal, educational researchers have identified a variety of strategies. Mostly anecdotal in nature, this literature falls short of providing mathematics educators with more sophisticated, theory-based understandings of how to effectively accommodate the communicative needs of ELL students. Teachers in the lower-grade levels have also incorporated a variety of means to communicate mathematics and science content to ELL students. Commonly found in practitioner journals, this literature identifies a wide variety of communicative strategies that elementary and middle-school teachers can adopt in their own classrooms. Few strategies are identified specifically for teacher adoption at the high-school level.

In the present inquiry, we set out to attend to the above limitations in the mathematics education literature by using accommodation theory, drawn from the field of communication, to explore communicative strategies employed by bilingual speakers to construct meaning during the discussion of word problems involving secondary algebra and geometry concepts. More specifically, we tackle the following research question: What accommodation strategies do a bilingual tutor and an ELL student adopt to overcome comprehension problems and communicate effectively during discussion of mathematics word problems? In the following section, we discuss our theoretical perspective.

### Accommodation Theory

Drawing on theoretical and empirical work from the field of communication, we conceive of mathematics as a school subject whose communication requires mastery over a specific *register*, that is, a specialized subset or context-specific variety of language (Saville-Troike, 2003). Furthermore, mathematics word-problem discussions are viewed as dyadic communicative events, wherein a bilingual tutor (treated as a “native speaker” of the language of mathematics) facilitates the interpretation of complex written input by an ELL who is also a “non-native mathematics speaker” with limited proficiency in the mathematical register. To make communication possible and

overcome potential comprehension challenges, the tutor supports the novice learner by contextualizing input, making it more easily understandable or interpretable (Gibbons, 2003). Expert communicators interpersonally adapt (Burgoon, Stern, & Dillman, 1995) to their recipients' communicative abilities, leading toward a more accessible learning experience for ELL's (both in message understanding and reciprocation) (Hatch, 1983).

Scholarly efforts to analytically account for speakers' tendency to make speech adjustments such as accentual modifications in interpersonal encounters have been heavily influenced by *speech accommodation theory* which, according to Street & Giles (1982), posits that "people will attempt to converge linguistically toward the speech patterns believed to be characteristic of their recipients when they... desire a high level of communicational efficiency" (p. 213). When successful, such accommodation and mutually influential behavior results in the reduction or elimination of language barriers as well as proclivity toward *communicative convergence* or similarity in speakers' ways of talking (Ireland et al., 2011), typically being well received (i.e., positively evaluated) by listeners.

In the present study, we conceive of mathematics discussions as communicative events wherein a mathematics tutor strategically incorporates verbal and nonverbal accommodation. As Allen (2000) points out, "teachers who use the FL [Foreign Language] as the language of instruction typically make both verbal and nonverbal accommodations to facilitate learners' comprehension of the language" (p. 155). By combining accommodation talk and gestures, the tutor draws on the student's current understandings and experiences as resources (Moschkovich, 2002) for comprehension of the textual contents of mathematics word problems.

A variety of strategies have been identified to promote ELL students' mathematical literacy, knowledge, application, and skills. This literature points to multimodal instruction (the combined use of multiple modes of communication) as an effective means to accommodate ELL students. However, how such multimodality can be systematically designed and implemented by mathematics teachers is not completely clear. Further research is necessary in the area of multimodal mathematics instruction to clarify exactly how it can benefit ELL students and foster mathematics learning. As argued by Chval & Chavez (2012), teachers' use of multimodal strategies must be "purposeful... [and] target the development of language and mathematics for the ELLs in their classroom" which is not a task to be taken lightly; it is a task that "requires thoughtful conversations and planning" (p. 265).

### Methodology

In order to explore the potential of multimodal dynamics in support of ELL mathematics learning, we conducted a microethnographic case study of tutor-student interactions. This particular inquiry adopted a qualitative research approach, a phenomenological underpinning, and aligned with socio-constructivist perspectives on human interaction (Robson, 2002). Patton (1990) states that case studies are used when "one needs to understand some special people, particular problems, or unique situation in great depth..." (p. 54). Our phenomenological orientation reflects our concern with participants' first-hand experience of a communicative phenomenon, namely accommodation. This case was explored through descriptive data systematically collected through open-ended research methods (video-recorded observations) and analyzed inductively to build a naturalistic account of a bilingual tutor's accommodation strategies when discussing mathematics word problems with an ELL student.

Our dataset was composed of ten hours of video-recordings of bilingual exchanges (Portuguese/English) between one of the authors (Alan Oliveira) and a female ELL student (Cassie) during one-on-one mathematics tutoring sessions. The curricular material was written exclusively in English, while the discussions were bilingual with Portuguese as the dominant language, the predominantly used linguistic code (Saville-Troike, 2003) in the oral mode of communication. As such, our video-recordings offer a unique opportunity to examine discourse strategies deployed by a

bilingual tutor to accommodate an ELL student's communicative needs and hence enable her to participate, by drawing on her bilingual capabilities, in mathematical word problem discussions involving secondary algebra and geometry concepts.

To examine accommodation strategies adopted by the mathematics tutor and ELL student to promote comprehension, we first transcribed the video-recordings of the tutoring sessions and then conducted a *microethnography*, a study of language-mediated social interaction in minute detail through an up-close and exhaustive examination of how people use language and other forms of communication to realize the social work of their daily lives (Erickson, 1996). Gee and Green (1998) define it as “a research language that describes the ways members of a social group construct the structures of daily life” (p. 132).

Our microethnographic analysis was conducted at the level of *episodes* or *key cultural scenes* (Erickson, 1996); short stretches of naturally occurring discursive interactions (tutor-student dialogues) with variable number of utterances. This microethnographic analysis initially revealed a recurrent, three-stage pattern in the bilingual problem-solving approach: aloud translation, mathematical transcription, and mathematical calculation. More specifically, the tutor and ELL student first translated each word problem aloud from English to Portuguese, then transcribed the word problem into an equation or diagram (drawn on a large whiteboard in front of the classroom), and lastly made their mathematical calculations both orally and in writing. Based on this initial finding, a written report was then produced describing and illustrating the tutor's main accommodation strategies in each of the three different stages of their bilingual problem-solving approach.

Multiple strategies were adopted during data collection and analysis to ensure validity and reliability. First, our approach to data collection was aligned with a tradition of educational research known as *action research* (Lewin, 1946). As the mathematics tutor facilitating the discussion, Alan was actively involved with the phenomenon being researched. This ensured familiarity and an insider perspective on the bilingual context of instruction. Second, *peer debriefing sessions* with external researchers (not directly involved with the tutoring sessions) were frequently held during data analysis, wherein key scenes were examined collectively, individual analyses shared, and interpretations discussed extensively. The emergent account was gradually adjusted to include any variation that surfaced from this reflective group interpretation. These sessions were frequently held to triangulate emerging interpretations of the data and guard against individual researcher biases (Robson, 2002).

### Findings

We now describe and illustrate general patterns which occurred during the bilingual problem-solving. Attention is given sequentially to accommodation strategies adopted during three different phases: aloud translation, mathematical transcription, and mathematical calculation.

#### Aloud Translation

Accommodation in this initial phase of the bilingual problem-solving process took various forms, verbal and nonverbal. Its main aim was to fill gaps in the ELL student's vocabulary that became evident when she was unable to orally translate a particular word problem from the source language (English) to the target language (Portuguese). The two main accommodation strategies deployed to ensure student comprehension of the written content of linguistically complex word problems were *literal translation* (i.e., explicit word-for-word translation of unknown terms) and *borrowing* (taking words from a source language when no equivalent exists in a target) (Fawcett, 2003). One instance of borrowing occurred when Cassie encountered difficulties translating the words “nickels” and “dimes,” two words for which there are no one-to-one equivalent translations in Portuguese which compromised her ability to demonstrate her knowledge of mathematical meaning.

Upon noticing Cassie's inability to demonstrate her knowledge of the mathematical meanings associated with the two English words "nickels" and "dimes," Alan interjected by posing a *confirmation check* (Long & Sato, 1983), a type of question whose main function is to check whether students have understood previous discourse. His query "You do know that each coin in the United States has a name, right?" is multifunctionally designed, in the sense that, it serves not only as a request for the student to explicitly confirm her comprehension, but also as a source of critical cultural knowledge for the student to comprehend the book writer's intended meanings (i.e., it is both a prompt and a hint). This cultural hint is then elaborated upon by Alan who proceeds to disclose the mathematical meanings behind each term used for informal reference to particular coins in English. Despite the unavailability of equivalent terms for "nickels" and "dimes" in Portuguese, Cassie is then able to successfully perform her aloud translation of the problem through borrowing.

Nonverbal accommodation during aloud translation took the form of *deictic gestures* (McNeill, 1992). More specifically, Alan used his index finger to point to objects nearby and designate the contextual location of the referent of unknown words or expressions. This particular accommodation strategy was deployed when Cassie experienced difficulty translating the expression "minute and hour hands of a clock;" he reacted by pointing with his index finger to the clock in the back of the room. Cassie's difficulty stems from the fact that Portuguese speakers use the word "ponteiros" which literally translates into English as "pointers." However, rather than simply providing Cassie with a direct translation of the non-literal meaning of the word "hands," Alan encourages her to independently deduce its meaning from direct examination of a real clock in the immediate classroom context. His pointing serves as an *illustrator*, that is, a type of gesture designed to physically illustrate the meaning of accompanying speech (Burgoon, Buller, & Woodall, 1989). By withholding and delaying his provision of a direct translation ("A pointer is what he is talking about"), Alan encourages Cassie to actively and independently translate words based on the available information, context, and her own experience rather than being passively told its meaning in the target language.

### **Mathematical Transcription**

Verbal accommodation in this second problem-solving stage took the form of *simplified rewording*. Because issues with translation had already been handled at this point, verbal accommodation typically took the form of restatement within the target language, as opposed to word transposition across languages. A good example of this form of accommodation took place during mathematical transcription of a problem which involved comparing line segments in a given ratio on the same line. Although Cassie had already been able to translate the word "respectively" into its Portuguese equivalent "respectivamente" without any problems, she had difficulties demonstrating that she had a clear understanding of the meaning of this term during mathematical transcription of the word problem into a geometrical diagram. This was evident during an exchange in which Cassie described how the diagram should be drawn.

By successfully translating the word problem aloud, Cassie initially gives the impression that student comprehension has occurred and teacher accommodation is not needed. However, when Alan probes further by prompting Cassie to describe how to mathematically transcribe the word problem, it becomes apparent that she does not comprehend the meaning of the word "respectively" as used in the mathematical register. This lack of comprehension becomes particularly evident when Cassie fails to successfully answer Alan's query "so, M and N respectively, so M is whose midpoint?" By re-articulating the word problem in everyday Portuguese terms, Alan provided Cassie with simplified input, thus accommodating the student's communicative needs not only in English but also in the mathematical register in her own native language.

Nonverbal accommodation during mathematical transcription took the form of *iconic gesticulation* (McNeill, 1992), that is, hand gestures that shared some sort of spatiotemporal correspondence (e.g., trajectory, direction) with abstract ideas or processes being representationally



communicated. This visual form of accommodation was deployed by Alan when he sought to help Cassie comprehend why the mathematical statement “the length of each side of a square (represented by the letter L) is 3 more than the length of each side of a regular pentagon (represented by the letter P)” was correctly transcribed as “ $L = P + 3$ .”

Alan uses his arms and hands to iconically express mathematical equality in terms of vertical spatial relations (up/down). Through his arm movements equality is spatialized as a state wherein both his hands (each representing one side of a mathematical equation) are at equal heights. Achieving this state requires either lowering the higher hand (i.e., subtracting three units from one side of the square) or raising the lower hand (i.e., adding three units to one side of the pentagon). Alan’s iconic gesturing provides an image of mathematical equality, a conception with which Cassie seems to be struggling.

### **Mathematical Calculation**

Verbal accommodation in this final phase also included deployment of simplified rewording within the target language. For example, while calculating the angles in a geometrical diagram Alan noticed that Cassie attempted to do her mathematical calculations through visual inspection despite the note “figure not drawn to scale.” Despite being able to translate the mathematical expression “not drawn to scale” aloud, Cassie’s subsequent actions (in this case mathematical calculation) reveals that she has not in fact comprehended the message, leading Alan to restate the mathematical register in simpler layterms she can more easily comprehend: “it’s just a little scheme, it’s not measured” and “it’s not measured, they did not measure it carefully.” A very similar instance was observed in a different problem with the mathematical word “adjacent,” which was first translated aloud by Cassie as “adjacente” (its Portuguese cognate) and later simplified by Alan (also in Portuguese) as “near, side-by-side” and “right by one’s side.” In both instances, student comprehension entailed literal translation as well as simplified rewording within the target language. Put differently, literal translation did not always suffice as a means to accommodate the ELL student’s communicative needs, especially when dealing with academic or mathematical words. Because this lexicon is not commonly found in everyday parlance, ELL students may occasionally hear it and yet not fully understand its specialized meaning within the mathematical register.

During mathematical calculation, there was also noticeable instances of combined verbal and nonverbal accommodation, usually in the form of *conceptual asides* – brief interruptions in the normal course of mathematical calculation to fill gaps in the student conceptual knowledge. One particularly interesting conceptual aside took place during discussion of a problem where the length of two of the sides of a triangle was provided. Upon noticing that Cassie lacked familiarity with the triangle inequality theorem, Alan interrupted the mathematical calculation to provide a conceptual aside. Rather than simply telling Cassie what this mathematical theorem formally states (i.e., that the sum of the lengths of two sides of a triangle must always be greater than the length of its third side) or the correct inequality for the given triangle, Alan engaged Cassie in a short discussion about a generic triangle drawn separately from their ongoing mathematical calculations. Not only is the triangle inequality theorem communicated in simple lay terms, but it is also made visually accessible through metaphorical spatialization, thus accommodating Cassie’s communicative needs and ensuring her comprehension.

### **Discussion**

The reported findings reveal that teacher accommodation of ELL students entails multiple dimensions. In addition to taking varied (non)verbal forms (the previously known dimension Verbal–Visual), accommodation can also be analytically placed along two additional continua (Linguistic–Epistemic and Literal–Metaphorical), depending upon their degree of orientation toward language versus ideas and the relative focus on literalness versus metaphoricity, respectively. These two additional dimensions are discussed below.

### **Linguistic and Epistemic Orientation**

Our findings revealed that tutor accommodation during bilingual problem solving had varied degrees of linguistic and epistemic (conceptual) orientation. These varied degrees were evident in the fact that the tutor's accommodation strategies were sometimes more focused on promoting ELL student comprehension of linguistic meanings (the textual contents of word problems) than on mathematical meanings (mathematical concepts or ideas encompassed in the word problem or required for its resolution). At other moments, the primary focus was on mathematical meanings while linguistic meanings remained secondary. Linguistically-oriented accommodation was characterized by an English-Portuguese focal alignment, wherein the tutor took on the role of a foreign language educator who helped the ELL student comprehend a word problem by explicitly establishing semantic equivalence (House, 1997), that is, identifying equivalent words in the target language. This type of accommodation invariably entailed *code switching* (Saville-Troike, 2003), strategic interlinguistic changes from English to Portuguese, typically taking the form of "label quests" (Martin, 1999).

By contrast, epistemically-oriented accommodation strategies had a Portuguese-Mathematics focal alignment, typically entailing *register switching*, intralinguistic changes from an academic to a conversational register (Cummins, 2000) within the same language (Portuguese). By strategically rewording academic and nonliteral mathematical words, the tutor assumed the role of a mathematics teacher who sought to help a mathematics learner comprehend specialized mathematical meanings needed for accurate mathematical transcription and calculation. Accommodation strategies with such epistemic orientation were aimed at enhancing the ELL student's conceptual knowledge (as opposed to improving her English proficiency). It is clear from this literature and our findings that effective ELL accommodation needs to be more focused on language meaning than language form, and that attention to conceptual understanding, in either the ELL student's first or second language, is necessary for academic achievement.

### **Literal and Metaphorical Accommodation**

Previous educational efforts aimed at accommodating ELL's communicative needs have been limited to student comprehension of literal input, for the most part overlooking the need for more metaphorical forms of accommodation. This tendency to focus accommodation of ELL students on the concrete is particularly evident in mathematics educators' frequent use of manipulatives (Fernandes, 2012), science educators' deployment of pictorial and replica models (Buck, Mast, Ehlers, & Franklin, 2005), and language educators' use of realia (real artifacts or cultural objects) (Ash, Tellez & Crain, 2009). However, as it pertains to mathematics instruction, such a trend is problematic in the sense that it is inconsistent with current scholarly work in the field of cognitive science which has highlighted the centrality of metaphoricity to mathematical thought and revealed the underlying metaphorical structure of basic mathematical ideas. The present shows how metaphorical accommodation in mathematics instruction can be effectively accomplished through strategic deployment of iconic gesticulation. More specifically, we found that iconic gestures served an important accommodation function during mathematical transcription and calculation, metaphorically structuring abstract mathematical concepts of algebraic equality and representing the triangle inequality theorem in nonliteral space. Such a finding is consistent with existing research showing that professional mathematicians use iconic gesturing to make metaphorical mathematical meanings more accessible and comprehensible to others (McNeill 1992) and that non-native language learners can effectively employ gesticulation to overcome communicative difficulties by compensating and eliciting help in the course of multilingual exchanges (Gullberg, 2011).

### **Significance and Future Research**

The main significance of the present study is that it introduces a theoretical framework for systematically examining ELL student's comprehension in mathematical discussion. The present

study increases the linguistic diversity of this research base by focusing on Portuguese. Our findings also have practical significance for classroom instructors of mathematics. In essence, the reported tutoring practices underscore how effective accommodation for ELL students during mathematical discussion requires continuous assessment of student comprehension. Such finding is consistent with the available literature which clearly shows that tutors, teachers, and peers successful in assisting ELLs are consistently attentive, noticing and adjusting to (mis)understanding as they go (Gerena, 2012). Rather than recurrently resorting to a single communicative strategy, the tutor deployed a variety of techniques as he continuously assessed and adapted to the ELL student's ability to comprehend the contents of mathematical discussion.

The reported findings point to potentially productive direction for future research. Evidence exists that many mathematics teachers lack awareness of the central role of language in mathematics learning as well as the importance of making linguistic accommodation for ELL students (Fernandes, 2012). In a similar vein, Echevarria, Vogt and Short (2008) point out that few content teachers receive in-service training on how to effectively teach ELLs and very few pre-service teacher education programs include instruction on teaching this rapidly growing student population. Such a state of affairs suggests a need for teacher educators to facilitate professional development that can make mathematics teachers more aware of the multiple dimensions of linguistic accommodation and use these dimensions as guiding principles for systematically designing and implementing mathematics instruction that can effectively promote ELL student comprehension of mathematical principles and concepts in their classrooms.

The present study takes a first step in this direction by identifying several strategies that mathematics teachers can potentially combine for the purpose of accommodating students in larger classroom settings. Nonetheless, despite this valuable initial insight, further analytical consideration will need to be given to how the identified strategies can be effectively integrated by teachers to promote multilingual accommodation in regular mathematics classrooms.

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