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Abstract: The student population in the U.S. and worldwide is becoming increasingly diverse, creating a need to support *all* learners, especially linguistically and culturally diverse subpopulations such as English language learners (ELLs). From a social equity standpoint, the need to support these learners is critical especially in mathematics classrooms. In the U.S, the demand for mathematics teachers who are adequately prepared to teach ELLs has in fact risen. Yet, little is known about what knowledge base is essential to teach mathematics to ELLs. Driven by the need to explore this knowledge base, in this paper I explore what is involved in reasoning about teaching mathematics to ELLs. To this end, a set of instructional scenarios illustrating the work of teaching mathematics to ELLs was utilized within an assessment environment. Interviews with 10 mathematics teachers reasoning about the scenarios showed that they drew on the information provided about ELLs' proficiency levels while reasoning through the scenarios. Also, teachers' reasoning seems to be qualified by the extent to which they could both use their content knowledge in mathematics and modify their instructional choices according to ELLs' language needs specified in the scenarios. This study motivates large-scale future studies examining what systematic teacher knowledge base might differentiate good teaching for ELLs from good teaching for *all* students.

Key Terms: Teaching mathematics, English language learners, teacher knowledge base, and instructional scenarios.

Introduction

As the student population in U.S. classrooms becomes increasingly diverse, it is critical that all teachers develop the knowledge and skills to support English language learners (ELLs) in mainstream classrooms at every grade level. However, the majority of teachers are not adequately prepared to teach academic content to ELLs (Lucas & Villegas, 2011). Mathematics may be especially challenging for ELLs (Martiniello, 2008). The National Assessment of Education Progress (NAEP) mathematics test results in 2013 (United States Department of Education, 2015) showed that the achievement gap between non-ELL and ELL students both at the 4th and 8th grades did not significantly differ from the achievement gaps reported in previous years in 2011, 2009, 2000, or 1996. Challenges in learning mathematics might preclude access to mathematical and scientific fields, which raises a critical issue of equity (Moschkovich, 2002; Oakes, 1990; Secada, 1992). Teachers play a key role in leveling the playing field for ELLs in mathematics (Moschkovich, 1999; Secada, 1998). However, there is a clear gap between the demands of teaching ELLs and the supply of mainstream mathematics teachers who are

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adequately prepared to teach (Ballantyne, Sanderman, & Levy, 2008). As the ELL population has increased up to 10% of public school students (National Clearinghouse for English Language Acquisition, 2011), the demand for trained mathematics teachers has as well; many, if not most, teachers need to develop the knowledge and skills needed to teach in classrooms with increasingly diverse populations of students.

Despite the need, little is known about the knowledge base needed to teach mathematics to ELLs. Recent conceptualizations of the teacher knowledge base (Ball, Thames, & Phelps, 2008) have not addressed how manifestations of it change depending on who the students in the classroom are and what they bring to the learning experience. To inform research on the teacher knowledge base, most of the existing scholarship on educational linguistics (de Oliveira & Cheng, 2011; Fang, 2006; Lucas, Villegas, & Freedson-Gonzalez, 2008; Schleppegrell, 2001) suggests that language is central to teaching mathematics and that mathematics teachers, even at the secondary level, should know how to identify the linguistic demands in the mathematical content and model mathematics-specific language use. This line of work suggests that language serves as a medium to understanding and communicating the content in mathematics, which in turn is central to the work of teaching mathematics to ELLs.

However, our understandings as to what this knowledge base entails and how it gets or should get enacted in mathematics classrooms are limited. To better understand the knowledge base and reasoning involved in teaching mathematics to ELLs, eliciting teachers' reasoning around particular scenarios formatted in an assessment environment might help. As research (Ball & Hill, 2008; Jacobson, Remillard, Hoover, & Aaron, in press) suggests, there needs to be a reciprocal interplay between conceptualizations of teacher knowledge base and measurement in that the development of teacher knowledge assessments needs to be informed by conceptual work in the domain of effective and equitable teaching of mathematics. To facilitate this interplay, new lines of research also show that authentic classroom scenarios formatted into the assessment environment could serve as powerful tools for eliciting teacher reasoning as well as reflective teacher learning (Lai & Howell, 2014). Further, emerging research shows that instructional scenarios help to situate explorations about pre-service and in-service teachers' reasoning about teaching (Grossman et al., 2009; Masingila & Doerr, 2002). This study was therefore based on the premise that the instructional scenarios might be instrumental in explorations of the knowledge base needed to teach mathematics to ELLs.

Driven by the need to explore essential knowledge for teaching mathematics to ELLs, in this study, we utilized a set of instructional scenarios embedded in an assessment environment to explore what is involved in reasoning about teaching middle school mathematics to ELLs. First, I developed a theoretical lens explicating how understanding the language demands in any content area is central to teaching the content in diverse ways to diverse learners. Second, we developed scenarios illustrating the work of teaching mathematics to ELLs in an assessment environment and conducted interviews with mathematics teachers to explore their reasoning about the scenarios. The current paper is part of a larger study (Turkan, Croft, Bicknell, & Barnes, 2012) and sought to address the following research questions. In addressing these questions, teachers' strong and weak reasoning about the given instructional scenarios as evident in cognitive interviews was contrasted as a way of anchoring the exploration of knowledge essential for teaching mathematics to ELLs.

1. How do I conceptualize the knowledge for teaching mathematics to ELLs?
2. How do practicing mathematics teachers reason about the teaching of mathematics to ELLs?

Towards addressing the first research question, the next section provides an overview of the theoretical framework. The framework informed the development of the measure. Description of the measure and methods is followed by the discussion of results addressing the second question about how a sample of mathematics teachers reasoned through the teaching of mathematics to ELLs. Finally, directions for future research are shared.

Theoretical Lens

Our assumption in identifying and proposing a knowledge base was that all teachers need to develop a specific knowledge base in order to make academic content accessible and meaningful to ELLs. This assumption has long been an argument among scholars that all teachers need to be provided with opportunities to develop an adequate knowledge base to make academic content accessible and meaningful to ELLs (de Jong & Harper, 2005, 2011; Lucas & Villegas, 2011).

Specifically, effective teachers of ELLs draw upon a specialized knowledge base in order to teach academic content in accessible ways called *disciplinary linguistic knowledge (DLK)* for teaching academic content to ELLs (Turkan, de Oliveira, Lee, & Phelps, 2014). These authors argued that DLK is needed to model for ELLs how language is used to communicate meaning and to engage them in disciplinary discourse. That is, DLK is a specialized knowledge that teachers need to have regarding how language is used to communicate the ideas and concepts within a particular disciplinary discourse. Discourse, in this context, refers to ways of knowing, constructing, and communicating knowledge. Involved within the discourse of an academic discipline is the academic register of the discipline that includes linguistic features specific to that discipline. DLK is an elaborated version of Reeves' (2009) use of the term, *Linguistic Knowledge for Teaching,* which is operationalized as the linguistic knowledge that English for Speakers of Other Languages (ESOL) teachers use to create opportunities for learners to communicate meaning. In this paper, however, I use DLK to refer to knowledge that *content* teachers need to facilitate ELLs' content understanding.

Additionally, this knowledge base is a facet of, but not equivalent to, content knowledge for teaching, CKT, (Ball et al., 2008). While the body of work on teacher knowledge measures and research on content knowledge for teaching (Ball, Hill, & Bass, 2005; Ball et al., 2008) is growing, it does not address the role of special student populations in how teachers attend to the tasks of teaching in the classroom. More specifically, CKT doesn't address what knowledge base content teachers draw on to teach special student populations such as ELLs. Outside general teacher education literature, several scholars (Bunch, 2013; Galguera, 2011) have conceptualized what knowledge base teachers need to teach content to ELLs. Bunch accounts for the pedagogical aspect of teaching content to ELLs while by proposing DLK, Turkan et al. (2014) complement Bunch's view that content teachers should also address ELLs' linguistic needs at the word, sentence, and discourse levels as these levels pertain to a particular discipline.

DLK encompasses teachers' knowledge of content-specific academic discourse as well as their ability to present conceptual language in multiple ways that are accessible to ELLs. Specific tasks of teaching subsumed therein include two subdomains: 1) identifying linguistic features of the disciplinary discourse and 2) modeling for ELLs how to communicate meaning in the discipline and engaging them in using the language of the discipline orally or in writing. These tasks are conceptualized further below. The measure of teaching quality for ELLs was developed (Turkan et al. 2012) according to this conceptualization of the targeted construct.

Identifying Linguistic Features

The argument for the first subdomain is that DLK entails particular knowledge for identifying and unpacking the linguistic features and language demands of a disciplinary discourse to make the content accessible to ELLs. We argue that, as part of the unique knowledge base for teaching ELLs, teachers know which linguistic features associated with the particular content might cause or constitute ELLs' misunderstandings or misconceptions about the content. That is, to resolve misconceptions and facilitate ELLs' comprehension and interpretation of the content, linguistic features need to be unpacked. There are two premises in this argument: 1) there are linguistic features that convey meaning and content in a given discipline, 2) the linguistic choices are made in each discipline at the word, sentence, and discourse level to convey meaning.

The first premise is that teachers identify the linguistic features that are specific to a content area. In doing so, they decode or unpack the linguistic features of the discipline to build connections between content and meaning and particular linguistic features and structures that convey the particular meanings. By 'unpack', we mean that teachers make the linguistic *form-meaning* connections of the disciplinary discourse explicit for students. In other words, teachers make the content-related input comprehensible and accessible to ELLs (Cummins, 2000). *Form* here refers to a string of words grammatically put together to carry *meaning*. A string of forms (words, sentences) might carry various meanings depending on the context in which it is being used. For instance, McCarthy (1991) discusses how the following sentences might carry the meaning of question, statement, or command: "You don't love me: (a) question (b) statement" or "you eat it: (a) statement (b) command" (p. 9). Form-meaning connections (Schleppegrell, 2013) are made when teachers attend to the features of language (i.e., form) and they simultaneously model for ELLs the ways in which meaning and content is communicated in the particular discipline. For example, linguistic expression such as "three times as big as…" has a particular correspondence in mathematics, hence a certain mathematical form-meaning connection. As teachers identify the linguistic choices made to convey meaning in a particular discipline like mathematics, they also make the content comprehensible to ELLs by explicitly teaching specific language functions, forms, or meaning behind the text in order for ELLs to learn how the linguistic choices are being used to convey the particular meaning. Once ELLs can differentiate and be made aware of the linguistic choices through the comprehensible input received, they can more readily participate in producing or using the language orally or in writing to convey their understandings about the content.

The second premise is that the ways in which meaning is communicated in content areas are instantiated through linguistic choices, for example, at vocabulary, grammatical and syntactical structures, and discourse levels (Christie & Martin, 1997; Gebhard, Willett, Pablo, Caicedo, & Peidra, 2011; Schleppegrell, 2004). The linguistic choices operate at the word, sentence, and discourse levels: at the word (e.g., *square root* of 25), sentence (e.g., *taking the square root is the inverse operation of squaring)*, and discourse (e.g., *taking the square root* *involves finding the number that, when multiplied by itself, gives* 25) levels. The linguistic choices at these three levels exist to communicate meaning and perform language tasks and functions associated with the particular discipline such as writing laboratory reports in the science classroom (Schleppegrell, 2004), explaining solution processes or describing conjectures in the mathematics classroom (Moschkovich, 1999), writing personal recounts of an event in the English language arts classroom (Brisk & Zisselberger, 2011), and retelling events or presenting debates in the social studies classroom (Fang & Schleppegrell, 2008).

The above premises led us to argue that teachers should be able to identify the linguistic features specific to a content area so that they can decode or unpack the linguistic features of the discipline and build connections between content and meaning, on the one hand, and particular linguistic features and structures that convey the particular meanings, on the other; and that teachers should be able to explicitly teach what constitutes appropriate linguistic choices in their discipline.

Modeling How to Communicate Meaning Orally or in Writing

The argument for the second subdomain is that DLK involves teachers' knowledge for modeling the ways in which the discourse of a discipline is constructed and for engaging ELLs in communicating meaning in the disciplinary discourse orally or in writing. When modeling the disciplinary discourse, teachers build on the mastery of the first domain to make the linguistic features of a content area explicit for ELLs. Further, teachers draw on DLK to engage ELLs in learning how the rules of the linguistic features function to convey meaning in the content area. In doing so, teachers encourage ELLs to explore and build *form-meaning* connections to read, write, listen, speak, and think in the language of the discipline. In this process, students produce work in writing or orally in which they demonstrate their knowledge of the discipline using the disciplinary language as it was modeled to them. Hence, students participate in using the language of the content for complex academic tasks such as "to generate new knowledge, create literature and art, and act on social realities" (Cummins, 2000). In the process of constructing *form-meaning* connections, students develop awareness of and knowledge about what linguistic features are used to represent the meanings and ideas associated with the content.

In this section, we have proposed that DLK encompasses teachers' knowledge of disciplinary discourse in order to represent the disciplinary content in accessible ways to ELLs. I have also argued that to make content accessible, every teacher needs to be able to identify and unpack the ways in which the linguistic features are connected to the meanings of a discipline. As teachers raise ELLs' awareness explicitly around how form-meaning connections are linked in the discourse of the discipline, they will be able to engage ELLs in reading, writing, listening, speaking, and thinking in the disciplinary discourse. Therefore, within the purview of DLK, teachers should know about the linguistic choices made in a given discipline and should be able to identify the language demands and unpack the meaning-form relationships for ELLs to model for them and engage them in using the discourse of the discipline.

Methods

To explore and identify the knowledge base needed to teach mathematics to ELLs, I have grounded my study in practice-based reasoning about teaching. Specifically, teachers' reasoning about the given scenarios of teaching mathematics to ELLs was elicited through interviews. In doing so, I also explored how the high and low performing teachers, as identified by their number correct scores, reasoned about the scenarios. The scenarios were designed as part of the operationalization of the theoretical framework described above. Scenarios were formatted as part of the assessment development process, which served as a means to operationalizing and refining the domain. Next, the assessment development process is explained; later, the interview data collection procedures are presented along with the analysis.

The assessment development process started with the identification and verification of the domain of teacher knowledge and skills required to teach ELLs mathematics content effectively. I initially identified this domain through a review of the academic literature base on teaching mathematics to ELLs, as well as review of the state standards for teacher certification in the three content areas: mathematics, science, and English language arts. Based on the general and content-specific literature, we developed a set of 67 statements describing what content teachers should know and be able to do (for more information, see Turkan et al., 2012). Based on the description of the targeted domain, we categorized these statements into two subdomains: pedagogical knowledge and linguistic knowledge. Under each domain, there were statements generic to all content areas and specific to particular content areas. To validate these statements, we conducted a national survey of practitioners and teacher educators, receiving 269 responses. Subsequently, a panel of 14 teacher educators and teachers further validated the statements by reaching consensus that the statements supported the claims of the assessment under development (for more information about the panel, see Turkan et al., 2012). The principles of evidence-centered design (ECD; Mislevy, 1994; Mislevy, Almond, & Lukas, 2003) guided the panelists' review of the statements about linguistic and content knowledge necessary to teach ELLs. The panelists helped to unpack specifically what teachers would need to perform to manifest that they have the essential knowledge and skills. Based on the performance indicators the panel helped to further specify, the assessment was developed to measure the validated domain of teacher knowledge essential to teach content to ELLs.

During assessment development, we identified the language demands inherent to the content standards and topics selected from the 6th and 8th grade mathematics curricula. We selected middle grades based on the content and language demands—and informed by the panelists-- we identified a set of instructional practices representative of effective ELL teaching. With that, we developed authentic instructional scenarios embedded in an assessment environment (see appendix for two sample items). The scenarios included variant and nonvariant features. Nonvariant features were the effective mathematics teaching practices targeted for assessment. Variant features included description of the learning objective, the ELL student's task, as well as the characteristics of the focus ELL(s), which include their ELL proficiency level descriptors. Various indicators of ELL proficiency in at least one of the four skills (reading, writing, speaking, and listening) were specified. These indicators were provided to guide teachers' understanding about what ELL(s) of particular focus could do or could not do. The learning or teaching objectives were informed by the targeted 6th and 8th grade mathematics standards. This then determined the language demands that are embedded in the particular learning or teaching objectives. The language demands guided what tasks ELLs, characterized by specific linguistic skills in the instructional scenario, were confronted with in the classroom. For example, item 1, illustrated in the appendix, focused on the mathematical concept of 'distributive property' in a classroom scenario in which teachers are faced with a choice to either use the definition that they find or to provide an illustration of the concept to make it accessible for the ELLs described in the scenario. This focus then determined the language demands in explaining and representing the concept for understanding by the specified ELLs. Similarly, item 2, discussed in the results section, focused on a learning objective; namely, writing and solving equations based on word problems. In the particular classroom scenario, ELLs were characterized as having grade-level content knowledge but needing linguistic support in understanding and solving the given word problem. This item is representative of the other items developed to assess teachers' knowledge of content for identifying the language demands embedded in the content. That is, most of the items focused on teachers' knowledge and skills for identifying and connecting the content and language aspects of the content knowledge for teaching.

Approximately 60 items were developed to assess the DLK needed to teach mathematics to ELLs. Twenty of the 60 mathematics items were selected as a representative sample of the domains targeted for assessment. The sample was administered online to 60 middle school mathematics educators who teach in school districts that serve large numbers of students who are ELLs. Samples of mathematics teachers represented southern, western, and northeastern regions of the United States. These teachers had a minimum of five years teaching experience in predominantly ELL school districts. The initial analysis revealed a Cronbach's alpha (α = .50) and only five items showed biserial correlation measures of item discrimination below 0.2.

Interviews

To address how teachers reason about ELL teaching, we invited all 60 in-service mathematics teachers who took the assessment for a follow-up interview. Only 27 indicated interest to participate in the interview. We ranked the test performance of these 27 potential interview participants according to their number-correct scores. Two mathematics teachers got 14 while seven teachers got 11 of the 20 items correct, which was the mode on the test. Twelve teachers got fewer than seven items correct. Low and high performing teachers were identified by the number of items they got right out of the 20 multiple choice items. Those who got 10 and above items right were considered high performing while other teachers who got 10 and below items right were considered low performing on this particular test. This cut off decision was arbitrary based on the distribution of the number-correct scores. Based on this decision, we randomly selected five high performing and 5 low performing teachers, who agreed to participate in the interview. All 10 teachers had taught mathematics for a minimum of five years at predominantly ELL school districts where each teacher had at least five ELLs in their respective classrooms.

The goal of the semi-structured phone interviews was to allow teachers to explain their reasoning as each of them recalled their response to a sample of six items randomly selected from the 20 items. The aforementioned five items with low item discrimination characteristics were not included in the interviews. The remaining items were distributed across the interview participants in a way that each eligible item would be discussed by two teachers. The selected group of items was sent to the participants at least 24 hours ahead of the interviews so that they could have the chance to explain their reasoning about the items. The goal of the interviews was to elicit teachers' reasoning about the items through the use of retrospective questions (see appendix) more than to evaluate or elicit their ability to recall their exact reasoning at the time of taking the assessment.

Analysis

I coded the transcriptions of the interviews using NVivo 9 software. The a priori themes were 1) relevance of scenarios to teachers' work within the specified domains (i.e., identifying linguistic features, modeling how to communicate meaning orally and in writing), and 2) relevance of domains to the items. The subsequent analysis followed an "expanding frame" in which the analysis of the qualitative data began with a tight focus on one element or a few elements (Lindlof, 1995). Within this frame, as the researcher collects evidence, and sees new ways to consider, the frame of evidence is widened in analysis. Specifically, the analysis initially focused on understanding the extent to which teachers considered the ELL proficiency levels identified in the given scenario. As I tried to further address what is involved in this, other themes emerged such as teachers' views about ELL teaching and reasoning about the language demands of the mathematical content. I noted the themes as they came up across participating teachers and the items they discussed during the interviews. Comparison of reasoning between high and low-performing teachers helped to further explain the patterns noted across the participating teachers.

Results

In response to the research question, there were three main findings. One is that seven teachers agreed on considering what ELLs can or cannot do in their instructional decisions. Three teachers argued that all learners (i.e., not just ELLs) have difficulty with the language of mathematics. With this assumption, one teacher claimed that good ELL teaching is effective for all learners. The second finding is that the depth of teachers' content knowledge and sensitivity about ELLs' language needs played a noteworthy role in their reasoning. This may have been a consequence of the particular scenario in the assessment that was used for the interview. If the scenario elicited not only teachers' content knowledge but also their sensitivity about ELLs' language needs, the depth of teachers' content knowledge seemed to surface more noticeably. Third, all ten teachers believed that one effective way to teach mathematics to ELLs was to use pictures as a way of simplifying language and/or removing any language demands specific to mathematics.

Role of ELL Proficiency Indicators

Cognitive interviews with mathematics teachers who either performed well or poorly on the test questions revealed how teachers drew on the information about students' proficiency levels or other information given in the instructional scenarios to reason through the scenarios. Both high-and low-performing teachers drew on the information in their reasoning across all the six scenarios that they discussed during the interviews. I recorded the presence or absence of teachers' reference to the information provided in the scenario. When asked to rate the level of importance for identifying ELLs' proficiency levels and explain why, seven teachers agreed consistently across all the scenarios assigned to them that it was highly important to modify instruction accordingly. However, three of the low-performing teachers consistently explained across the six scenarios that language proficiency descriptors were of low relevance to mathematics instruction and they did not consider what ELLs can or cannot do in identifying the most appropriate instructional practices. One of these particular teachers' assumptions was that language of mathematics was challenging for all students and there is nothing special to the work of teaching mathematics to ELLs.

One teacher did not see the relevance of understanding what students could or could not do in their second language. The teacher reasoned that mathematics itself is a second language for everybody, not just for ELLs, and therefore ELLs should not receive special consideration during instruction above and beyond non-ELLs.

> I(nterviewer): Okay, on a scale of 1 to 5 with 5 being the most important, how important do you think it is for math teachers of ELLs to identify the language proficiency levels of their students?
>
> R(espondent): I think, well I think that; I would call it about a 2, meaning not as important, if I got your scale right. Because, you know, the way I think of math, and I tell them this, is that math is a language all by itself, and so everybody learning math is in fact kind of learning a second language. So in a math class, they may be using English to learn an additional language, that being math, so everybody's kind of at a disadvantage in a way.

Along similar lines, these three teachers thought that effective ELL teaching is good teaching for everyone. This reasoning might bear two related interpretations. One might be that teachers think that there is no uniqueness to the quality of teaching mathematics to ELLs. Another is that if a particular effective teaching benefits ELLs, it would benefit everyone. One teacher who represents this line of reasoning stated:

> R: No, but you know the thing is is that the way I conduct my classes, when I am doing whole group instruction, or we have a word problem, I basically teach those the same way whether I have ELLs in my class or not, in that we read them out loud, and making sure that even some kid that was raised in America on English may not understand some of the idiomatic ways of expressing ourselves that sometimes creep into these questions. So sometimes you know whether I have ELLs or not, I spend a second making sure that everybody understands what the question says. And the pictures and some of those things that help ELLs help everybody. So if you, to me, if you teach with ELLs in mind in general, you're helping everybody.

All in all, teachers found it helpful to consider what ELL can or cannot do in their instructional decisions. A few teachers, though, claimed that language of mathematics is difficult for all learners and that there is no distinctness to the work of teaching ELLs.

Teachers' Reasoning about ELL Teaching

As for teachers' reasoning about the scenarios, there were several dynamics that played a role. One was the content and focus of the items. Since the items focused on teachers' content knowledge and guided teachers to pay attention to ELLs' proficiency levels, the strength of teachers' content knowledge determined the depth of their reasoning. This relationship was observed in varying degrees along a continuum of depth in all 10 teachers' responses. Here, the continuum of depth in teacher reasoning is presented by illustrating a few sample responses from high and low performing teachers.

To illustrate, item 1 (see appendix) contextualized the teacher's task as introducing the distributive property and providing examples to scaffold students' understanding of this property.

The teacher, in this scenario, has to have a good understanding of the concept 'distributive property' to make the connection that options A and B are two different but accurate representations of the same concept. One representation utilizes mathematical symbols (option A) while the other explains the concept with numerical and graphic illustrations. Item 1 assessed teachers' ability to represent the concept in relation to the particular characteristics of the students, tapping into knowledge of content and students. In terms of student characteristics, the scenario specified that the teacher has newly arrived ELLs whose placement test results indicate that they are weak in mathematics and low in English proficiency. Given the ELLs in the class, the teacher in the scenario decides to introduce distributive property with an illustration, instead of starting the lesson with a linguistically complex definition of distributive property. One of the teachers participating in the interview who had performed low on the overall assessment did not choose option B, intended key, because to her, *there was too much going on in that illustration* (see the original line from her below) and so it would be hard for ELLs to follow. According to this teacher, option A, on the other hand, conveyed the central conceptual understanding behind distributive property. However, this teacher seemed to have missed the nuance that option B conveyed the same conceptual understanding except with more illustration, which was more helpful for the particular ELLs than option A, as well as the more linguistically demanding illustrations given in options C and D. Option A was not helpful for the particular needs of the ELLs with weak mathematics and language skills as it just offered a symbolic representation of the definition for distributive property and so did not serve the instructional intentions of the teacher mentioned in the scenario. We observed that by choosing option A, the participating teacher did not combine her content knowledge and linguistic needs of the ELLs in the instructional scenario.

> R: I'm almost positive A was my answer on the thing as well.
>
> I: Okay. And why not B?
>
> R: Too much going on. I just think there's way too much going on there. A is a clear example where you can see how the number outside the parentheses was moved to meet each of the numbers inside the parentheses. I just think showing them all those blocks, there's way too much going on there.
>
> I: And you think A is the simplest way.
>
> R: Um hmm.
>
> I: But what other information in the item did you draw on when selecting A?
>
> R: When selecting A?
>
> I: Yeah.
>
> R: Because they don't want to, they want to illustrate the distributive property and the distributive property says that you multiply the number outside the parentheses .... the number inside and add it together. I just think A clearly states that, you know, showing the mathematical symbols and everything like that and showing how one side of the equal sign equals the other.

Another teacher who scored higher on the test was swift in combining the characteristics of ELLs in the scenario with her content knowledge about mathematical representations of distributive property. This provided her the affordance to be able to reason that low English proficiency kids would still get lost with the teacher explanation that option A calls for, unless they were strong in mathematics and she eliminates this option.

> I: Can you tell us in your own words what information from the question helped you to select an answer?
>
> R: Basically the characteristics of the focus ELLs. In most questions, that was the thing that I cared the most about was the characteristics of the focus ELLs. These were newly-arrived again. Here, unlike the last one, you gave me more information about them – weak in math – which is not a characteristic of ELLs, that's a characteristic of most kids – and have low proficiency in English. So these are low proficiency English kids which meant to me that they needed pictures. You know the instructional scenario, there's the definition, the definitions, mathy definitions are horrifyingly difficult to follow even for people who speak English.
>
> R: And then when I got down to the choices, you know A is okay because, again, math itself is a language and I can, as a math teacher, clearly say that that's essentially the definition of the distributive property. But really I knew I didn't want to go straight into word problems down in C and D and using those pictures and B, which is my answer choice, that that seemed to me clearly the way to go.

Furthermore, seven teachers, regardless of how well they performed on the test, consistently conceived ELLs as the special student population that constantly needs linguistic support in the form of either linguistic simplification or removal of language demands specific to mathematics altogether. I interpreted this conception in a way that language of mathematics and mathematical content are separate entities. When one is present, the other one should be removed. This view, in turn, might have justified all ten teachers' reasoning in favor of using pictures or manipulatives, that is, anything not language-based, in relevant instructional scenarios. In one interview, for instance, the teacher was given a scenario in which a mathematics teacher gives the following word problem to her students (see item 2 in the appendix): "In 1996, the salary of the governor of New York was about $50,000 less than triple the salary of the governor of Arkansas. The total of the two salaries was $190,000. Find the 1996 salary of each state's governor." The teacher in the scenario wants to support the ELLs in being able to understand and solve the problem. ELLs in this class have grade level content knowledge, and their English reading proficiency has been identified at WIDA Reading Level 3[1](there are six WIDA levels). Options include a) providing ELLs with explanations of the difficult phrases in the problem, b) providing ELLs with visual illustration of the problem, c) giving ELLs a version of the problem in simplified English, and d) giving ELLs the equation that the problem is based on and have them solve the equation. The word problem included linguistically demanding phrases such as "$50,000 less than triple…" and "the salary of the governor of New York" that needed unpacking for the particular ELLs in the scenario to solve the equation. Given the scenario and ELL characteristics, option A was the best instructional strategy because providing a version of the problem in simplified English (option C) or visual illustration of the problem

[1] According to WIDA 6-8 grade cluster can-do descriptors, the ELLs with a WIDA reading level 3 can 1) Identify topic sentences, main ideas, and details in paragraphs; 2) Identify multiple meanings of words in context (e.g., "cell," "table"), 3) Use context clues; 4) Make predictions based on illustrated text; 5) Identify frequently used affixes and root words to make/extract meaning (e.g., "un-," "re-," "-ed"); 6) Differentiate between fact and opinion; 7) Answer questions about explicit information in texts; 8) Use English dictionaries and glossaries

(option B) would not significantly help the ELLs make the meaning-form connection between the mathematical concept and its linguistic representation in the word problem. Along the same lines, it would not be the best strategy to readily give the ELLs the equation (option D) without helping them understand the connection between the word problem and mathematical equation. The low performing teacher we interviewed explained that she would prefer the visuals over all the other options, as stated in the excerpt below. When prompted further, the teacher explains what she understands 'simplified English' as referring to "*taking difficult phrases and making them simplified or putting them in simplified forms*" and she says this strategy would be the same as providing explanations of the difficult phrases in the problem. In other words, the teacher discards the two options because she believes them to be identical.

> I: So just tell us what information this question gave you and what it asked you to do.
>
> R: Well it gave me a word problem and it first gave me some information about this particular ELL grade level class, that their content knowledge is at grade level and what their reading level is at. And it's asking which strategy I would use to support them in this word problem.
>
> I: Okay. So what was your answer?
>
> R: I don't remember. I remember doing it very late at night but I think what I would probably do is a visual and then the next explanation; and I wasn't sure on this if they want one answer or more than one. Because I might use a combination; now that I'm looking at it, I might use a visual and then explanation because of the difficult phrases.
>
> I: Yeah. If you had to go to choose one, which one would you say?
>
> R: I'd pick visual.

Overall, participating mathematics teachers seem to have taken into account the information about what ELLs can do at particular proficiency levels. Even though the majority believed in scaffolding ELLs' understanding of mathematics linguistically or otherwise, a few teachers also stated during the interviews that language of mathematics is hard for all learners, not just ELLs. Further, teachers' content knowledge might play a role in the depth of their reasoning about the language demands embedded in the mathematical content. Another pattern was that effective ELL teaching was equated to removing all the language demands or simplifying language to the extent possible through the use of pictures or visuals.

Discussion

While presence of any systematic teacher knowledge base specific to teaching middle school mathematics to ELLs still requires further investigation, teachers drew on some sources of knowledge to reason through the scenarios. One belief that seemed to exist in teachers' reasoning is that effective ELL teaching is not unique above and beyond teaching all learners. While this view has conceptually and linguistically been debunked over the years (Harper & de Jong, 2004, 2009; Schleppegrell, 2001), only recently have we come to an empirical understanding that some teachers tend to be more effective with ELLs (Loeb, Soland, & Fox, 2014).

Loeb et al. (2014) examined the extent to which teachers' effectiveness is the same with ELLs as it is with non-ELLs and how much teacher effectiveness changes across classrooms with ELLs and non-ELLs. The premise here is that teacher effectiveness might vary depending on the specific group of students in the classroom. The findings showed that teachers who are effective with ELLs are also effective with non-ELLs and vice versa. However, when the authors regressed student test performance onto teacher characteristics such as Spanish fluency and attainment of a bilingual certification, they found that teachers with a command of Spanish proficiency and bilingual certification were more effective with ELLs, most of whom were Spanish speaking. This finding supports the emerging stance that good teaching for ELLs is characterized differently from good teaching for all (Harper & de Jong, 2004). Based on this understanding, scholars (Bunch, 2013; Galguera, 2011; Turkan et al., 2014) have attempted to identify pedagogical and linguistic aspects of the work of teaching content to ELLs.

From the current small-scale study, it is observed that the majority of the teachers view ELLs as a group of students who need specialized support in learning mathematics. Those who were observed to be skillfully integrating the information given about ELL characteristics with their content knowledge also performed high on the overall assessment. Teachers who had a better understanding about the content and language demands of the material were more flexibly able to reason through the scenarios. All in all, all the participating teachers integrated their existing knowledge or understanding about students, specifically, the given ELL characteristics into their reasoning about the scenarios. However, the extent to which they were able to integrate their knowledge of content and students was limited. One explanation for this might be that the depth of their specialized content knowledge determines the level of flexibility in which they could reason about the mathematical content in relation to its language demands. In other words, a unique contribution of this study might be that there is an interplay between teachers' content knowledge and DLK, which needs further investigation with more mathematics teachers on a larger scale.

These observations about the interviews might suggest that mainstream mathematics teachers need to draw on a systematic knowledge base to facilitate ELLs' linguistic and content-related challenges, as they are not routinely trained to differentiate their instructional practices according the needs of ELLs in the classrooms. Further research is needed to examine at a larger scale what mathematics teacher knowledge base differentiates good teaching for ELLs from good teaching for *all*.

Conclusion and Future Directions for Research

There is both a growing population of ELLs in U.S. schools and a lack of preparation on behalf of the mathematics teachers who will be teaching them. This paper has barely scratched the surface of identifying and assessing the knowledge and skills needed to teach mathematics to ELLs. Identifying this knowledge base and testing its existence through assessment development is an essential first step towards understanding: What are the most effective pedagogically and linguistically responsive practices for teaching mathematics to ELLs? How can we meet the long term goal of preparing teachers for linguistically and culturally diverse learners? What will constitute quality professional development of mathematics teachers of ELLs?

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Appendix

Interview questions

1. Can you tell in your own words what information the question gives you and what it asks you to do?

2. What was your answer?

3. What information in the item did you draw on when you selected this answer choice ____ (e.g., A)?

4. What information in the item helped you to eliminate the other choices _(e.g., B, C, D)? OR

- *You indicated that you chose __as the answer. Why do you think that's the best answer? Let's go through the other options. Why didn't you select__?*

5. Does the scenario present a challenge of teaching ELLs that you would encounter in your classroom? Which middle grade level is the scenario most appropriate?

6. Does the scenario present a learning challenge that you would encounter with your ELL(s) in your classroom?

7. On a scale of 1-5, how important do you think it is for (math or science) teachers of ELLs to identify the ELL language proficiency levels? On a scale of 1-5, how useful was it to be informed about the proficiency levels of the ELL(s) characterized in the item?

8. On a scale of 1 to 5, with 5 being the most important, how important do you think the knowledge being tested in this item is for math/science teachers who teach ELLs?

- How important is it for teachers of ELLs to know how to answer this question?
- How important is it for teachers of ELLs to be able to answer this question?

9. Was there anything about the question/scenario/problem that you found unclear or ambiguous?

Item 1.

Read the learning objective, teacher task, characteristics of focus ELLs, and instructional scenario, and then answer the question that follows.

Learning objective: Students will understand how to rewrite expressions using the distributive property.

Teacher task: The teacher is introducing students to the distributive property and providing examples to scaffold the students' understanding of the distributive property.

Characteristics of focus ELLs: ELLs in the class are newly arrived in the school. Their placement-test results indicate that they are weak in mathematics and have low proficiency in English.

Instructional scenario: While preparing for a lesson on the distributive property, a teacher looks up the definition given in the textbook. The definition is shown below.

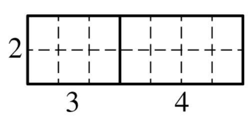
> *Distributive property—the product of a number and a sum is equal to the sum of the individual products of the addends and the number*

Rather than begin the lesson with the definition, the teacher wants to give an illustration of the distributive property.

Which of the following examples should the teacher write on the board to best scaffold the ELLs' understanding?

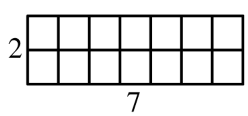
A. $a\,(b + c) = ab + ac$

B.



$2 \times 3 + 2 \times 4$

$6 \;+\; 8 \;=\; 14$



$2 \times 7 = 14$

$2\,(3 + 4) = 2\,(3) + 2\,(4)$

C. At a store, each book costs \$4, and each video game costs \$15. Ellen is buying a book and a video game for each of her 3 children. How much does Ellen spend altogether?

D. The ingredients in a cookie recipe include 4 cups of flour and 2 eggs. Bob is doubling the recipe. How many cups of flour and how many eggs will Bob need to make the cookies?

Item 2.

Read the learning objective, student task, characteristics of focus ELLs, and instructional scenario, and then answer the question that follows.

Learning objective: All students will understand how to write and solve equations based on word problems.

Student task: Students will write and then solve an equation based on a word problem.

Characteristic of focus ELLs: ELLs in the class have grade-level content knowledge, and their English reading proficiency has been identified as being at WIDA Reading Level 3.

Instructional scenario: During a unit on solving word problems that involve multi-step equations, a teacher gives the problem below to the students.

> *In 1996, the salary of the governor of New York was about $50,000 less than triple the salary of the governor of Arkansas. The total of the two salaries was $190,000. Find the 1996 salary of each state's governor.*

Which of the following is the best strategy to support the ELLs in being able to understand and solve the problem?

A. Provide ELLs with explanations of the difficult phrases in the problem.
B. Provide ELLs with a visual illustration of the problem.
C. Give ELLs a version of the problem in simplified English.
D. Give ELLs the equation that the problem is based on and have them solve the equation.