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"You Got the Word Now": Problematizing Vocabulary-Based Academic Language Instruction for English Learners in Science

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Abstract

With increasing numbers of English Learners enrolling in public schools, teachers of core academic subject area classes are facing the challenge of integrating English language development into instruction. This article describes how teachers' understanding of infusing language into science teaching can shape instructional practices and consequently influence the simultaneous English language development and science learning of English Learner students.

A quality science education is essential to the future success of all students, as is proficiency in the English language. Since limited English proficient (LEP) students learn English skills most effectively when they are taught across the curriculum, it is especially productive to integrate science and English teaching (Sutman et al., 1993).

As the student population in US schools becomes increasingly culturally- and linguistically-diverse, the body of knowledge and skills required to be an effective teacher is changing. The growing presence of English Learner (EL) youth means that more teachers of core academic subjects, like science, are confronted with instructional issues related to second language acquisition.[1] Nearly half (41%) of public school teachers in the U.S. report having ELs in their classes, but only 2.5% have a degree in ESL or bilingual education, and only 30% report having received any professional preparation to assist them in implementing effective EL instruction (National Center for Educational Statistics, 1997). Thus, the majority of teachers are not prepared to integrate a language development focus within their subject area instruction (Baker & Saul, 1994; Adler, 1995; 1998; Rollnick & Rutherford, 1996; Rollnick, 2000; Stoddart et al., 2002); they are, instead, likely to be insufficiently aware of the interaction between the linguistic and cognitive demands of their subject areas and therefore will find integrating science and English teaching, as called for in the opening quote, a challenging task.

In this article, we highlight the nature of this challenge and, in so doing, hope to contribute to the emerging body of research on teachers' understandings and implementations with respect to integrated instruction in science. This literature documents how professional development efforts currently target the enhancement of science teachers' knowledge and skills in integrating language and literacy goals into science instruction and, moreover, documents the challenges that exist in changing teacher understandings and putting these understandings into practice (Fradd & Lee, 1999; Hart & Lee, 2003; Lee, 2004; Lee, Hart, Cuevas, & Enders, 2004; Stoddart el al., 2002). In contributing to his literature, our objective is to examine what a teacher's ideas about integrating language goals "do" to science instruction. We go beyond merely showing the unsophisticated nature of teachers' understandings of academic language to, in addition, discussing how those understandings play out in a didactic tension between language and content teaching in EL science classrooms.

Drawing on interview and observation data from a larger study on explicit academic language instruction for ELs in science, in this article we describe a teacher's understandings about the linguistic elements of his science lessons, as well as document his practices related to the direct instruction of these linguistic elements to students. More specifically, we share Leo Rosenmeyer's understandings of integrated science teaching and examine in what ways his implementation of those understandings might affect both language and content development for his seventh-grade EL students.

ELs in Science: The Need for Integrated Instruction

While the majority of ELs live in urban areas of notable "EL states" such as California, Texas, New York, Florida, Illinois, and New Jersey, there has been a dramatic increase in immigration to traditionally non-EL states. Ruiz-de-Velasco & Fix (2000), for example, cite a 40% increase in such immigration between 1990 and 1995. This has resulted in the changing demographics we are witnessing in Iowa, the location of our research, where recent census findings show an 80% climb over a ten year period in the number of elementary- and secondary-aged children with limited English proficiency (Iowa Department of Education, 2001). Added to this backdrop of the geographic spread of language minority communities across the nation is the context of a federal mandate (No Child Left Behind, 2001a; 2001b) which brings ELs into the accountability and assessment spotlight in an unprecedented way (Bailey & Butler, 2003). Thus, EL achievement is increasingly becoming "everybody's" concern as school systems and teachers with little to no previous histories working with ELs now find themselves responsible for monitoring EL performance and progress. This is a daunting responsibility, particularly as data on schooling outcomes for the EL population show lagging achievement, grades, and teacher expectations that may result in higher drop-out rates, most especially among youth of Latino origin (Ruiz-de-Velasco & Fix, 2000; Waggoner, 1999).[1]

Enhancing the science education experiences of ELs, however, is more easily said than done. These students, research shows, may take four to ten years to acquire the kind of academic English needed for success in school (Cummins, 1981). Withholding content instruction until they have acquired the requisite English language skills is not a viable option as this only serves to widen the already large achievement gap that exists between them and their native English-speaking peers. What is needed are long-term, rigorous programs of instruction that integrate English language development goals with core academic coursework. Integrated programs of this nature are the only way to provide ELs with the kind of instructional exposure necessary to help them approach achievement levels on par with their native-speaking classmates.

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1 The majority of ELs in the classrooms we studied were Latino youth, more specifically, youth of Mexican heritage. Given the fact that Latinos are this country's youngest and fastest growing population and that they are not generally well-served by schools, we find this student population a necessary and compelling focus. In Iowa, for instance, the drop-out rate in the Latino community is more than 3 times that of whites (Iowa Department of Education, 2001).

Unfortunately, policymakers and practitioners may respond to the need for integrated instruction with a singular focus on language development that overlooks the role that content learning plays in decisions to reclassify a student from limited- (LEP) to fluent-English proficient (FEP). As Linquanti (2001) points out, a redesignation decision is not only based on the mastery of basic and academic language skills, but "also requires meeting academic achievement standards in grade-level subject matter using English" (p. i). He writes, "while the goal of English language development is central to why students are classified as LEP to start with, students' *academic achievement* is key to their subsequent reclassification as FEP" (p. 3, original italics). Thus, ascertaining how science teachers' understandings and implementation of language instruction may affect their students' potential for academic achievement is an important objective. The semiotics of science, or the study of the use of linguistic resources in the representation of scientific meaning, is a tool toward this end.

Theoretical Framework

Semiotics and a Sociocultural Understanding of Integrated Instruction in Science

The appropriate use of linguistic resources in science, as Lemke (1990) importantly notes, is more than just *talking* science; such use is inherent to actually *doing* science. Therefore, learning the language of science is an essential feature of being identified (by oneself and by others) as one who does science, aka as one who is a "scientist." The relationship between the use of linguistic resources and the construction of meaning, and the role of that relationship in a community of practice, has been captured by principles of social semiotic theory (see Lemke, 1990, pp. 183-213 for a helpful overview). In particular, the work of Halliday (1978), drawing on the framework of systemic functional linguistics (SFL), has illustrated the ways in which individuals, as members of particular communities, construct particular systems of meaning using particular ways of talking about things and processes. These particular ways of talking about things and processes in science constitutes the language of science and learning to talk this language is an essential feature of being a member of a scientific community of practice. The language of science, more specifically, is characterized by its expository or analytical nature as it is used "to express relationships of classification, taxonomy, and logical connection among abstract, or generalized terms and processes" (Lemke, 1990, p. 158). Effective science teaching provides students with the conceptual content related to these terms and processes, modeling how configurations of linguistic resources are used to express them and, further, providing student opportunities to use those linguistic resources to generate their own meaning.

Because of the nature of educational services provided them due to their LEP designation, however, ELs often learn academic content as part of communities that do not provide them with exposure to the same kinds of semiotic formations to which their proficient English-speaking grade-level peers are exposed, formations that would more closely match what is expected in demonstrating grade-level achievement in a content area. Thus, the key to productive integrated instruction, if it is indeed to narrow the achievement gap, is to provide EL students with listening and speaking opportunities that contain and model the kinds of semiotic formations upon which mainstream (normative) performance expectations rely.

On the one hand, the call for integrated instruction in science is certainly the result of a growing awareness that students who speak English as a second or additional language may be at a decided disadvantage in comparison to their monolingual English-speaking peers. Thus, professional development efforts now specifically target the enhancement of science teachers' knowledge and skills in integrating language and literacy goals into science instruction. On the other hand, however, the way that teachers ultimately understand and implement integrated instruction is certain to affect science instruction in ways that themselves merit examination. In its comprehensive review of the literature on improving schooling for language minority children, the National Research Council (August & Hakuta, 1997) identifies as a high priority the question of how teaching in the subject areas is affected by the presence of English learners in classrooms. The answer to this question implies examining, for example, how the call for integrated instruction has been taken up in EL science classrooms and to what effect. Not only do researchers need to attend to how teachers develop their understandings of the role of language in learning (Schleppegrell, 2004), but, in addition, they need to further investigate how teachers implement those understandings and to what outcome. In other words, what does a teacher's understandings about integrating language goals "do" to science instruction?

The Didactic Tension Between Language and Content Development

In the case we present, we illustrate what we regard as a didactic tension (Mason, 1988) between language and content in integrated science instruction for ELs. Our interest in this tension revolves around Mason's observation that that the more explicit the attention put on language by the teacher, the more likely language will be mistaken by the students as the substance of instruction itself (Mason, 1988, in Pimm, 1994 p. 143). Teaching, then, as Pimm (1994) remarks with respect to mathematics instruction, "necessarily operates within the constraints of [a] tension" (p. 144) between providing students with information about academic language while not creating an "artificial" learning environment. He comments on the desirability of having teachers provide learning opportunities in which students are engaged with the ideas at the conceptual core of the content area while simultaneously developing their written and spoken language. Roth (2005), speaking from the science perspective, agrees. He emphasizes that the acquisition of scientific literacy results not from merely decontextualized "talking" but from contextualized "doing" science, stating, "We become competent speakers of a language when we participate in using it for some purpose rather than when we learn it for its own sake" (p. 52).

But for culturally- and linguistically-diverse students, the benefits of explicit form-focused instruction have, indeed, been noted as essential to their success in school (Delpit, 1988; August & Hakuta, 1997; Colombi & Schleppegrell, 2002). Thus, Brown (2004) writes that "if science educators hope to assist students in developing use of discourse in ways that enables [sic] them to readily apply science discourse in "natural" ways," the initial instruction using science discourse must become explicit" (p. 831). He describes what he calls his Directed Discourse approach to explicit instruction. Following the Pre-Assessment Instruction and Content Construction phases, he introduces students, in an Introduction of Discourse phase, to "the language of the content" through talk and written assignments. Then, in the Scaffolding phase, he engages the students in assessment activities that have them "write and explain the concepts being discussed using the technical discourse of science" (p. 832). Explicit attention can and should, he asserts, be given to how language functions as a representational technology in science.

It should be noted, of course, that science teachers' effective use of an approach like Brown's depends on what they understand the "language of content" to mean. If science teachers have limited understandings of the "language of the content," attempts at explicit instruction may stress the didactic tension further. The teacher may explicitly teach forms that, in fact, only partially or superficially align with the semiotic formations used in the expression of conceptual understanding. Thus, while the teacher may believe in the goals of integrated instruction, in the way she is able to put those beliefs into practice, she may be emphasizing some semiotic formations only to continue to obscure others. She may, in effect, not adequately or accurately capture "the language of the content." In "watering down" (Martin, 1993) the linguistic technology, she also may be 'watering down" the content of science.

It has elsewhere been noted that teachers' understandings of academic language are indeed limited. They revolve, as researchers have remarked, most pivotally around the idea of vocabulary (O'Toole, 1996; Solomon & Rhodes, 1995).[2] These vocabulary-based conceptions of academic language ignore other important linguistic features, such as the unique grammatical and discursive patterns that comprise the genres (recounts, narratives, reports, expository essays, etc.) of a content area (Schleppegrell, 2001; Colombi & Schleppegrell, 2002; Schleppegrell, 2004). In this way, linguists help us see that the goal of integrating explicit academic language instruction into science will be insufficient without attending in a comprehensive way to how a complex configuration of linguistic features interact to structure the kinds of written and oral texts expected at school. Vocabulary-based approaches to academic language instruction, therefore, albeit against best intentions, are likely to continue to withhold from ELs the very linguistic modeling and practice they need in order to acquire the essential semiotic formations of science. Thus, while teachers may have the best of intentions when it comes to explicit academic language instruction, their limited understanding of language may act as a counterweight to efforts to improve their classroom practice with ELs.

Methodology

The research we report on here was part of a larger exploratory study examining explicit academic language instruction in science classrooms. Over a 4-month period, we used qualitative methodology to collect data from seven elementary, intermediate, and secondary Iowa classrooms (grades 4, 7, and 9). The classrooms we observed had English learner enrollments ranging from zero to 100%. Three of these seven classrooms (one 9th-, and two 7th-grade classrooms) we regarded as "focal" data collection sites: we visited these classrooms five times, as opposed to just once, over the data collection period. The data we collected for these focal sites consisted of semi-structured teacher and student interviews and, as our primary data source, videotaped unstructured classroom observations. In this article we share data from seventh-grade science teacher's Leo Rosenmeyer's[3] interview that we conducted before our first

2 For an explanation of how vocabulary-based understandings of academic language are rooted in a tradition of science as primarily written discourse, see Halliday & Martin, 1993.
3 All people and place names in this article are pseudonyms.

visit to his classroom and the classroom observation data from our first visit to his classroom. The purpose of the first interview with Leo was to gather background on his teaching history and his understanding of academic language and approaches to EL instruction. The purpose of the videotaped observation of his classroom was to document his approach to explicit academic language instruction in a science lesson. The lesson we describe here was typical of Leo's approach to academic language instruction that we observed in the subsequent four visits to his classroom; thus, we have selected it as a case (Goode & Hatt, 1952; Strauss, 1987) to discuss how we saw the didactic tension between language and science instruction operating in his instruction.

Consistent with the case study approach, here "the focus of attention is the case, not the whole population of cases" (Stake, 1988, p. 256); that is, we are interested in understanding this particular teacher's understanding of academic language and his implementation of that understanding, rather than claim generalizability to all science teachers and classrooms. We want to use Leo's teaching to raise significant questions about the impact of explicit academic language instruction on opportunities for conceptual and linguistic development for ELs in science classrooms. We hope our discussion will be useful to others invested either as researchers or teachers in issues related to the science education of EL students and aspire to that goal as a measure of our work's validity (Lather, 1991).

Our approach to data analysis was heavily influenced by Lemke (1990, see Appendix, pp. 215-232). We first transcribed the videotaped classroom observations, and, next, taking up Lemke's approach, reviewed the classroom transcripts for 1) the instructional segments of the lesson (ie., its review/motivation, information, practice, and application/review phases); 2) the activity types used in the lesson (teacher exposition, triadic dialogue – a teacher initiation-student response-teacher evaluation sequence, groupwork, etc.) and teacher-student control strategies (admonitions, asserting irrelevance, disengagement, etc.); 3) the semantic relations inherent to the lesson's thematics (nominal, taxonomic, transitivity, circumstantial, and logical relations)[4]; and 4) the teacher-student thematic development strategies (selection and modification, foregrounding and backgrounding, glossing, repetition with variation, marking old information, etc.). In the case we present here, however, our primary focus is on the semantic relations of the lesson's thematics. Thus, again following Lemke's lead, we present these semantic relations by way of a thematic diagram. This diagram summarizes the lexical elements of the conceptual material (the key vocabulary or *nodes* of meaning) presented in the lesson and indicates the semantic relations (or the *networks* of meaning) that bind the lexical elements together. We found this form of diagramming very helpful in focusing our attention on the (dis)connection between Leo's use of explicit academic language instruction and the actual semantic relations and thematics of the science lesson.

4Nominal semantic relations include those of attribution, classification, or quantification. Taxonomic semantic relations include those of hyponymy, meronymy, synonymy, and antonymy. Semantic relations of transitivity include those related to agent, target, medium, beneficiary, range, identification, and possession. Circumstantial semantic relations include those related to location, time, material, manner, and reason. And logical semantic relations include those related to elaboration, addition, variation, and connection. A detailed explanation of these semantic relations is beyond the scope of this article. For a thorough discussion, please see Lemke, 1990, pp. 221-224.

"So OK, You Got the Word Now": A Case of Academic Language Instruction for ELs in Science

Leo Rosenmeyer has devoted twenty years of his life to teaching K-12 science. Murray, the rural community in which he teaches, began seeing a trend in Mexican immigration about ten years ago. Now, 25% of Murray residents are Latino, predominantly Mexican or of Mexican descent. At Murray Jr. High School, where Leo teaches, 30% of the 397 total enrollment figure is Latino and 45% of total enrollment participates in the federal lunch program, a number well above the 30% state average for this grade.

Murray is definitely facing the challenges of educating an increasing number of ELs. In 2003-4, Murray did not meet the district's reading comprehension goal; only 57% of all 8th graders were proficient as measured by the Iowa Test of Basic Skills. In fact, Murray students performed below state and national averages for reading comprehension and science proficiency. Reading comprehension figures for Latinos in particular show that only 42% of these 8th graders were proficient in reading comprehension. The figures are similar for science.

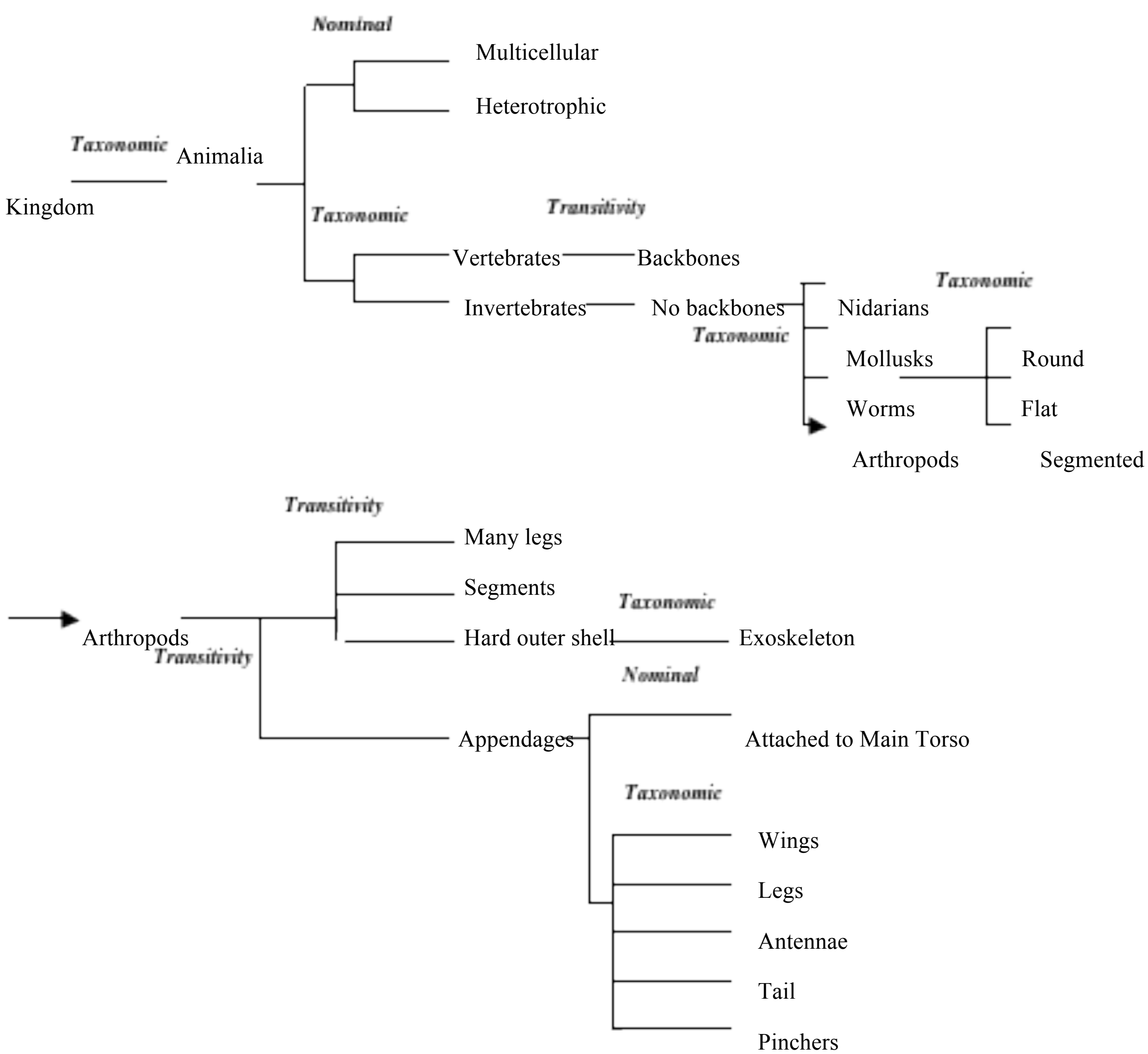
Leo recalled that he began having ELs in his mainstream science classes about 6 years ago. In the year of our research, he had four EL students in the science class we observed. In his interview, Leo told us he had not been officially prepared to work with EL students such as these; he relied, he said, on his instincts. His instincts told him that teaching academic language meant teaching "words and vocabulary that are specific to that key academic class." For Leo's science instruction, this understanding of academic language led him to use visual aids to present and define new terms. He added that he also made explicit references to the Latinate roots that are present in technical scientific vocabulary because he recognized a link between these roots and the Latinate base of his ELs' Spanish. We saw these vocabulary-based approaches in the following lesson on arthropods.

The Arthropod Lesson

Leo started his Arthropod lesson with a Motivation/Review phase. Through triadic dialogue, he and the students established that they had been studying the kingdom of animalia and that some defining features of animalia are their multicellular and heterotrophic (not making their own food) characteristics. They then established that there are two types of animalia, the invertebrates and the vertebrates. They reviewed the kinds of invertebrates they had studied as well as examples of those. Then Leo transitioned into the Information phase by introducing arthropods as another kind of invertebrate. In the Practice/Groupwork phase, the students looked at jarred specimens of arthropods and generated a class list of their potential features. In the Application phase, they responded to a presentation in which Leo showed them slides of arthropods and they applied the class-generated features to the creatures in the slides, ultimately determining what key arthropod characteristics were.

In Leo's lesson, semantic relations of taxonomy figured prominently. First, there was the division of "kingdom" into "animalia." Second, there was the division of "animalia" into subclasses of "invertebrates" and "vertebrates. " Third, there was the division of "invertebrates" into a number of creatures, among them, the focal topic of the lesson, "arthropods." However, as we will show, because Leo taught academic language as vocabulary, he did not make explicit to his students the linguistic resources required to express these taxonomic relations; he explicitly taught the nodes, or discrete lexical/semantic items without the accompanying networks of meaning. These nodes and networks of Leo's Arthropod lesson are illustrated in Figure 1 below:

Figure 1. *Thematic Diagram: The Nodes and Networks of Meaning in Leo's Arthropod Lesson*



The following examples show how the implementation of Leo's understanding of academic language as vocabulary had the effect of creating a didactic tension between content and language, limiting student opportunities for extended output, and affecting homework expectations. They serve to illustrate his emphasis on teaching the nodes, not the networks, of scientific meaning.

Example 1: "So What's the Other One?"

Leo has asked his students, "In order to classify it as an animal, what do we need?" Angelo, instead of replying with a syntactic formation ("We would need it to be multicellular" or "For it to be multicellular"), offers just the lexical item "multicellular." That this lexical item had been previously taught as part of a set of information bits associated with the concept "animalia" was made clear when Leo, accepting that answer, asked "So what's the other one [information bit]?"

Leo: OK, so far we've been talking about . . . what kingdom, Chad?

Chad: Animalia.

Leo: OK, the animalia, so the animal kingdom [holding up a red card with the word "animal" on it]. In order to classify it as an animal, what do we need? [pointing at a student to elicit answer]

Angelo: Multicelular.

Leo: Multicelular, which means what, Angelo? Do you know what multi means? Come on . . . Multimillionnaire [inaudible] . . . Deanna.

Deanna: Many cells.

Leo: Many cells . . . if I am I multimillionaire, I got . . . many millions, OK? So multicellular . . .and what's the other one?

In an extension of this triadic dialogue sequence, Deanna provided the answer Leo was looking for, "heterotroph," thus completing the two-part information bit associated with the concept of animalia: "multicellular" and "heterotroph."

Notable here are the techniques Leo used to mark a lexical item as academic language. In this example, he invoked Latinate morphology ("What does 'multi' mean?" "If I am a multimillionaire, I got . . . many millions") and used word cards (one bearing the word 'animal'). These techniques served to signal an explicit shift in instructional discourse away from the science content and towards language itself in a way that, undoubtedly, Leo intended to be helpful to his ELs. In the following example, however, we see how Leo's vocabulary-based approach affected opportunities and expectations for student talk.

Example 2: "And What Were Some of Them?"

Continuing the Motivation/Review phase in triadic dialogue sequence, Leo then began a question series that highlighted the taxonomic relationships underlying the lesson's thematics. In the example below, note how his questioning, however, does not encourage students to express themselves those underlying taxonomic relationships.

Leo: Then we took all of those animals and we put them in one group, right? Ah, two groups, excuse me . . . What are the two groups that we divided them into? Deanna?

Deanna: Invertebrates and vertebrates.

Leo: Invertebrates. And what is invertebrates? Yeah, what's the difference? . . . Raymond.

Raymond: Vertebrates have a backbone. Invertebrates don't.

Leo: OK. Uh, the animals that we've studied so far... Are they invertebrates or vertebrates?

Amadeo: Invertebrates.

Leo: Invertebrates . . . OK . . . and what were some of them.

Jason: Nidarians.

Leo: Nidarians . . . and some examples of those.

George: Jellyfish.

Leo: OK, what do they have?

Sam: They have milocites.

Leo: Milocites . . . OK, which are?

Peter: Like tentacles.

Leo: OK . . . What else do we have?

Maura: Mollusks.

Leo: Mollusks . . . What are the characteristics of mollusks?

Maura: Inner and outer shells.

Leo: They have inner and outer shells. And an example of mollusks.

Maura: The octopus.

This example shows how the focus in Leo's questioning was on having students supply the nodes of meaning, or the discrete lexical items of the lesson's thematics, without articulating themselves the network of meaning that bound those lexical items together in the larger taxonomy. In other words, we see how Leo's understanding of teaching academic language generally resulted in eliciting one-word (or sets of one-word) responses from his students; they supplied the appropriate word at the right time upon his cue. When Leo asked, "What are the two groups that we divided them [animals] into?," Deanna replied, "Invertebrates and vertebrates." When he asked, "The animals that we've studied so far... Are they invertebrates or vertebrates?," Amadeo responded, "invertebrates." When he asked, "What were some of them?," Jason replied, "Nidarians." And when he asked, "And some examples of those?," George replied, "Jellyfish." Leo's questioning allowed students to show they knew the important nodes of meaning, or vocabulary, that made up the lesson's focus on invertebrate taxonomy, but it did not provide prompts that required them to talk through, on their own, the network of meaning, or, in this case, the taxonomic relations related to 1) the difference between invertebrates as opposed to vertebrates, 2) the different kinds of invertebrates, and 3) the different examples of those different kinds of invertebrates. Doing so would have required them to demonstrate a more sophisticated and integrated understanding of the target science content, while also utilizing extended linguistic resources.

The exceptions to this single-item response pattern were the questions, "What's the difference [between vertebrates and invertebrates]?" and "What do they [jellyfish] have?" that elicited somewhat more extended answers by Raymond ("Vertebrates have a backbone. Invertebrates don't.") and Sam ("They have milocites."). Both of these students used longer syntactical structures containing "have" to express transitivity relations related to possession that stand out in relation to their peers' single-word responses, but they were still nonetheless only being required to provide information at one level in the larger taxonomic relationship. A different prompt could have provided them the opportunity to talk through the entire taxonomic relationship on their own and, in so doing, demonstrate their conceptual mastery of the scientific material. Simultaneously they would have been manipulating all the key vocabulary items, or nodes of meaning, within larger networks of meaning constituted by a number and variety of different syntactical elements more expressive of the academic understanding and language of science.

Example 3: "You Got the Word Now"

Leo's approach to introducing the homework reading assignment helps us again see his vocabulary-based understanding of academic language instruction in action.

Leo: . . . So notice that we have a reading assignment for tomorrow which is to read page two eighty four to two eighty six . . . which is general information about our arthropods . . . It's guided reading so as you're reading along . . . the questions go in order . OK . and um . . . Now if you look at the questions . uh some of those terms we talked about show up again. For example number five . the exoskeleton . shows up . number seven . molting . then on the back page . I think question number uh . let me see . uh . number ten . the word appendage . . . OK and you got the word now.

In this example, Leo again emphasized student learning in terms of discrete lexical items, stating that students are to use the "terms we talked about" to answer text questions for their homework. In sum, this example reiterates how Leo's implementation of academic language-as-vocabulary generally served to ignore the broader linguistic resources necessary to express the semantic relationships of taxonomy that were so prominent in his lesson's thematics. For the most part, students were not expected to use linguistic resources beyond the lexical level needed to express those relationships. Learning to talk science was about students "getting a word," not making personal linguistic choices to express unique scientific meanings. In this way, we argue, we saw the didactic tension between explicit language instruction and underlying content goals operating in his lesson.

Discussion

Large numbers of freshmen ELs enter higher education institutions with language difficulties that prevent them from succeeding in their courses. They are required to participate in specially-designed programs to address these difficulties (Scarcella, 2002). Second language theorists currently suggest that explicit teaching of academic language is necessary for ELs to develop the advanced levels of literacy required for success in schooling, especially at the university level (Scarcella, 1996; Schleppegrell, 2002; Doughty & Williams, 1998).

With respect to science, as Martin (1993) writes, taxonomies (along with other semantic relations) figure prominently in scientific literacy. Modeling for students the linguistic features necessary for representing these semantic relationships of taxonomy, for instance, should be an important part of the science teacher's role in helping them prepare for more advanced studies, requiring more advanced literacy, in science. This modeling cannot take place in a linguistically- and conceptually-reduced science teaching situation. "Diluting scientific discourse," Martin warns, "necessarily involves diluting the science that is taught . . . The linguistic technology is the key. Ways must be devised to provide access to this technology. And the answer must not involve watering the technology down" (p. 202).

For teachers of science, taking the call for integrated instruction seriously means taking what is known about quality science education and infusing into those goals of cognitive development, corollary goals of language development. Just as science education is about meaningful inquiry into real-world problems and the opportunity to apply and generate conceptual knowledge in collaboration with students, teachers, and other members of the scientific community (Goldman, 1997; Krajcik et al., 1998; Merino & Hammond, 1998; Mercado, 1993), it is also about the language and literacy technologies upon which such activities of inquiry, application, generation, and collaboration rely.

Leo's case helps us see the particular kinds of semantic relations upon which science instruction relies and how, while students may be exposed to the semantic relations as part of the conceptual content of science, they may not be provided, in the course of instruction, with opportunities to use the linguistic resources necessary to express those semantic relations. It helps us see how a focus on academic language as vocabulary may be an adequate approach to preparing students to talk and write *school* science (if talking science means one-word verbal and written responses to teacher or text questions), but will be inadequate in preparing students to talk and write in the extended discourse of genuine scientific inquiry and explanation.

While Leo's case can't stand in for all EL settings, it gives us a glimpse of the learning environments that may exist for science instruction and the role that language plays in creating those. It provides a cautionary example of what can happen to science teaching and learning when a simplistic approach to academic language instruction is facilitated by a school-science frame. It helps us understand that, in providing integrated instruction for ELs, striking a balance between teaching the content and language of science merits further attention and that, moreover, vocabulary-driven approaches are not the quick fix to English learner science that some educators and policymakers may want them to be. Simplified understandings of explicit academic language instruction, in leading to simplified science talk, result in simplified science.

Conclusion

Based on the case we have presented, we conclude that, when generated from simplistic understandings of academic language, the goals of language and content development exist in a "didactic tension" (Mason, 1988) that does not facilitate productive integration, and may, in fact, impede effective content teaching. Since explicit academic language instruction is promoted as an instructional objective more in classrooms with ELs than in classrooms without, problematizing the negative effects of the didactic tension that results from teachers' simplistic understandings of academic language is necessary if we are to ensure educational equity for ELs in science.

Framed by an interest in enhancing the science and language achievement of ELs through teacher education and professional development, the information this study provides is of significant interest to those seeking to understand how to teach the language and content of science to ELs and how the teaching of science itself may be affected by EL-oriented approaches to instruction. The insights of this study will be useful in developing methods that enhance access to and equity in science education and the science professions for linguistically-diverse youth (Hart & Lee, 2003). It shows that science teachers need more information about academic language and, crucially, that lack of information about explicit skills instruction in the language of science can actually sabotage ELs' opportunities to not only talk, but think, like scientists.

"What special considerations must teachers heed when seeking to promote science discourse in language minority classrooms?" ask Yerrick & Roth (2005, p. 4). One special consideration to heed is the teachers' own understandings of what academic language means. Attempts to integrate science and English teaching without knowledge of science's unique and complex linguistic configurations may have its own unintended discursive effects. If teachers are limited in their awareness of the nature of academic language, they will be unable to bring sophistication to integrated instruction and the science gap between ELs and their mainstream peers will continue to grow. For this reason, as advocates for ELs and their teachers, we urge for continued research on the relationship between language and content in science instruction and the dissemination of that research throughout programs of teacher education and professional development. The "learning-to-teach" literature (e.g., Cochran-Smith & Zeichner, 2005; Darling-Hammond & Bransford, 2005; Richardson & Roosevelt, 2004) advises us that professionalization is a complex process and, in particular, we know that teachers' prior beliefs can be unexamined and persistent and, therefore, hard to change (e.g., Kagan, 1992). Because these beliefs emerge from what Lortie (1975) referred to as the "apprenticeship of observation," the lack of attention to language development in their own science schooling reinforces teachers' limited understandings of the potential role their own classrooms could play as zones for rich language development. Therefore, developing teachers' knowledge and skills related to academic language – what it is and how best to teach it – means working with them to reflect on their prior (mis)understandings (Danielowich, 2007). This reflection can take place through interviews and observations related to their teaching, in tandem with sustained coaching to help teachers identify with and achieve the goal of integrating effective language instruction into their science teaching identity (Luehmann, 2007).

As Stevens et al. (2009) note, however, in their discussion of the implications of a language-learning agenda in science teacher education, the capacity for programs of teacher preparation to provide language-related knowledge and skills to pre-service science teachers rests upon the knowledge and skills, as well as beliefs, of the program faculty. Thus, problematizing academic language instruction in science entails problematizing the relationship between literacy and science courses and, indeed, of the faculty who teach them. Just as we opened this article, we will close it: The increasing cultural and linguistic diversity in US schools means we must do away with business-as-usual in science classrooms and the university methods courses that prepare teachers to work in them. The body of knowledge and skills required to be an effective educator – *and* teacher educator – is changing.

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