Towards the Characterization of Academic Language in Upper Elementary Science Classrooms

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TOWARDS THE CHARACTERIZATION OF ACADEMIC LANGUAGE IN UPPER ELEMENTARY SCIENCE CLASSROOMS

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Abstract

This report details an exploratory study that employs qualitative methods to characterize the academic language used by teachers and students in 4th and 5th grade mainstream science classrooms. Teacher oral language, and to some degree student talk, was observed during content instruction. This type of data allows for a broad descriptive representation of language use and vocabulary choice rather than fine-grained structural analyses. Print materials and student written products were also examined in this manner. Primary research questions include (1) how does teacher language function in the classroom? (2) how do teachers support academic vocabulary growth? The inductive approach taken led to the development of a matrix of teacher-produced academic language within three instructional contexts; concept instruction, vocabulary instruction, and process/application instruction. Describing the language embedded in oral and written classroom discourse has implications for both educational research and practice. The focus on mainstream classroom talk will serve as a baseline for future research of academic language and English language learners. Specifically, this study has created a conceptual framework with empirical illustrations that should prove valuable for (1) conducting further study of effective classroom instruction that includes academic language, and (2) the development of language assessments that measure student progress towards academic language proficiency.

Introduction

This study is an exploratory effort that employs qualitative methods to analyze the academic language used by teachers and students in upper elementary mainstream[1] science classes. There is a deliberate focus on mainstream science lessons to help determine the language demands that English language learners

[1] *Mainstream classes* refers to general education classes for native English and highly proficient non-native English speaking students.

(ELLs)[2] will eventually face once they have been redesignated for instruction in mainstream classes. The work is an outgrowth of previous research at CRESST that has sought to address assessment issues impacting ELLs in U.S. schools (Abedi, Leon, & Mirocha, 2000; Bailey, 2000a; Butler & Castellon-Wellington, 2000; Butler & Stevens, 1997; Butler, Stevens, & Castellon-Wellington, 1999; Stevens, Butler & Castellon-Wellington, 2000). The goal of this research is to formulate an approach for operationalizing academic language by observing the language used in instruction within a single content area. A guiding assumption for the work reported here is that equitable inclusion of ELLs in the curriculum and in the assessment process for accountability begins with equitable exposure to and learning of the language of the classroom and of standardized content assessments. While ELLs may have well-developed proficiency in every-day talk in their first language and very often in English—their second language—these students may not have had the opportunity to gain proficiency in the language of the classroom (Gibbons & Lascar, 1998). By describing the language embedded in oral and written mainstream classroom discourse, it will be possible to create a framework for classroom instruction that includes academic language and for future language assessments that measure student progress towards academic language proficiency.

Upper elementary Grades 4 and 5 were selected for the study. Beginning in the 4th grade, instruction focuses less on literacy skills embedded in social language and more on negotiating academic content in textbooks. Instead of learning to read, upper elementary students are reading to learn (National Research Council, 1998). In the upper elementary grades, the content areas become more specialized, and the classroom discourse becomes more linguistically complex and cognitively demanding.

The content area of science was selected because it utilizes the full range of linguistic domains, including unique discourse structures, complex grammar, and a high concentration of specialized content vocabulary not necessarily found to the same extent in other subject areas (Bailey, 2000a). Moreover, there has been increasing interest within the field of science education in the role of language in

[2] *English language learners* in this paper refers to students who are acquiring English as a second language and do not yet have the language proficiency to participate in mainstream classes.

science instruction and learning. This interest appears to comprise at least two strands. One pertains to issues of equity, namely the opportunity to learn or access science curricula and the fairness of current assessment procedures used with cultural and linguistic minority students that mirrors the very motivation of this research report in spirit (see, for example, Lee, editor, and others in a special issue on language and culture in science education in the Journal of Research in Science Teaching, 2001). The second strand, to which this research report may also contribute in part, focuses on the nature of classroom discourse and how it can inform educators about the conundrum of why student scientific understanding does not necessarily change and mature as a result of being taught science concepts (e.g., Lemke, 1990). Specifically, this report may illuminate how science concepts are presented to students linguistically—revealing the assumptions teachers may make about students' linguistic capabilities to handle science concepts, as well as how students may incorporate the language of science and the academic environment into their own scientific reasoning.

To capture the use of academic language in mainstream science lessons, teacher oral language used in the classroom (henceforth *teacher talk*), and to some degree student talk, was observed during content instruction and then analyzed. Print materials and student written products were also examined. This use of academic language in mainstream content area classes will serve as a baseline for the eventual development of assessments of academic language proficiency and curricula materials. The dearth in content-based language tests has been recognized in the field of ESL study (Turner, 1997), but the need to define, operationalize, and document academic language in order to create such assessments remains. The long-term goal will include the development of test specifications that are based on empirical classroom data in order to provide a meaningful and fair measure of the readiness of ELLs for mainstream content instruction. For other efforts in this area see Gibbons and Lascar (1998). Evidence of academic language use in a variety of functional contexts within science lessons is the focus of the data analyses in this study. Explication of the data takes the reader through language functions as they cut across contexts of instruction.

Overview of Paper

The paper is organized in the following way: First, a review of the literature presents a working definition of academic language, the central focus of this research effort. The literature review then turns to discussions of general instructional approaches to teaching and to specific approaches for teaching English as a second language (ESL). These discussions help provide an instructional perspective for analyzing the classroom discourse that was observed. The research questions for the study are then presented, followed by the conceptual framework that guided data collection and analysis. Next, the methodology for the study is described, followed by the data analysis section which is organized around the data types discussed in the conceptual framework. Finally, the discussion of the findings leads to suggestions for further research.

Literature Review

The literature review provides a context for thinking about academic language as a critical skill to be learned. It further presents pedagogical approaches and practices that currently exist and may impact student opportunity for acquiring academic language.

Working Definition of Academic Language

As mentioned above, the goal of this research is to document the language students are exposed to and expected to use in mainstream 4th and 5th grade science lessons. This language of the classroom is often referred to as *academic language*. The use of the term *academic language* has meant different things to different researchers (see Cummins, 2000, for a recent review), as well as different things to different teachers (Solomon & Rhodes, 1995). The definition of academic language used in this study is consistent with definitions used in previous CRESST work (Bailey, 2000a; Bailey, 2000b; Butler, Stevens & Castellon-Wellington, 1999) that sought to characterize academic language at the lexical (vocabulary), syntactic (forms of grammar), and discourse (rhetorical) levels. The current work expands this characterization of academic language to include a focus on the functions of language in the classroom. This view of academic language corresponds to that of many of the teachers reported in Solomon and Rhodes (1995). These teachers

identified academic language in terms of the language needed by students to effectively participate in classroom activities.

Academic language is defined by Chamot and O'Malley (1994) as "the language that is used by teachers and students for the purpose of acquiring new knowledge and skills…imparting new information, describing abstract ideas, and developing students' conceptual understanding" (p. 40). A student who is academically proficient in a language (first or second) can use global and domain-specific vocabulary, language functions, and discourse (rhetorical) structures in one or more fields of study to acquire new knowledge and skills, interact about a topic, or impart information to others.

In their work on the academic language of content assessments, Stevens, Butler, and Castellon-Wellington (2000) identify three categories of words: (1) high frequency general words, those words used regularly in everyday contexts; (2) nonspecialized academic words, those academic words that are used across content areas; and (3) specialized content area words, those academic words unique to specific content areas. In this report, following Stevens et al (2000), the terms *nonspecialized* and *specialized academic vocabulary* refer to words that can be used across content areas and within a specific content area, respectively.

According to Chamot and O'Malley (1994) academic language functions (e.g., being able to explain, describe, contrast, etc.) are "the tasks that language users must be able to perform in the content areas" (p. 40). They are the range of communicative intents for which a teacher or student may use language in the classroom. This feature of analysis, and one of the central foci of the work reported here, draws on the speech act theories of Austin (1962) and Searle (1970) which suggest that each communicative attempt serves a functional purpose or role. The communicative intent of the interaction serves as the unit of analysis. That is, each intent was categorized discretely by language function (e.g., explanation, description), rather than structural/formal boundaries. For example, a communicative intent can cut across multiple utterances until the intended purpose of the interaction is complete.

Rhetorical structures are those used in talk and texts to organize and impart information. For example, in order to set up comparative arguments a speaker/writer can introduce the first argument with "on the one hand…" and a competing argument with "on the other hand…" Some academic vocabulary, language functions, and rhetorical structures will vary from genre to genre (i.e., narrative versus expository discourse) and from one field of study to another, whereas others may be shared across genre and fields.

To achieve further specificity, academic language is defined here as language that stands in contrast to the everyday informal speech that students use outside the classroom environment. It comprises both the specialized content-specific language, such as the conceptual terminology of science (e.g., *osmosis, igneous, biodiversity*), as well as the nonspecialized language that cuts across content areas. This latter form of academic language is a mode of communication (oral/print) that is not specific to any one content area, but is nevertheless a register or a precise way of using language that is often specific to educational settings. For example, formal vocabulary, such as *examine* and *cause* that students encounter at school, contrasts with everyday vocabulary such as *look at* and *make* that they encounter in less formal settings (Bailey, 2000b; Cunningham & Moore, 1993).

Cummins (1980) provides a multi-dimensional view of language proficiency by including cognitive demands alongside the formal/informal distinction in his characterization of oral language, a perspective reemphasized by Cummins (2000). The distinction contrasts Basic Interpersonal Communication Skills (BICS), acquired and used in everyday interactions, and Cognitive Academic Language Proficiency (CALP), acquired and used in the context of the classroom. For example, ELL students who are reasonably proficient speakers of everyday (BICS) English, but who have not had as extensive an exposure to complex syntax, idioms, and depth of vocabulary (e.g., antonyms, synonyms, etc.) as native speakers of English of the same age, may find lessons more challenging because their language proficiency levels do not match the demands of the academic language of the classroom. ELL students may easily understand an interrogative sentence such as "Where do you think the fins on a whale are?" because it is the sort of language that they may encounter in everyday speech or in widely read materials, such as newspapers and

magazines. However, the same request for information may be conveyed in very different language in a classroom setting. For example, “What is your best estimate of where the fins are located on a whale?” This version of the question includes not only the unfamiliar use of *best* (to mean *most accurate*) and the formal *are located* for *are*, but also an embedded wh-question in the second clause: “…where the fins are located on a whale?”

Previous CRESST work cited above adds two additional features to the CALP definition of academic language. First, academic language implies the ability to express knowledge by using recognizable verbal and written academic formats. For example, students must learn acceptable, shared ways of presenting information to the teacher so that the teacher can successfully monitor learning. These formats or conventions may or may not be explicitly taught as part of a curriculum, but their use is expected of all students. Second, academic language is most commonly used in decontextualized settings. These are settings where students do not get aid from the immediate environment in order to construct meaning. There is little or no feedback on whether they are making sense to the listener or reader, so students must monitor their own performance (spoken or written) based on abstract representations of others’ knowledge, perspectives, and informational needs (e.g., Snow, 1991; Menyuk, 1995). Therefore, to be "proficient," a student needs to be able to interact in situations in which there may be fewer opportunities to negotiate meaning or to use context than one might find in many social settings. Ultimately, students must learn to recognize and make sense of the varied conventional ways academic material will be presented to them and expected of them in decontextualized settings.

The acquisition of academic language is critical for effectively negotiating the content and interaction of the classroom. Teachers have a range of instructional approaches available to help them support student acquisition of academic language. The discussion now turns to a focus on these approaches.

General Instructional Approaches

As might be expected, the teachers observed in this study employed multiple strategies in teaching content material. These instructional strategies reflected the

individual's experiences, philosophy of teaching and learning, and goals for the curriculum, as well as the teacher's perceptions of a learner's linguistic needs. The review of pedagogical approaches below helps to provide a framework for characterizing the practices observed in the classrooms visited and the academic language associated with these practices.

A constructivist approach to teaching. Constructivists view learning as an active endeavor that involves mental manipulation and revision of existing schema[3]. According to this view, children learn best through active interaction with others and their environment. These interactions lead them to continually assimilate or interpret new information, fitting this information into existing structures or schema (Piaget & Inhelder, 1969). In extending this view to the teaching of academic language, teachers would build on existing schema, in this case less formal language skills, to help students expand their language skills to the academic domain (e.g., Gibbons, 1998).

In addition, according to Piaget (1967/1972), there are three different kinds of knowledge that children acquire through interaction with others and their environment: social arbitrary, physical, and logico-mathematical. He theorized that as children develop cognitively, more language is necessary to support thought structures or schema. As students progress through school and continue to construct and refine their knowledge of the world, they are forced to elaborate their language use in the academic domain. Students are often required to access all three kinds of knowledge to demonstrate their understanding of a given concept. For example, in a science classroom, a teacher may ask students to compare two objects. To do this, students must incorporate social arbitrary knowledge (e.g., use of the terms such as *centimeters*), physical knowledge (e.g., descriptions of the objects), and finally logico-mathematical knowledge (comparison of the objects' various features.) As this example illustrates, academic language cuts across the three types of knowledge.

[3] The term *schema* refers to an individual's working model or current understanding of a given topic. Schemata are constantly revised as individuals encounter new information and experiences. Piaget and Inhelder (1969) describe this revision process of adapting and organizing new information into existing schemata as *assimilation* and *accommodation*. Assimilation refers to adapting existing meaning to a new working model while accommodation refers to changing an existing model to match new information.

Complementary to the constructivist view is Vygotsky's (1962) theory of tool mediation, that is, the construction of meaning not through the manipulation of objects alone, but through social interaction that includes the use of the objects. Vygotsky viewed language as an important tool that mediates understanding. Through language children construct their understanding of reality. In addition, Vygotsky (1978) believed that children learn best through the help of experts who present challenges within a child's zone of proximal development (ZPD), the distance between the child's actual developmental level (what can be currently accomplished independently) and the level of potential development that can be achieved with adult guidance. In the classroom for example, teachers often scaffold activities for students to help them complete tasks through discussion, use of open-ended questions, problem solving, or modeling. (For a recent example of constructionist influence on science instruction, see Polman & Pea, 2001.)

Common components within many constructivist-influenced curricula and that may be evident in the teaching observed for this study are: discussion and active student participation within activities, incorporation of student's prior knowledge, collaborative work, and joint problem solving. Initially, teachers and students may discuss what students already know or wish to know about a thematic subject, and may even create semantic maps or charts to remind students of their learning journey. Teachers may also explicitly teach metacognitive or metalinguistic strategies to help students independently construct knowledge later. Examples of constructivist curricula and practice include: cooperative learning, inquiry or project-based learning (i.e., learning through authentic activities such as the K-W-L model, discussed on page 26), and performance-based assessments.

Direct instruction. Direct instruction also promotes active student involvement within learning. In contrast to constructivist teaching, which encourages students to participate in shaping the content and concentration of the lesson, in direct instruction the teacher explicitly teaches students skills in the desired content area (e.g., Gersten & Carnine, 1986; Rosenshine, 1986; Rosenshine & Stevens, 1986). In addition, direct instruction methods approach content material from "part to whole." For instance, students may learn about the behavior of a specific animal through teacher instruction, then transfer or generalize this understanding to the larger

animal population. In contrast, constructivist methods frequently begin by polling students' prior knowledge about animal behaviors in general and later progress to more specific investigations.

Several direct instruction curricula, such as DISTAR in the reading/language arts, math, and social studies domains (Adams & Engleman, 1996) promote highly regimented and teacher-scripted approaches to learning.[4] Common components of direct instruction curricula that may be evident in the teaching observed in this study include: choral response and repetition of information by students, a rapid pace of instruction, systematic and scripted lessons, and explicit and immediate student correction.

Instructional strategies. In many mainstream classrooms today, teachers use a variety of instructional strategies within an individual lesson in order to convey knowledge, introduce vocabulary, and create mental models for their students. Most teachers use both explicit and implicit approaches by incorporating both constructivist strategies and more directive or behavioral strategies in their teaching. In addition, effective teachers appear to be better attuned to the type of instruction and level of challenge that individual students require (McDonald, Pressley, & Hampston, 1998). They are also better able to coordinate different techniques and to incorporate mini-lessons or serendipitous events into on-going instruction. In addition to choosing appropriate instructional strategies, teachers must select materials and assignments that are challenging yet within different student zones of proximal development.

Many educators and theorists promote teaching strategies that incorporate multiple modalities or multiple intelligences (Gardner, 1993). For instance, students may be guided to construct knowledge via a kinesthetic route through their involvement in physical games and hands-on activities. Teachers may incorporate visual aides such as graphs or diagrams into instruction, use technology to "concretize" concepts, or display artifacts for independent student exploration within the classroom. Indeed, because students have a range of learning styles,

[4] Direct instruction and scripted curricula have been criticized as being reductive literary practices for ELLs (Gutiérrez, Asato, Santos, & Gotanda, 2001). These practices are discussed here because they are used in many mainstream classrooms today.

teachers need multiple instructional strategies to help them acquire academic language proficiency.

Teacher language. Effective instruction requires teachers to combine their pedagogical beliefs and content knowledge with effective instructional discourse. As Wong Fillmore and Snow (2000) write, "Teachers need to understand how to design the classroom language environment so as to optimize language and literacy learning and to avoid linguistic obstacles to content area learning" (p. 8). In presenting material, a teacher must not only have a solid grasp of conceptual information but must also be able to use effective communicative strategies. In addition, teacher awareness of student home language patterns and communication styles is essential (Wong Fillmore & Snow, 2000). Culture and culturally influenced discourse patterns (e.g., Delpit, 1995; Heath, 1983; Philips, 1972) can hinder communication between teachers and students and may increase the risk of misinterpretation or miscomprehension. For some students, academic discourse patterns present greater challenges in understanding content material. Teacher communicative strategies, therefore, are key to students' active construction of new information or knowledge.

There is a tradition of research exploring the social and cultural dynamics found within classroom discourse (e.g., Cazden, 1980; Erickson, 1987; Gee, 1996; Gutiérrez, 1995; Philips, 1972). Using ethnographic methods, researchers have investigated the social organization of classrooms and its influence upon discourse patterns. This report, however, concentrates primarily on the language functions and academic vocabulary that teachers and students use within the classroom.

In summary, the constructivist teaching and direct instruction approaches provide a pedagogical framework for content instruction. The review of this literature shows that effective teachers use a combination of these approaches, tailoring their teaching to their perceptions of individual student learning styles. In addition, effective teachers use language that is appropriate for and effective in conveying information and ideas to students. To focus more specifically on the range of possible language teaching approaches and techniques, the discussion turns next to strategies traditionally used to teach ESL.

Approaches to Teaching English as a Second Language

The techniques and approaches for teaching ESL are examined to provide insight into academic language instruction for all students including native English speakers. Justification for this review of ESL teaching approaches stems from the articulation of *academic language as a second language* for many students. Under this view, academic language is thought to be learned primarily in a formal, structured context rather than in the informal environment of a student's home. Therefore, review of ESL teaching techniques is important to foreground how teachers might use and instruct students in the acquisition of academic language. Indeed, researchers have noted elsewhere that mainstream teachers could and should have exposure to ESL techniques when teaching content area classes (e.g., Kaufman, 1997).

In this section, general language teaching/learning models for ESL are discussed to provide an overview of the variety of basic approaches used by ESL teachers**.** In addition, specific content-based language teaching/learning models are presented to indicate the application of ESL techniques in the service of academic content instruction.

General language teaching/learning models. Most K-12 content-area teachers experience the pressures of teaching ELLs without the benefit of training in ESL methodology. Although methods and approaches for teaching ESL were originally designed for instructing adults, some have been adapted for use with K-12 students and intersect with general instructional pedagogy. (See Echevarria & Graves, 1998, for examples of adaptation.) The grammar-translation method, widely used throughout the world, requires students to learn the grammatical rules of the target language and then translate from one language to the other. It is often combined with elements of the audio-lingual method, which involves direct use of the target language with a great deal of repetition and choral response in that language.

The Natural Approach developed by Krashen and Terrell (1983) stresses the "i + 1 principle" (i refers to L2 input, i.e., input in the second language, in this case English). That is, the teacher uses English at the appropriate difficulty level for the students so that it is comprehensible for them and then gradually adds slightly more

complex and varied linguistic structures to nudge students forward in their acquisition of English. This approach shares much with Vygotsky's ZPD, though the ZPD refers to degrees of cognitive difficulty of tasks regardless of the linguistic structures needed to describe them. Both the Natural Approach and ZPD assume that there is a difference between the student's actual developmental level and the level of potential development or achievement and suggest that teachers scaffold instruction accordingly.

Total Physical Response (TPR), an approach popular in beginning ESL instruction, has teachers give commands (e.g., stand, sit, smile) while the students act out the words physically (Asher, 1982). As the students begin to acquire the vocabulary, sentences become more and more complex, requiring the students to perform multiple actions. The Notional-Functional Approach (Wilkins, 1976; Wilkins, 1979) focuses on language functions (e.g., description, explanation, comparison) and how language use will change depending on the communicative goal (e.g., expository language to convey conceptual knowledge to another person). While all of these approaches influence the work described here to a greater or lesser degree, the functional approach adopted in this research—with its emphasis on relevant academic uses or functions of language across content areas—resonates most with the notional/functional approach to ESL teaching.

Content-based language teaching/learning models. Content-based language teaching/learning models currently used with ELLs offer teachers the opportunity to help students develop and enhance their second language skills within meaningful academic contexts. Schools typically choose from a variety of language programs that are designed to teach language skills concurrently with academic content (Brisk, 1998; Richard-Amato & Snow, 1992; Snow, 2001; Snow & Brinton, 1997). The most commonly practiced programs for ELLs in K-12 schools are (1) ESL pull-out classes, (2) bilingual classes, (3) sheltered content/structured immersion classes, and (4) adjunct classes.

In the ESL pull-out model, students from non-English speaking backgrounds are taught by an ESL specialist. All instruction is in English and students are expected to reach a level of language proficiency that will allow them to be mainstreamed into regular academic programs. Many K-12 ESL programs include

theme-based instruction where language learning is structured around thematic or topical units. Although the themes are not necessarily tied to content-area curricula, many ESL specialists base their thematic units on grade-appropriate learning standards (Gianelli, 1991). The theme dictates a wide variety of language activities that are both contextualized and significant, so students learn grammar and vocabulary in context. For example, it is easier to teach the past tense in a theme-based unit on dinosaurs rather than on a theme-based unit about a type of animal that is not extinct. The past tense is used naturally when talking about dinosaurs (e.g., "When the dinosaurs were alive..."). Teachers are encouraged to create thematic units that interest ELLs and to teach language forms that are used in mainstream classes.

Bilingual classes provide an instructional alternative that incorporates both the first and second languages in classroom activities. There are a variety of bilingual program models that structure the day differently, but in most cases, content (e.g., math, science, social studies) is taught in the students' native language, at least until the students' English language skills are strong enough for them to receive some content instruction in English. While students develop academic proficiency in their native language, they also receive ESL services that support the development of their English language proficiency.

The third model is sheltered content instruction (Echevarria & Graves, 1998) or structured immersion.[5] Content courses are taught in the learner's second language by a content area specialist (e.g., a science or math teacher). Sheltered courses differ from theme-based ESL models because they utilize the curriculum of an already established content course, such as math or social studies. An instructor who is trained in ESL strategies adapts the content materials specifically for the ELLs' linguistic needs. The content teachers are encouraged to use a wide range of instructional strategies (e.g., the use of realia—objects from the real world, including pictures and texts) in their lessons as much as possible to further contextualize academic language.

[5] Structured immersion differs substantively from sheltered content instruction in that with structured immersion, the students share the same first language and may have a teacher who speaks the language and uses it occasionally in the classroom for additional support (Brisk, 1998).

The final model is adjunct learning instruction in which ELL students are enrolled in a sheltered language course that is linked to an integrated content course (Snow, 2001). The sheltered language course allows ELLs to have specialized language instruction in a safe, non-threatening environment while concurrently participating in a content course with native English speakers. In this model, the two courses share the content curriculum and complement each other by coordinating assignments. The adjunct model is collaboration-based and demands extensive coordination between teachers, but it is argued that such integration (especially combined with a constructivist approach) is necessary for the academic success in mathematics and science of language minority students (Kaufman & Brooks, 1996).

All of these content-based models offer possibilities for combined emphases on academic language and content, with the goal being to support the development of both.

ESL techniques to teach academic language. Because all K-12 students must acquire academic language to some degree to be successful in the U.S. educational system, perhaps a second language approach to teaching *academic language* would benefit native speakers and ELLs alike. Students who are proficient in English are expected to acquire academic language as they move from grade to grade without necessarily receiving direct instruction specifically in academic language skills, and they do so presumably with varying degrees of success. ELLs, on the other hand, often receive direct instruction in language, though not necessarily in academic language, through specially designed programs discussed above. Within this context, a question pursued here is: Do mainstream teachers currently support the acquisition of academic language in some of the ways ESL teachers support the acquisition of ESL? An implication of this inquiry is that mainstream teachers could benefit from professional development in proven pedagogical approaches for teaching ESL in an attempt to assure that all students learn academic language. The work reported in this study describes how some mainstream 4th and 5th grade science teachers use academic language in presenting science content to their students. It provides initial insight into their pedagogical approaches to academic language. A discussion of the conceptual framework for the study follows.

Conceptual Framework for Research and Development

In order to capture the nature of the academic language that students encounter in upper elementary science classrooms, four broad language domains are considered: oral academic language exposure, written academic language exposure, oral academic language production, and written academic language production. Academic language exposure and production can also be characterized as input (from teachers) and output (from students), respectively. Academic language exposure experienced by students includes teacher talk and exposure to classroom print materials such as textbooks and worksheets. Academic language production by students includes student talk and print materials produced by students such as essays and completed worksheets.

In addition to the distinctions made above, the communicative-functional approach to language analysis described earlier in the working definition of academic language is also taken. The lexical (word) level that captures the nonspecialized and specialized academic vocabulary and, to a much lesser extent, the structural (sentence complexity) level of talk have also been included in the data analysis for this study. The primary focus on the communicative-intent level is a consequence of the communicative-functional approach lending itself best to the type of data collected, that is, classroom observations in checklist and fieldnote format, rather than audio-recording of verbatim interaction. Verbatim interaction data, on the other hand, is suitable for both communicative-functional analysis and the analysis of the formal structures of language. A revision of this conceptual framework at some future date may include a more extensive articulation of teacher and student talk at all levels of language (e.g., lexical, syntactic, communicative, and discourse features). This possibility is revisited in the final discussion section.

Figure 1 is a matrix that results from the combination of the four language domains (oral / print, exposure / production) with the communicative-functional approach. Together these form the primary conceptual framework that guided this study in terms of data collection strategies and analytic approach. Specifically, both the oral and print domains primarily focus on the identification of communicative intents. These communicative intents differ depending on whether the teacher input

perspective or the student output perspective is taken, although there are shared communicative intents across the two perspectives.

	Oral	Written
Academic language exposure (Input)	Teacher talk (primary focus on communicative intents)	Teacher provided materials, published worksheets, textbooks (primary focus on communicative intents)
Academic language production (Output)	Student talk (primary focus on communicative intents)	Student produced print materials (primary focus on communicative intents)

Figure 1. Conceptual framework of academic language exposure and production.

In the oral domain, the communicative intents comprise (1) language functions (e.g., explanation of a science concept by either teachers or students; assessment on the part of teachers only), (2) repair strategies such as clarification that teachers or students may use to amend their initial communicative attempt if they sense it has gone awry in some manner, and (3) classroom management factors that include directing student behavior on the part of teachers and responding appropriately to questions on the part of students, that will also require students to listen attentively to teacher input.

In the print domain, the communicative intents comprise (1) the functions to which language can be put, and (2) classroom management factors such as teachers directing student behavior during reading/writing tasks and students responding appropriately to teacher questions while reading print and/or producing their own written products. The appropriate response to teacher prompts and questions during writing tasks may even be indicative of students' developing perspective-taking skills. This ability to take into account the eventual reader's degree of knowledge, or lack thereof, is necessary for the development of the decontextualized language so highly desired in academic writing. Note that repair strategies (discussed on p. 57) are unlikely to surface in the print domain because writers have few to no opportunities to amend their writing based on the comprehension (or lack thereof) of their readers (with the notable exception of process writing in which

students prepare and edit drafts based on teacher and/or peer comments). Within the field of science education, student writing has begun to emerge as an important feature of concept instruction and learning. Keys (1999), for example, has argued that writing can foster the development of new scientific understanding because it expands students' conceptual structures. By writing in the different communicative genres of science (e.g., experiment, report) students are able to spend time thinking about science concepts that may lead to the generation of new inferences about science data or information, as well as provide opportunity to verbalize (i.e., put into language in print) their understanding.

Two final considerations in the conceptual framework for research and development in this area are as follows: (1) While interest exists in the field of science education in the quality of content instruction, it is not the intent of this study to evaluate the science instruction observed. Although not all examples of teacher talk are of equal quality and accuracy in terms of their scientific content, the focus here is on whether the examples share formal/functional linguistic properties that can be reliably identified. (2) Academic language production in both the oral and print domains can be thought of as academic language proficiency on the part of students, although this study makes no attempt to assess the quality of academic language produced by any one student. Instead, this study describes a range in the types of academic language students produced during the science lessons observed.

Research Questions

The purpose of this study was to describe the academic language students are exposed to and expected to produce during mainstream 4th and 5th grade science lessons. This information will serve as a baseline for determining the language ELLs must also eventually acquire in order to do well in mainstream science classes. The findings will lead to the development of test specifications and guidelines for curriculum development that focus on academic language.

The overarching research question for this work was: What is the nature of the academic language mainstream students are exposed to and expected to produce in 4th and 5th grade science classes? The conceptual framework above guided the data

collection effort that allowed researchers to begin to answer this research question. Four additional research questions were addressed:

1. What language functions are used by science teachers and in what instructional contexts do they occur?
2. What academic language is used in print materials selected by teachers?
3. What evidence of academic language emerges in student talk?
4. What evidence of academic language emerges in student written products?

The primary focus and effort for this study was to answer Question 1 and, to a lesser extent, begin to explore Questions 2 through 4.

Methods

Participant Schools

The data collection methodology for this study included a series of observations of 4th and 5th grade classrooms within four Southern California public school districts and a publicly funded school not affiliated with a school district. The five schools included in this study represent economically and ethnically diverse populations within the Los Angeles county area. In total, ten classes were observed within the two grade levels for a total of 19 class periods. Two 4th grade classes, four 4th / 5th grade classes, and four 5th grade classes were observed; all but one of these classes were observed twice. One class was observed three times, twice in the primary classroom and once in the science lab. Ten teachers and one technology instructor were observed. One teacher taught two separate classes (one at the 4th and one at the 5th grade level), and two teachers were responsible for teaching the same class in separate periods. Two of the teachers were science specialists and three were men. Table 1 provides the general demographic information for the schools visited.

Table 1

Demographic Information for Schools Visited

School[a]	Student population	ELL population	Ethnicity [b]	% Reduced Lunch	% Credential Teachers	API [c]
Gardner	430	Not available [d]	African American (12%) Asian (12%) Caucasian (49%) Latino (21%) Other (6%)	Not applicable [e]	Not available	Not applicable
Revere	311	19%	Caucasian (83%) Latino (14%) Other (3%)	25%	100%	778
Longfellow	501	18%	Caucasian (60%) Latino (35%) Other (5%)	30%	92%	731
Thoreau	454	41%	African American (20%) Asian (7%) Caucasian (23%) Latino (47%) Other (3%)	71%	81%	614
Florence	227	16%	African American (7%) Asian (7%) Caucasian (58%) Latino (26%) Other (2%)	35%	94%	791

Note. Data taken from 2000 California Academic Performance Index (API) Base Report, http://api.cde.ca.gov, except for Gardner School, a publicly funded school not affiliated with a school district.

[a] The names of schools have been changed for purposes of confidentiality.

[b] API data reports the number of students enrolled in second grade and higher on the first day of testing. The data does not provide information on enrollment levels for students in preK – 1st grade.

[c] API ranges from 200 to 1000. The statewide median score for year 2000 was 675.

[d] Student population for this school includes preK – 1st grade students.

[e] Approximately 115 students (27%) have family incomes < $35, 000.

The percentage of teachers holding credentials varied by school, from approximately 81% to 100%. In addition, student socioeconomic status, measured by free or reduced-price lunch eligibility, ranged widely from 25% to 71% of a school's population. Enrollment by ethnicity also varied among the schools. Although most of the observed classrooms had Caucasian students as the majority ethnic group, Latino students represented a significant proportion of the student population in four out of five schools and were the majority in two of the five

schools.[6] In addition, African American students were significantly represented in one school.

While the choice of classes was general education science, in reality, the English language skills of the students could not be assumed to be uniform across the ten classrooms observed. Indeed, the proportions of ELLs in these general education classes differed considerably, ranging from a few students to more than half of the students in one class; all of these ELL students had been designated by the district as sufficiently proficient in English to be included in a mainstream classroom. While there was no way to independently assess the English language skills of these students, there is some evidence of varied language ability based on teacher instructional strategies and student writing samples, both discussed below.

Instruments

In order to document teacher talk, the Academic Language Exposure Checklist (ALEC), a classroom observation checklist for language use, was developed a priori based on the literature dealing with functional approaches to language use (Austin, 1962; Searle, 1970) and existing instruments. (For a similar instrument designed for teacher use in the classroom, see Chamot & O'Malley, 1994.) The ALEC was revised on an on-going basis to make it a more efficient observation tool. (See Appendix A for the current version of the ALEC.) The current version of ALEC has four main sections. The first section, *Classroom Activities,* contains four questions on classroom activities observed, materials used, and interlocutors addressed. The second section, *Teacher's Language Use in Instruction*, consists of four questions involving oral language functions and academic vocabulary. The third section, *Student Oral Language,* involves five questions on oral language functions, academic vocabulary, and student lack of understanding. The fourth section, *English Only (EO) Versus English Language Learners (ELLs) Practices,* consists of two questions on teacher and ELL/EO language use.

[6] In order for a minority population to be considered significant within the Academic Performance Index (API) Base Report, groups must (1) contain at least 100 students with valid test scores or (2) comprise at least 15% of the school population tested and contains at least 30 students with valid scores.

A second checklist highlighting language complexity and academic language usage was developed for use with print materials (e.g., textbooks, teacher-created worksheets, etc.). (Also see Chamot & O'Malley, 1994, for a materials checklist designed for teachers.) The Academic Language in Materials Checklist (ALMC) was also developed based on the literature. (See Appendix B for the current materials checklist.) The ALMC has four main sections. The first three sections, *Textbooks*, *Worksheets/Handouts*, and *Students' Journals or Homework*, involve questions on sentence structure, academic vocabulary, and language functions. The fourth section, *Student Reaction to Classroom Materials*, contains two questions on student difficulty reading texts and how lack of understanding is signaled.

Procedures

Prior to observations, teachers were notified that the focus of the study would be on the academic language encountered by students during regular science classes. Study participants were asked not to make any special preparations so that—as much as possible—a typical science lesson could be observed. Each classroom was observed twice during regular science periods except for one class that was observed three times. The observations ranged from 40-70 minutes with an average of 55 minutes. There were at least two observers at any given observation to help maximize the breadth and depth of the observation fieldnotes. It was hoped that by having multiple observers, the information transferred to the checklists from the fieldnotes would be a more complete and accurate portrayal of the language used in the classroom interactions. Of the 21 observations, nine had more than two observers.

During observations, researchers sat in different sections of the classroom. Individual researchers used different strategies to complete the ALEC, either recording observations directly onto the checklist, supplemented by fieldnotes or, after the observation, transferring information from fieldnotes to the checklist. During early visits, researchers focused on either teacher or student language. However, as it became apparent that most of the observed language was produced by teachers, researchers primarily focused on teacher talk, capturing as much of the discourse as possible. If teachers were available after class, they were asked if the specialized academic vocabulary used during lessons had been introduced to the

students previously. This allowed observers to differentiate when teachers were introducing new vocabulary from when they were reviewing vocabulary.

The language of the students was primarily noted in terms of student responses and interactions with the teacher in a whole-class setting. As expected, student talk was captured to a lesser extent when students were working individually or in small groups. In both instances, talk between pairs of students or within any one group of students was difficult to capture because of the logistical problem of not being able to hear everything students said to one another. The limited data on student talk in the study made it difficult to draw conclusions about student understanding of concepts and use of academic language.

To form a more complete picture of academic language used within science classrooms, observers collected artifacts that were used during classroom visits. The print items collected consisted of textbooks, teacher-created worksheets, published materials, and website activities. In addition, before each class began, researchers made note of the language used on bulletin boards, posters, and other media presented in the classroom.

Because the research team was interested in the relationship between academic language exposure and academic language production, only student-produced works that were directly related to classroom observations were collected. Three of the ten observed classrooms included substantial student-produced work. Participating teachers in these classrooms gave the research team copies of student essays, science projects, letters, and tests.

Overview of Analytic Approach

Teachers use multiple methods to impart information to the students in their classrooms. In doing so, they use a range of language functions and structures to teach science content material, introduce nonspecialized and specialized academic vocabulary, and prepare students for carrying out classroom activities. The focus here is on the language teachers used to impart information to their students (i.e., carry out communicative intents) across three instructional contexts.

Data Reduction

A number of steps were necessary for data reduction after classroom observations and observer checklists were completed. The first step was to transfer the data from the checklists and open-ended fieldnotes to electronic files. This was accomplished by entering the data into the format of the qualitative software program NUD*IST 4.0 (QSR, 1997). NUD*IST 4.0 allowed for the examination of teacher and student language across observations using the same categories pre-assigned on the ALEC (See Appendix C for a sample of NUD*IST output.)

The next step was to analyze each of the four main sections of the ALEC. The analysis of the data collected with the ALEC followed the sequence below. First, the data from the Classroom Activities section were aggregated to create summaries of each observation (See Appendix D for a sample observation summary.) Then, the individual 4^{th}, $4^{th}/5^{th}$, and 5^{th} grade observation summaries were analyzed and a summary of all of the observations was written for inclusion in this report. (See Summary of Classroom Observations, p. 25.) Next, the section on Teacher's Oral Language Use in Instruction was analyzed. Individual oral language functions and academic vocabulary support categories (i.e., explanation, definition, etc.) were compiled using NUD*IST and then analyzed. After the original ALEC categories were analyzed, additional categories were created in NUD*IST 4.0 as necessary to present a more detailed understanding of teacher oral talk. Finally, the section on Student Oral Language was analyzed in the same manner as teacher oral language. The last section of the checklist, English Only (EO) Versus English Language Learners (ELLs), did not yield enough data for analysis due to the limited observations of ELLs within classrooms. The lack of this type of data, however, was not an issue because ELLs were not the focus of the study. As mentioned above, the focus of the work reported here is on the language all students were exposed to during science lessons in mainstream classrooms.

The final step was to turn our attention to data consisting of print materials that originated with the teacher (output) and student written products from two classrooms. These materials ranged from textbook excerpts to websites and included teacher handwritten class notes and student essays. Four print materials from across the grades and representative of different writing styles were chosen to

be included and analyzed in this report. Random paragraphs were selected for analysis using the ALMC.

Reliability

The task of coding teacher talk was divided among the research team with one team member responsible for the initial coding of a specific part of the ALEC. Given the exploratory nature of this research, coding decisions were then discussed by the entire team to reach consensus. A research analyst blind to the initial coding decision-making process was then trained to independently code 16% of the data in terms of each token's communicative intent, context of instruction, and, where relevant, subtype for vocabulary and process/application instructional contexts. Reliability was calculated as the percentage of agreements divided by agreements and disagreements. Agreement on coding communicative intents was 95%, agreement for coding contexts of instruction was 93%, and agreement for subtypes with vocabulary and process/application instruction was 90%. Future research will need to explore the issue of reliably applying the coding system. In particular, making the operational definitions of the coding categories more explicit with additional new data will allow for greater reliability in identifying vocabulary subtypes where currently most disagreements occurred.

Limitations

Because this study was exploratory, the sample size was relatively small. While the generalizability of the findings were thus limited—possibly making them unique to the classrooms observed—the intent of the study was to begin to develop a methodology for future research of this nature.

The research team did not have permission to audiotape or videotape science lessons. Therefore, as mentioned above, to ensure accurate reporting of language use in the classrooms visited, at least two observers were always present. Student voices were often difficult to hear; thus, observer fieldnotes differed in the amount and detail of student conversation and language.

Data Analysis

Summary of Classroom Observations

In this section, the activities and classroom participant structure captured in the checklists for each of the classroom observations are described. Each of the grades is summarized separately. These summaries are designed to provide background and contextual information for the analysis of academic language to follow.

Fourth Grade Science Classrooms. Two 4th grade science classes were visited. One of the classes focused on planetary sciences at both observations; the other focused on fish morphology and habitat. All of the 4th grade observations involved whole class instruction as well as peer-peer collaboration and/or individual work. Individual work was most often followed up by regrouping the students or pairing them to build on what students had produced alone. The students conducted their own experiment in one of the classes.

An illustration of 4th grade activities and participant structures comes from an observation of one of the planetary science lessons. The planetary science unit in this class was already in progress before the first observation. At the first observation, the teacher activated prior knowledge by having the students sketch something to do with space (three minutes) and then share that sketch with a partner. The whole class then participated in a teacher-led brainstorming session about "what we know for sure" about space. This exercise led to students composing additional questions individually. The teacher called on several students to read their questions aloud to the whole class. Although never overtly stated, the teacher appeared to be using the first two components of the K-W-L model (Ogle, 1986) which is used to remind students what they know (K) already, establish what they want (W) to know next, and then review what they learned (L).

At this point, the lesson shifted to the teacher giving directions for an experiment to prove the earth moves. The class had obviously conducted experiments before because the teacher reviewed a wall chart of the components of an experiment (e.g., title, hypothesis, problem, chart, data, etc.). In addition, the teacher assigned students to three-person teams in which each student took one of the three roles of supply person, engineer, or recorder of the experiment. The

students then began their experiments outside the classroom. The experiments involved the student "engineer" placing an object (e.g., a book, water bottle, etc.) on the playground and using chalk to draw around the shadow created by the object. The teacher then concluded the science lesson by explaining that the teams' recorders would be responsible for checking on the placement of the chalk outline later in the day.

Fourth/fifth grade science classrooms. Four 4th/5th grade combination science classes were observed. One class was observed three times, as discussed previously (p. 19). Two of the classes focused on oceanography at both of the observations; the three remaining classes focused on plant life. One teacher demonstrated an experiment, another class was given directions for conducting an experiment on their own as part of their homework, and in yet another class, students conducted their own experiments. As with the 4th grade observations, classes included whole group instruction, as well as peer-peer collaborations and/or individual work. Language use in the class that comprised a dominant number of ELLs was characterized by a choral response to teacher questions, as well as students calling out questions to the teacher.

The teachers used a wide variety of instructional materials including (1) video documentaries that provoked question and answer sessions pre and post viewing, (2) instruction for using computer software to graph ocean temperatures, (3) science tools—specifically microscopes—to observe the skin of an onion, and (4) an oral quiz asking individual students questions, with the rest of the class serving as an audience. In addition, in some 4th grade lessons, teachers used the K-W-L model.

Fifth grade science classrooms. Observers visited four 5th grade science classes. The four classes covered a range of topics: oceanography, planetary science, food chains, habitats, and mineralogy. The same participant structures were observed as those observed in the 4th grade classes and 4th/5th grade classes. Students in three of the four classes conducted experiments. These experiments included such things as simulating the supply and demand forces on food chains and analyzing the mineral content of sand using hand-held magnifiers. In addition, in two classrooms students were observed graphing the data they had generated.

Science topics across grades. The science topics covered were relatively similar across grades. Science content that combined the 4th and 5th grade Science Content Standards for California Public Schools for physical, life and earth science topics were taught. There were, however, two exceptions: one 4th / 5th grade class and one 5th grade class included units on ocean life such as whales that did not appear in the State Standards at these grade levels. These standards are desired by the state but are offered as guidance and are not obligatory (California State Board of Education, October 1998). Classrooms were also similar in terms of participant structures. However, more experiments were conducted by the students themselves in 5th grade classrooms. The 4th / 5th grade and 5th grade classes also appeared to include more variety in terms of activities (discussion of videos, creation of crossword puzzles, use of magnifying glasses and microscopes, etc.).

Teacher Talk Observed During Science Lessons

Figure 2 provides a visual representation of the categories used for the analysis of teacher talk observed during science lessons. The shaded cells represent the intersection between communicative intent and context of instruction observed. The numbers in the cells represent only a rough indication of the occurrences of oral language functions, repair strategies, and classroom management discourse across the contexts of instruction. Those numbers should be interpreted relative to one another because there was no a priori criterion (i.e., no external reference point) by which to judge whether the frequency of instances is high or low and therefore representative of other science classes at the same grade levels. Moreover, the frequencies in the figures are not exhaustive of the teachers' total communicative intents because the checklist approach was designed to capture only salient examples of the intents and not all instances. Nevertheless, the relative frequencies recorded do reflect the prevalence of one category type relative to another.

Communicative Intent	Context of Instruction									
	Science Instruction	Academic Vocabulary Exposure or Instruction					Process/Application Instruction			
	Concept Instruction	Introduces term using definition	Introduces term using synonym	Introduces term using example	Introduces term using repetition		Presents and ensures students understand task	Presents instructions/ techniques to accomplish task	Presents materials needed to accomplish task	Presents a strategy to help students accomplish task
Oral Language Functions										
Explanation	14	21	9	8	4		1	14	2	2
Description	2	9	4	9	6		3	5	4	
Comparison	15			6	1			2		
Assessment	5		1				5			
Repair Strategies										
Clarification	1	7	1				1	9		2
Paraphrasing	6	2	18[a]	1	N/A[b]					1
Classroom Management										
Directing Instruction			1				8	25		6
Directing Behavior								14		

Note. The unshaded cells indicate that no interaction for those categories was observed. This does not mean that the specific communicative types would not occur in instruction.
[a] Two of these tokens are cross linguistic paraphrases (i.e., Spanish paraphrase of the initial English utterance).
[b] This cell cannot be filled because a paraphrase by definition cannot be a verbatim repeat of a previous utterance, but rather must modify it in some way.

Figure 2. Matrix of individual instances of teacher talk observed during 4th & 5th grade science lessons

As mentioned above, this matrix illustrates the intersection of instructional contexts (the relationship of a given utterance within the larger classroom dialogue) and teacher communicative intents (the purpose of a given utterance). Three categories of instructional contexts appear on the horizontal axis: (1) Science

instruction, (2) Academic vocabulary instruction, and (3) Process/application instruction. On the vertical axis, three categories of communicative intents appear: (1) Oral language functions, (2) Repair strategies, and (3) Classroom management. The shaded cells indicate the number of instances that a specific communicative intent (i.e., explanation, description, etc.) was observed across classroom visits. Moving from the top left-hand corner to the bottom right-hand corner of the matrix, the instructional language becomes less content-area specific (specialized) and more general (nonspecialized).

Context of instruction. For the purposes of this report, teaching practices—the methods teachers use to impart information to students—are defined as (1) science instruction, (2) academic vocabulary exposure and instruction, and (3) process/application instruction. A combination of deductive and inductive approaches was used to formulate these categories. In addition, these approaches capture the variety of instructional contexts observed in 4th and 5th grade science classrooms. Science instruction entails the teaching of content material which includes, but is not limited to, scientific theories, concepts, and facts. Academic vocabulary exposure and instruction includes both nonspecialized and specialized academic vocabulary that may be explicitly or implicitly introduced by the teacher. Finally, process/application instruction involves the multiple teaching practices teachers use to assist students in classroom activities.

Communicative intent. A combination of deductive and inductive approaches to the data analyses enabled the identification of the following salient teacher communicative intents: four oral language functions, two repair strategies, and two classroom management categories.

The four oral language functions identified are: (1) *explanation*, defined as "to make clear or easy to understand by giving information, to give reasons for;" (2) *description*, defined as "to say or write what something is like, to provide a verbal picture;" (3) *comparison*, defined as "to examine or look for differences and/or similarities between two or more things" (adapted from the Cambridge International Dictionary of English, 2001); and (4) *assessment*, which for the purposes of this study is defined as the informal evaluation of students' comprehension and knowledge during the course of a lesson. The critical distinction made in the

operational definitions for this study between an explanation (e.g., plants require sunlight and water for development) and a description (e.g., a sunflower has bright yellow petals and a long green stem) is that an explanation addresses a scientific process whereas a description provides a characterization of a scientific object or phenomenon. These are the functions for which teachers put their language to use in the science classrooms observed in this study. While other functions of language are possible in a classroom context (e.g., summation of what students learn in a lesson), they were not observed in these classrooms.

Repair strategies are those utterances used by a speaker when communication breaks down. They differ from the language functions because their intent is to recommunicate the original language function to make it accessible to the listener. They are interactive in nature in that they usually require some indication on the part of the listener that the communication failed. Teachers, then, will use a repair strategy when they sense that their original utterances failed to adequately transmit the intended information to students. These repairs may be self-initiated on the part of the teacher (e.g., the teacher realizes that students do not understand something by their silence) or they may be other-initiated (e.g., students signal to the teacher that they do not understand) (Schegloff, Jefferson, & Sacks, 1977; Schegloff, 2000). Repair strategies here exclude those instances where teachers reformulate their own ungrammatical sentences. However, in other regards, a broad approach to repairs is taken compared with other applied linguistics research that has confined repair analysis to adjacent or relatively closely occurring utterances (Schegloff, 2000). This is done in order to best capture teachers' attempts to repair their communicative acts by either clarifying (e.g., teachers can clarify by repeating, elaborating, or providing more specificity), or by paraphrasing their previous utterances and/or printed texts used during a lesson or even across lessons.

The two repair strategies identified in the data are (1) *clarification*, defined as "to make clear or easier to understand by giving more details or a simpler explanation," and (2) *paraphrasing*, defined as "to repeat something written or spoken using different words, often in a simpler and shorter form that makes the original meaning clearer" (Cambridge International Dictionary of English, 2001). These repair strategies were used by the teachers in conjunction with any or all of

the language functions, presumably to ensure that students understood the information being presented. Although elaboration is a form of clarification that may occur in the classroom context, teachers were primarily observed clarifying by repeating themselves or providing more specificity (e.g., distinguishing among concepts) in terms of the science concepts, academic vocabulary, or activities they were teaching.

In the literature, paraphrasing has been identified as a form of conversation repair (e.g., Abunahleh et al., 1982). However, in some instances, paraphrasing has a pedagogical purpose that differs from clarification. Although it sometimes appears similar to clarification in that it supports the repair of language functions across instructional contexts and can itself be a form of clarification, it can also function to avoid repair in some instances. By first using language familiar to students and then paraphrasing that language using academic language, some teachers were able to avoid having to repair their explanations and descriptions because they guided and scaffolded students' meaning-making from the outset of the interaction. Because paraphrasing emerged not simply as a repair strategy, but as a substantive pedagogical function as well, both uses are discussed together beginning on page 60.

The two classroom management categories are (1) *directing instruction* and (2) *directing behavior*. Both were identified inductively from the data. Directing instruction refers to occasions when teachers give students explicit instructions during classroom activities, (e.g., "Write your name on the top of the paper"). Directing behavior refers to occasions when teachers give students instructions regarding how they should behave in the classroom, (e.g., "You should be sitting quietly during the movie"). Directing instruction was observed in academic vocabulary instruction and process / application instruction; directing behavior was observed only in process / application instruction.

Science instruction across communicative intents. To facilitate 4th and 5th grade science instruction, teachers used the oral language functions of explanation, description, comparison, and assessment and the repair strategies of clarification and paraphrasing. Explanation and comparison were most frequently recorded on the ALEC and were observed in 8 of the 10 classes. Assessment and paraphrasing were observed in 3 classes, description in 2, and clarification in 1.

Examples of each of the oral language functions are provided below. In the examples, material in square brackets [ ] was added by the researchers to provide contextual information and was not part of the actual teacher/student talk. Information in parenthesis ( ) describes physical actions or classroom activities included in the original transcript. The letters XXX indicate that part of the utterance was unintelligible.

Explanation in science instruction. Explanation was most frequently used to (1) demonstrate scientific relationships, (2) make scientific concepts understandable, and (3) give reasons for scientific theories and experiments.

(1) Teachers explained the scientific relationships of the stars and the sky, predators and prey, and plants and insects, among others. In Example #1, the teacher explains how certain fish might have mutualistic relationships.

Example #1	(4^{th} grade)
Teacher:	Does it have a mutualistic relationship? The clown fish will actually protect the sea anemone. That's a mutualistic relationship.

(2) Teachers also used the language function of explanation to make scientific concepts understandable. Some of the scientific concepts that teachers explained included territorial fish, hybrid plants, plant reproduction, and photosynthesis. In Example #2, the teacher explains the function of roots in a plant.

Example #2	($4^{th}/5^{th}$ grade)
Teacher:	The roots of the plants. Its job is to deliver water. Running up the stem, it only goes one way. It always goes up.

(3) Explanation was used to give the scientific reasons for theories and experiments. In a different $4^{th}/5^{th}$ classroom, the teacher introduced the scientific process of "crossing." He explained to the students that a scientist might take two of the same type of flowers but of different colors and then cross them. This process would produce the same flower but of a third color. The students then interacted in a lab to practice "crossing" paper flowers. After the lab was completed, the teacher

introduced the concept of controlled pollination and then explained the reason why scientists cross flowers and plants as illustrated in Example #3.

Example #3	(4^{th} / 5^{th} grade)
Teacher:	What you did was you controlled the pollination. You crossed your flower with someone else's flower. Scientists do this to produce new types of flowers and fruits.

Description in science instruction. Teachers used description to give students a mental picture of a scientific concept. Teachers described food chains, sand erosion, and plant growth, among others.

One 4^{th} / 5^{th} grade teacher described the process of photosynthesis. She told the students that a plant makes its own food by taking light from the sun. In Example #4, she describes how a plant absorbs light through its leaves.

Example #4	(4^{th} / 5^{th} grade)
Teacher:	It moves. The plant has leaves like a dish, a satellite dish, to get light.

Although this example could be categorized as a comparison, it has a distinct feature that makes it a description. In this case, the teacher likened the leaves of a plant to a satellite dish to help the students see in their minds how the flat and long leaves move toward the sun to absorb as much light as possible. Perhaps the teacher was not trying to compare the mechanical aspects of the satellite dish with a plant, but rather was attempting to paint a detailed, visual picture for her students.

Comparison in science instruction. Comparison was used in 4^{th} and 5^{th} grade science instruction to compare (1) a new scientific theory, concept, or fact to another theory, concept, or fact that is familiar to the students and (2) the similarities and differences among two or more scientific theories, concepts, or facts.

(1) Teachers introduced new scientific theories, concepts, or facts by comparing them to other theories, concepts, or facts that were already familiar to the students. This technique is aligned with the constructivist notion of activating student prior knowledge. In one classroom, a teacher described the differences in the seasons of the Northern and Southern hemispheres. First, he asked the students

what the weather was like in Southern California in the summer. The students replied that it was sunny and hot. Then he asked an English language learner from the Southern Hemisphere what the weather was like in July in her country. She said the weather was cold because it was winter. Finally, to ensure that the comparison had taught the students that seasons are opposite in the Northern and Southern Hemispheres, he asked a comparative question as seen in Example #5.

Example #5	(4^{th} / 5^{th} grade)
Teacher:	When it is summer here, what is the weather in Perth, Australia?
Student:	Opposite season. Winter.

In this example, the language function of comparison serves multiple purposes. The teacher was able to activate student prior knowledge, introduce a new scientific fact, and assess that the concept was learned by using a series of comparative questions.

(2) Teachers frequently compared two or more scientific theories, concepts or facts to presumably ensure that students understood their differences and similarities. This helped students learn how to categorize multiple scientific concepts, for example. Teachers compared the solar system to the digestive system, gray whales to orcas, and omnivores to herbivores and carnivores. One teacher discussed the function of each individual part of a flower with his class. He demonstrated that a plant needs the *stigma* of the flower to reproduce. The function of the *stigma*, then, is to attract *pollen*. In Example #6, the teacher illustrates how a *stigma* attracts *pollen* by comparing it to a *magnet*.

Example #6	(4^{th} / 5^{th} grade)
Teacher:	This right here would be yellow white, called the *stigma*, a sticky part.
	(Teacher uses a diagram shown on an overhead projector.) What does your brain say would be the reason for [the] sticky part?
	Think about a *magnet* (gestures, with hands coming together)
Student:	Something gets stuck.
Teacher:	Yes, something gets stuck. XXX. [A] flower has a *mechanism*, if very colorful 'bzzz' (makes the sound for a bumblebee) *attracted* for [sic] *pollen*.

After the teacher was certain that the students understood how the *stigma* of a flower functioned like a *magnet*, the teacher compared the *stigma* to a previous science unit on whale reproduction.

Example #7	(4^{th} / 5^{th} grade)
Teacher:	Flowers have mechanisms of attraction like whales have *echolocation*.

In Examples #6 and #7, comparison allowed the teacher to demonstrate the interconnectedness of three seemingly different scientific concepts: magnetism, flower reproduction, and whale emission.

Assessment in science instruction. Assessment was used as an informal method of determining (1) student prior knowledge and (2) whether students had learned previously taught scientific concepts.

(1) Many teachers initiated their lessons by asking the students what they already knew about a scientific concept. Assessment was used in this case to determine the students' prior knowledge of a specific science topic. In Example #8, the teacher is very explicit about assessing prior knowledge.

Example #8	(4^{th} / 5^{th} grade)
Teacher:	Can you tell me what you already know?

In the majority of classes, however, the teachers assessed prior knowledge without alerting the students that they were doing so, as in Example #9.

Example #9	(5^{th} grade)
Teacher:	How does sand get to the beaches?
Student 1:	From the waves.
Student 2:	From the beaches.

(2) When teachers began their lessons, they often assessed whether or not students had learned previously taught science material. Teachers assessed whether stars are planets, how sand arrives on beaches, how rocks are formed, and more. In Example #10, the teacher explicitly states that she is assessing a concept that she had previously taught.

Example #10	(4^{th}/5^{th} grade)
Teacher:	What did we learn in our last unit on water properties? What does the ocean water have besides salt that makes it different?

Because the teacher had already taught a unit on water properties, she expected the students to be able to answer her questions. In this example, she also used assessment to connect the new science lesson on ocean movement to the previous lesson on water properties.

Clarification in science instruction. Teachers used clarification to repair misunderstanding of scientific concepts. A 4th/5th grade teacher explicitly explained that scientific models replicate what happens in nature. As the students created a model of river water, she explained to them that the model was not a real river. Scientific models allowed students to understand how rivers worked in nature without having to visit an actual river. At a subsequent class meeting, the teacher opened the lesson by explaining that the students would make a model of the ocean. In Example #11, a student asks the following question:

Example #11	(4th/5th grade)
Student:	Are we studying the ocean?
Teacher:	We're not studying the ocean. We're doing a model. Remember our other experiment? Did we go to the river?

Because the teacher had already explained the purpose of models in the previous lesson, she initiated a repair to clarify the distinction between scientific models and nature.

In summary, the science instruction observed involved four oral language functions: explanation, description, comparison, and assessment. These functions possibly act as conduits by which scientific concepts are presented to students. The use of these functions by teachers likely facilitates student understanding of the scientific concepts because they are organized in that the same sequence of four functions is largely used and repeatedly so to eventually become predictable to students. Science instruction in the classrooms visited also involved two repair strategies: clarification and paraphrasing. As mentioned previously, because of its

apparent substantive pedagogical contribution, discussion of paraphrasing in science instruction is reserved until page 60. The classroom management categories were not used in science instruction. The next section describes academic vocabulary instruction across the three communicative intents.

Academic vocabulary across communicative intents. This section addresses three main areas: (1) ways teachers support academic vocabulary learning, (2) the concurrent use of different supports within teacher talk, and (3) other language demands at the lexical level.

(1) Four types of academic vocabulary supports. The academic vocabulary noted, both nonspecialized and specialized, was part of teacher talk. There was generally no effort on the part of the teacher to highlight individual words unless a new science term was being introduced. In Example #12, using multiple academic vocabulary words as indicated by italics, the teacher described the materials needed for an activity.

Example #12	(4^{th} / 5^{th} grade)
Teacher:	You will need a clear bottle or jar. Whatever the *container* is, it must have a lid that tightens *securely*. You need *mineral oil* and you can get it from the *pharmacy*. You also need water. Will you have any trouble getting water?
Student:	No.
Teacher:	A*quarium putty*. It's *optional*. *Aquarium putty*. Do you know what I am talking about? It *seals* so it won't leak.
Student:	I have something like that. It's clear. It dries. It holds the *aquarium* together.

When support was used, teachers employed a range of techniques to help students understand the meanings of words. Much of this support can be characterized as either definitions (see Example #13), synonyms (see Example #15), examples (see Example #19), or repetition (see Example #22) by the teacher. Two additional types of support that teachers used to heighten student awareness were (1) to explicitly call attention to new vocabulary by indicating to students that a specific word was important for them to know, but not necessarily elaborating further and then (2) to ask students to practice saying the term. For example, a 4^{th} / 5^{th} grade teacher highlighted the specialized term, *photosynthesis*, by saying to her

students, "That's one of those fifty dollar words." She then asked them to practice the term by repeating it.

The vocabulary support varied in the level of explicitness. Explicit support is direct and exact assistance. In the data for this study, explicit support generally took the form of a definition: "A *drought* means a lack of water." By contrast, implicit support merely hints at or suggests but does not directly state the meaning of a word. Students must infer the meaning of a word from the context. Implicit support generally takes the form of an example, synonym, or repetition of the word. A teacher may indicate by example what happens when a drought occurs instead of defining the term explicitly: "When there is a *drought*, the grass and trees are extremely dry, and fires are a dangerous possibility." As another form of support, a teacher may offer a synonym for *drought*, such as *dry spell*, or may also repeat the term *drought* throughout the lesson as a way of emphasizing the new vocabulary word once it has been defined either explicitly, implicitly, or not at all.

Discussions of the four types of academic vocabulary supports observed in this study follow. The discussions help illustrate the complex interactions between academic vocabulary support and oral language functions.

1. Definition

The observed teachers frequently gave informal rather than explicit definitions[7] for new specialized vocabulary words. Although they often defined a term, their verbal definitions rarely took the form of formal, dictionary definitions. Nonspecialized words were rarely defined explicitly and were often not defined at all. Nonspecialized academic vocabulary words were typically not the focal point of a discussion. Instead, the words were used in the course of explaining or describing a specialized term or concept. For example, a 4th grade teacher asked her class, "What is a *system*?" When students looked in the glossary for a definition, they found two entries divided by a semicolon. The teacher explained, "The *semicolon* tells you there's a break."

[7] The definitions that teachers provided were not necessarily complete or fully accurate, but do illustrate the use of definition by teachers in the study.

Also, a common strategy seen across grade levels was the use of teacher questions in order to garner definitions. This may be an attempt by the teacher to assess student understanding. In the majority of these instances, students were asked to give a definition of a specialized term, often by reading from their existing science notebooks or textbook glossaries. For example, 4th grade students were asked to define the term *gravity*: "What's *gravity* mean?"

On occasion, teachers also defined a term by breaking it into meaningful parts. For example, a 4th / 5th grade teacher explained the term *photosynthesis* by telling students, "All kinds of plants have different ways to get light. In Greek, *photo* means light…*synthesis* means put together. Put together light." In this way, the teachers provided a definition to support student understanding of new vocabulary while supplying students with word-analysis tools or strategies for later learning.

Additional examples of the use of definition to support student learning follow.

Definition in explanation

In Example #13, the teacher explains the word *sustain* by offering the explicit definition, "It means you keep going and going."

Example #13	(4th grade)
Teacher:	(Speaking to an individual student) Do you know what it means to *sustain*? It means you keep going and going. Think of the tuna…

Definition in description

The teacher in Example #6 on page 35 gave his students a definition of the *stigma* of a flower, "This right here would be yellow white, called the *stigma*, a sticky part." By describing what it looked like ("yellow white") and how it felt ("sticky"), he was able to describe and define the specialized term, *stigma*. He then proceeded to describe the purpose of a *stigma* in plant reproduction: "A flower has a *mechanism*, if very colorful, buzzz..." The teacher made the sound of a bumblebee buzzing and then said, "*Attracted* for [sic] *pollen*."

Definition in clarification

In Example #14, the teacher had previously taught the students the meaning of the specialized term *vacuole*. In order to review the term's definition, the teacher asks the students the following question:

Example #14	(4th / 5th grade)
Teacher:	What is a *vacuole*?
Student:	A brain.
Teacher:	The *vacuole* isn't a brain. It stores food and nutrients for the cell.

Because the student answered that a *vacuole* was "a brain," the teacher realized she needed to make a conversational repair to clarify how the function of a plant cell *vacuole* differed from the function of a cell nucleus or the brain. First, she initiated the repair by stating, "The *vacuole* isn't a brain." This alerted the student that his understanding of the teacher's original definition of *vacuole* was incorrect. Then, she repaired the misunderstanding by clarifying that "It stores food and nutrients for the cell."

Paraphrasing is discussed beginning on page 60. None of these teachers was observed using comparison or assessment to define academic vocabulary.

2. Synonym

Teachers in all grades used synonyms as a means to support academic vocabulary learning. In general, teachers supplied synonyms for academic vocabulary within conversation without explicitly stating that they were providing a synonym for understanding.

Synonyms in explanation

One 5th grade teacher used the word *solar* as a synonym for *sun* explaining, "but I like the word *solar*, it is a science word." The teacher wrote the word *solar* in brackets after *sun* on the blackboard to highlight the synonymous relationship of the two words.

Synonyms in description

In Example #15, the teacher describes the *powder* he observed in Griffith Park, and a student offers the synonym *pollen*. The teacher then uses the conjunction *or* to reinforce that *pollen* and *special powder* are synonymous.

Example #15	(4th / 5th grade)
Teacher:	I go to Griffith Park and observe. I see all this *powder*...
Student:	*Pollen*.
Teacher:	Why would I need *pollen* or *special powder* to reproduce?

Synonyms in assessment

Synonyms were also used to assess whether students understood the lesson. In Example #16 a teacher offers the synonym *handwriting* when she feels students may not have understood the term *cursive.*

Example #16	(4th / 5th grade)
Teacher:	Anyone having trouble reading the *cursive*? *Handwriting*?

Synonyms in clarification

After teachers explicitly defined a specialized term, they expected the students to use the term. Sometimes, the students offered nonspecialized synonyms instead of the target vocabulary word. In one 5th grade class, the teacher asked the children what deer need to survive. Students offered "food," "water," and one student answered "space." In Example #17, the teacher initiates a repair to clarify the distinction between the nonspecialized term, *space*, and the specialized term, *shelter*.

Example #17	(5th grade)
Student:	*Space.*
Teacher:	What is that called? *Shelter.*

The teacher alerted the student that his response was not entirely correct by asking, "What is that called?" He then finished the repair by stating the target word, *shelter.*

Synonyms in directing instruction

In one instance, a teacher demonstrated a science experiment that investigated the density of salt and fresh water. The teacher used synonyms to clarify task instructions. While directing instruction (Example #18), the teacher used the nonspecialized academic words, *explain, conclusion,* and *judgment*. When the students were ready to write in their science journals, the teacher asked:

Example #18	(4^{th} / 5^{th} grade)
Teacher:	How do you think we can *explain*? Remember how we said you need to make a *conclusion* or *judgment*?

Teachers were not observed using synonyms with the language function of comparison.

Visual synonyms

In addition to using verbal synonyms, teachers also used visual synonyms to support vocabulary learning. This technique is similar to the Total Physical Response (TPR) method used primarily in ESL classrooms. For example, a 4^{th} / 5^{th} grade teacher discussed the behaviors of spiders in Costa Rica stating, "Wasps would land on the web and lay an egg on the spider's *abdomen*." While telling students this, she placed a hand on her own abdominal region.

3. Example

Teachers also used examples to support academic vocabulary. In order for students to use these examples as a tool for understanding academic terms, however, they must use their world knowledge or prior experiences. In some instances, teachers may incorrectly assume that a student will understand their inferences or examples. These examples may not clarify a word's meaning but complicate or increase language demands even further, especially so if the student does not share the same sociocultural context with the teacher (e.g., Fradd & Lee, 1999).

Examples in explanation

In Example #19, students need to know that Big Bear is a Southern California ski area. The teacher refers to Big Bear in order to explain the specialized vocabulary term, *sea level.*

Example #19	(4th / 5th grade)
Teacher:	We *measure* a lot of things with *sea level*.
Teacher:	Big Bear is 4000 feet above *sea level*.

Examples in description

During a discussion about whale blubber, a teacher offered examples to help her students understand the meaning of the term *dense*. In Example #20, rich descriptions are provided to compare angel food cake ("that's not very *dense*") to brownies ("much more *dense*"). Using this strategy, the teacher also repeats the term *dense* several times, finally summarizing that "*dense* is very thick and heavy."

Example #20	(5th grade)
Teacher:	[Blubber] is high *density* fat. That is no air, *dense*. XXX.
	Angel food. That's not *dense*. How about a brownie? Much more *dense.* XXX.
	Dense is very thick and heavy.

Examples in comparison

To demonstrate the purpose of a fish's *pelvic fin* in Example #21, the teacher compares it to a football. First, the teacher uses a model of a fish to elicit the name of the pelvic fin. In addition, the teacher reminds students of a mnemonic strategy for remembering the fin's name.

Example #21	(4th grade)
Teacher:	Remember 'Elvis the Pelvis'?
Student 1:	(Answering the teacher) The *pelvic fin*.
Student 2:	It helps it from spinning around.
Teacher:	(The teacher demonstrates how the pelvic fin stabilizes a fish using the model.) Like a *football*.

Assessment, clarification, and paraphrasing were not observed in the introduction of new terms using examples.

4. Repetition

Repetition as a support for academic language learning occurred throughout a given lesson and most often in conjunction with other functions, as illustrated in Example #20 above. Although teachers repeated specialized academic vocabulary within a lesson, rarely was a nonspecialized academic vocabulary word repeated. In only one class were students asked to orally repeat specialized academic vocabulary words as a class. It is important to note that roughly half of the students within this class were ELLs. An example from this lesson is given below.

Repetition in explanation and description

In Example #22, the teacher both explains and describes the specialized content words *phloem* and *xylem*.

Example #22	(4^{th} / 5^{th} grade)
Teacher:	Plants are just these wonderful *factories*. Now, hold this up. They *drive* the food and the water through *bundles*. The *bundles* are *phloem* and *xylem*.
	(The teacher shows a drawing / diagram with labels of this process.)
Teacher:	The *xylem*. Can you all say *xylem*?
Students:	*Xylem*.
Teacher:	It's blue and *represents* water. Its job is to *deliver* water to the plant. And *running* up the stem, *running* up the plant...

In this example, the teacher explains that the *xylem* delivers water to the plant. The teacher also describes how plants are like *factories* that move food and water through *bundles*: the *phloem* and the *xylem*. It is important to notice that the teacher focused on specialized vocabulary words only (*xylem* and *phloem*). Note that the nonspecialized words (*factories, drive, bundles, represents, deliver,* and *running*) are not explained by the teacher. Moreover, *drive* and *running* are used in an obscure (non-literal) way. Although these words are almost certainly familiar to 4^{th} and 5^{th} grade students, the use of these terms in the above example may be novel.

Repetition in explanation

In Example #23, the teacher begins explaining the term *levels* by using it repeatedly, but provides a clue when the repetition fails to communicate the term's meaning.

Example #23	(4^{th} / 5^{th} grade)
Teacher:	How many *levels* are there in the ocean? (Teacher repeats this several times.)
Student:	What do you mean by *levels*?
Teacher:	Maybe you'll need to figure out. XXX.
	It's hotter at the top, colder at the bottom.
	How many *levels* are there? Two?

Comparison, assessment, and clarification were not observed in use with repetition to introduce new vocabulary terms.

(2) *Concurrent use of supports in teacher talk.* Teachers occasionally used the above strategies of definition, synonym, repetition, and example concurrently. In the following example, students were asked to write about a fictional fish. Students were to describe the fish's character traits. Before students began writing their essays, the teacher led a discussion on fish habits, and provided examples and definitions for the terms *territorial* and *solitary*.

Example #24	(4th grade)
Teacher:	Okay, the *Gariboldi* we saw in the *aquarium protected* his *territory*. Your fish may be *territorial.*
	Solitary. Some of you play *Solitaire*, the card game. You play it alone. So *solitary* means by itself.

In Example #24, the teacher used variant forms (words derived from the same root) of the terms *territory* and *solitary*. In the first statement, she provided an example using the terms, *territory* and *territorial*. In the second statement, the teacher defines *solitary*, using the term *solitaire*. Several of the teachers observed for this study used variant forms of academic vocabulary words, in general without support. Therefore, language demands may arise not only from the introduction of new vocabulary, but also from the use of variant forms, homophones, and idiomatic phrases within discourse.

(3) *Other language demands at the lexical level.* Students in this study encountered homophones within classroom discourse. In one 4th / 5th grade classroom, the teacher explicitly told his students that the new vocabulary word, *pistil*, was a homophone stating, "*Pistil* of the plant, sounds like *pistol*, but it's not. It's a different spelling. It's a homophone that sounds the same."

In addition, idiomatic phrases were observed in teacher talk across grade levels. Although idioms are not classified as academic vocabulary, their use can increase a lesson's language demand. In the course of a 4th / 5th grade class discussion about the video, *Voyage of the Mimi* (Bank Street College of Education, 1984), a teacher described one of the characters as having difficulty working with others. She told the class, "It is not his *cup of tea*, but he is trying." A 5th grade teacher used the phrase, "pang of honesty" while discussing a class game where students acted as deer trying to find food. A few teachers incorporated idioms into their discourse, perhaps in an effort to create a level of familiarity or informal rapport with their students. For example, one 5th grade teacher used the idioms "up the ante," "divvy the load," "tad of info," and "eager beavers" all within one lesson.

In summary, additional language demands for students result from the volume of academic vocabulary found within teacher utterances. Academic vocabulary terms, both nonspecialized and specialized, rarely occur in isolation. Instead, as the examples from this section illustrate, teacher talk is made more complex due to the density of academic vocabulary. Students then may require more teacher support in the form of definitions, synonyms, examples, and repetition when learning new academic vocabulary. Students may also encounter difficulty processing homophones, idiomatic phrases, or slang.

In the following section, the four Process / Application Instruction categories are explored.

Process/application instruction across communicative intents. After introducing students to new content material and vocabulary, teachers used a variety of teaching practices to prepare students for participation in classroom activities. Explicit instructions from teachers helped students to understand the task and the actions necessary to complete the task. This aspect of instruction is designated

process/application instruction. The data show process/application instruction to be similar to both science and academic vocabulary instruction in teacher use of multiple language functions and repair strategies. However, process/application instruction differed from science and vocabulary instruction in that the classroom management categories were more frequently observed.

The practices teachers used in process/application instruction are organized into four categories that were derived inductively from the data and did not originally appear on the checklist. The process/application categories are located on the right side of the first row of Figure 2 (p. 29). The categories are: (1) teacher presents and ensures students understand the task, (2) teacher presents instructions and techniques to accomplish the task, (3) teacher presents materials needed to accomplish the task, and (4) teacher presents a strategy to help students accomplish the task. These categories describe the ways teachers used language to guide students through classroom activities. Each category is discussed below, with specific reference to relevant language functions, repair strategies, and classroom management.

(1) *Teacher presents and ensures students understand task.* Teachers utilized three oral language functions, one repair strategy, and one of the classroom management categories to present and ensure that students understood the task they were asked to perform. Directing instruction was recorded in 4 of the 10 classes, assessment in 3, description in 2, and explanation and clarification in 1. Teachers were not observed using comparison or directing behavior to present or ensure understanding of a task.

Explanation to understand task. Teachers used explanation to introduce science lesson topics. In Example #25, a teacher begins the lesson by explaining that students will analyze the mineral content of sand.

Example #25	(5^{th} grade)
Teacher:	Today we are going to analyze sand. What kind of rock it comes from and look at its mineral content. Sand is made from rocks.

In this example, the teacher explicitly states the scientific content of the lesson (the mineral content of sand) while simultaneously introducing the task (sand analysis).

Description to understand task. Description was used by teachers to relate a "real-life" story to current or previous class work. The teachers described anecdotes to show the students that science is not isolated to the classroom, but is also connected to the real world. One $4^{th}/5^{th}$ grade teacher introduced a lesson on ocean water movement by describing the saltwater aquarium her husband has at home. In another 5^{th} grade class, the teacher began the lesson by reading a postcard. It had been sent from a marine biologist who had been a guest speaker in the class a few weeks before. The teacher went on to describe a newspaper article about cooking calamari that was written by the same biologist. Although the topic of the lesson was not calamari, the teacher began the lesson with a "real-life" story of a marine biologist's varied job duties to connect the science of the classroom with the real world, a strategy to promote student interest and activate possible prior knowledge.

Assessment to understand task. After a task was introduced, teachers used assessment to see if students understood what was expected of them. In one 5^{th} grade class, the students were expected to work together as a group to fill out the first two columns of a K-W-L chart on the earth. In Example #26, the teacher decides to assess whether students have learned what the acronym K-W-L means to ensure they understand the task.

Example #26	(5^{th} grade)
Teacher:	Which [column of the K-W-L chart] is not going to have anything in it?
Student:	L. What we learned.

Since the student answered her question correctly, the teacher felt that the class understood the task and was prepared to move forward.

Clarification to understand task. Teachers used clarification to demonstrate the meaning and purpose of lab experiments. In Example #11 on page 37, a $4^{th}/5^{th}$ teacher clarified the conceptual distinction between scientific models and natural occurrences. This same example also serves to illustrate clarification of the purpose

of the task. In the beginning of the lesson, the teacher stated that the students would create a model of the ocean. When it became apparent that some students were still not clear about the task's purpose (Student: "Are we studying the ocean?"), the teacher provided the repair ("We're not studying the ocean [itself]. We're doing a model.")

Directing instruction to understand task. Another way teachers attempted to ensure that students understood the task was to model how it should be completed. In directing instruction, teachers explicitly demonstrated to the students how to complete each step of the task correctly. Some teachers were observed modeling how to do entire lab experiments from start to finish. For example, one teacher used an entire class period to model how to conduct a sand analysis experiment. Other teachers modeled more minute aspects of a task. In Example #27, a teacher models the specific sentence structure students can use when answering lab questions.

Example #27	(4^{th} / 5^{th} grade)
Teacher:	*Relate* back to [the] *hypothesis*. For example, my *hypothesis* worked because… Think about the oceans and *relate* your *experiment* to that.

In Example #28, another teacher directed students to generate questions about plants.

Example #28	(4^{th} / 5^{th} grade)
Teacher:	Fill the paper. You'll be able to put at least five questions. This is my question: What came first, plants or animals?

In this example, the teacher began with a general direction to "Fill the paper." Then he gave the more detailed direction to "put at least five questions." Finally, to ensure that the students understood what was expected of them, he modeled a sample question, "What came first, plants or animals?" If the teacher had only directed the students to "Fill the paper," it would have been very difficult for his students to complete the task properly.

(2) Teacher presents instructions and techniques to accomplish task. Teachers used three oral language functions, one repair strategy, and both classroom management

categories to present the instructions and techniques students needed to accomplish tasks. Directing instruction was recorded in 9 of the 10 classes, explanation in 7, clarification and directing behavior in 6, description in 5, and comparison in 2 classes. Teachers were not observed using assessment to present instructions.

Explanation to accomplish task. Explanation was used to present students with instructions to help them accomplish tasks. Teachers explained how to create a model of the ocean, participate in a food chain game, categorize knowledge about the earth, produce a sea creature crossword puzzle, and more. In Example #29, a teacher explains how students should use their worksheets to discover if a sand sample contains coral. In this lab, students were required to consult a series of questions on a worksheet to discover the composition of their sand sample. The teacher explained how to complete the task by using a worksheet to make scientific inductions about the mineral content of sand.

Example #29	(5th grade)
Teacher:	I know it's coral because watch: Question nineteen says, "Grains show many small rounded holes."
Students:	(The class confirmed that their sand samples showed small rounded holes.)
Teacher:	Okay, go to twenty and question twenty says, "Grains are composed of coral."

In this example, the teacher explains how to complete the task by explaining how to use the worksheet to make scientific inductions about the mineral content of sand.

Description to accomplish task. Description was also used to present instructions and techniques for accomplishing tasks. Teachers described how to invent new fish species, create models of the ocean, use the software program Excel, and more. In Example #30, the teacher describes how students will participate in a lab demonstration on whale blubber.

Example #30	(5th grade)
Teacher:	We're going to do two things today. Here's a bucket with ice cold water. You'll put one hand in [the water] with imitation blubber and the other hand

> bare. Can you feel the difference? Is the blubber working?

After describing what the students would do, the teacher then described the questions students should ask themselves to draw conclusions about whale blubber. Thus, the teacher described not only the physical actions necessary to complete the blubber lab, but the mental actions as well.

Comparison to accomplish task. Teachers used comparison to ensure that students understood how to accomplish the task correctly. Comparison was used to explain (1) task directions and (2) methods of assessment.

(1) Teachers compared task directions to ensure that students understood the correct method for completing activities. In a $4^{th}/5^{th}$ grade class, the teacher expected students to write descriptive conclusions about a lab demonstration on ocean water. To ensure that the students wrote the conclusion correctly, she asked them to write, "What you SEE, not what you DID."

(2) Teachers also used comparison to explain how tasks would be assessed. The same teacher mentioned above also used comparison to explain her grading system. She told her students that their lab on salt water would be evaluated "on a 3, 2, 1 scale." She then went on to compare a "3" point lab (meaning excellent) with a "1" point lab. By comparing the types of grades students would receive, she ensured that the class knew how the task would be evaluated.

Clarification to accomplish task. Clarification was used to ensure that students understood the instructions for accomplishing tasks. Task clarifications were observed in nine instances. Six of the clarifications were student initiated and three were teacher initiated. In Example #31, the teacher gives instructions for the students to "cross" flowers[8]. After the teacher presents task instructions, the students ask many questions about the assignment. Student 3 initiates a conversation repair to clarify the instructions.

[8] See Example #3 (p. 33) for a description of the flower crossing task.

Example #31	(4^{th} / 5^{th} grade)
Teacher:	Draw petals of a flower like this. Flowers [must be the] same types. Important [that they are] the same.
	(The teacher continued to give instructions for the class demonstration of flower crossing.)
Student 1:	We do it?
Teacher:	Yes, that's why it's called crossing.
Student 2:	White [and] red [flowers] cross. Would [the] flower be pink?
Teacher:	That's a possibility.
	(The teacher gives the children an example of a red flower and blue flower being crossed.)
Student 3:	Does it matter if it's a different flower?
Teacher:	Yes, it must be the same type of flower.

Because the teacher had already explained to the students that the flowers must be the same type to be crossed, the student's question was an initiation of a repair. The teacher repaired the communication failure by restating his original direction, "Yes, it must be the same type of flower."

In another 4^{th} / 5^{th} grade class, the students used microscopes to look at the cells of an onion. As the students conducted the lab experiment, the teacher initiates a clarification of the task as shown in Example #32.

Example #32	(4^{th} / 5^{th} grade)
Teacher:	(To an individual student) You're supposed to observe and write on your paper.

In this example, the teacher has assumed that the students understood the original directions presented, "observe and write on your paper." The clarifying repair is highlighted by the marker, "You're supposed to," because within it is the implication that the students should *already* know the task directions.

Directing instruction to accomplish task. Teachers used directing instruction to give specific, detailed instructions for accomplishing tasks. Directing instruction was used to instruct students in the (1) completion of assignments and (2) participation in games.

(1) Teachers gave detailed instructions to help students complete assignments. Students were directed to draw circles, place straws in water, copy vocabulary words from the overhead, and glue graph paper to lab worksheets. In

Example #33, a teacher directs instruction for an experiment on ocean water that the students are expected to do at home:

Example #33	(4^{th} / 5^{th} grade)
Teacher:	The jar or bottle must have a lid that tightens securely. (The teacher gave instructions on how to prepare the experiment.)
Teacher:	1. Add tap water. 2. Add blue food coloring.

In this example, the teacher discussed the specific instructions students would follow to create a model of the ocean.

(2) Directing instruction was also used to instruct students in the rules of games. One 5^{th} grade teacher prepared students for a quiz on oceanography and whales by playing a review game. Before the game began, she explicitly explained the rules the students needed to follow. In another class, a teacher used a game called "Oh, Deer" to demonstrate the fragility of the ecosystem. In the game, some students were deer and others were food, water, and shelter. In Example #34, the teacher gives the following instructions for the "deer" to recognize food, water, and shelter during the game:

Example #34	(4^{th} / 5^{th} grade)
Teacher:	Let me show you the symbols we are going to use. Hands over stomach [means] food. Hands over mouth [means] water. Hands over head [means] shelter.

By participating in the game, students were supposed to learn that if there were not enough food, water and shelter for the current deer population, some deer would die. Because the students had been given detailed instructions, they were able to accomplish the task and participate in the game correctly. Thus, the students were able to draw conclusions about the fragility of ecosystems.

Directing behavior to accomplish task. Directing behavior was used to define the appropriate social roles students needed to complete a task. Teachers used directing behavior to remind students to raise their hands, to control their "lips and legs," and

to take turns when writing in pairs. In Example #35, the teacher directs the oral performance of a student.

Example #35	(4th / 5th grade)
Teacher:	Speak so T. and B. can hear you. (T. and B. were two students located across the classroom.)

In Example #36, a 5th grade teacher defines the class' social role prior to a group of students reporting their findings to the class.

Example #36	(5th grade)
Teacher:	Remember, you are an audience now.

In this example, the teacher assumed the students had been taught how audience members should act, so she did not define the specific behaviors she expected of them.

(3) *Teacher presents materials needed to accomplish task.* To present the materials needed to accomplish a task, teachers used two oral language functions only: explanation in 2 of the 10 classes and description in 3.

Explanation of materials needed. Explanation was used to present the materials students would need to complete classroom activities. Teachers explained that students would need to use nutrition charts, web sites, microscopes, mineral oil, lab books, magnets, and other materials. The 4th / 5th grade teacher in Example #37 explains how students should study the materials found at their lab tables.

Example #37	(4th / 5th grade)
Teacher:	Pay attention to underlined parts. At your table, find this sheet. Nutrition chart, vitamin and food source.

The teacher explains how to use the materials before she asks the students to look at them.

Description of materials needed. Description was also used to introduce materials students needed to accomplish tasks. Teachers described a "blubber-like glove / mitt" that would be used to simulate whale blubber, a sand sample taken

from a "mystery" beach for analysis, and others. In Example #12 (p. 38), a teacher described the steps students would need to construct a model of the ocean. In Example #38, she describes the materials the students need to build the model.

Example #38	(4^{th} & 5^{th} grade)
Teacher:	You will need a clear bottle or jar. Whatever the *container* is, it must have a lid that tightens *securely*. You need *mineral oil* and you can get it from the *pharmacy*. You also need water. Will you have any trouble getting water?
Student:	No.
Teacher:	A*quarium putty*. It's *optional*. *Aquarium putty*. Do you know what I am talking about? It *seals* so it won't leak.
Student:	I have something like that. It's clear. It dries. It holds the *aquarium* together.

The teacher did not have a clear bottle or aquarium putty to show the class. Therefore, she decided to describe the materials so the students would know what they needed to acquire to accomplish the task.

(4) *Teacher presents a strategy to help students accomplish task.* This category of process/application instruction involves a teacher encouraging students to use metacognitive reflection on their own learning processes. This is in contrast to simply giving directions on how to perform a task. Teachers used one oral language function, two repair strategies, and one of the classroom management categories to present strategies to help students accomplish tasks. Explanation and directing instruction were used in 3 of the 10 classes. Clarification was used in 2 of the classes and paraphrasing in 1. Teachers were not observed using description, comparison, assessment, or directing behavior to present strategies to help students accomplish tasks.

Explanation of learning strategy. Explanation was used to help students apply strategies to accomplish tasks. Fifth grade students were expected to place various animals into three categories: carnivores, herbivores, and omnivores. Students discovered that it was difficult to classify fish because some fish were carnivores and others were herbivores. The teacher explained that science is often "fuzzy—not cut and dry" conveying in less formal, idiomatic language that there may be multiple answers to one scientific question. By explaining that the study of science is often

fuzzy, the teacher gave students a new way of thinking about science. This new schema for the organization of their knowledge of science may help with successful completion of the science task. In Example #39, a 4th / 5th grade teacher explained the following mnemonic strategy to help students remember which axis of a graph was X and which was Y.

Example #39	(4th & 5th grade)
Teacher:	I have a hard time [remembering which axis is the Y axis.] My husband helped me to remember. The Y-axis has a tail.

Clarification of learning strategy. Clarification was used to present strategies to help students accomplish tasks. One 4th / 5th grade teacher wanted the students to write detailed paragraphs about the lab experiment they had conducted. First, she directed students to describe what they had observed. Then, she initiated a self-repair of the direction by clarifying that *describe* meant "picture the thing in the mind." This repair of the initial description gave the students a strategy to help them write detailed paragraphs about their lab experiments.

Directing instruction to apply learning strategy. Teachers also used directing instruction to show students how to accomplish tasks by applying strategies. Directing instruction differs from explanation because teachers do not explain why students should apply strategies. In Example #40, a teacher provided the following strategies for reading scientific text:

Example #40	(4th & 5th grade)
Teacher:	First you just tell what you see. Look at page 18, the pictures, and anticipate—think in advance—what you might read.

The teacher does not explicitly state why anticipation is an effective reading strategy for accomplishing tasks.

In Example #41, a teacher presents the strategy students should use when answering questions on a test.

Example #41 (5th grade)
Teacher: When you take a test, you must give me all the information.

Again, the teacher does not explain why the students should give him "all the information." He simply directs them to apply the strategy to the task.

In summary, process/application instruction describes the various teaching practices that are used to prepare students for participation in classroom activities. Explanation was the only language function used across all four process/application categories. Although the classroom management category, directing instruction, was not observed in the presenting of materials category, it was observed more frequently (39 instances) than explanation (19 instances) in process/application instruction. The classroom management category, directing behavior, was observed only in process/application instruction because it does not involve the teaching of content material or academic vocabulary, but rather focuses on the social behavior of students. There was no category in process/application that used fewer than two oral language functions, repair strategies, and classroom management categories suggesting that teachers use a range of such communicative intents to help students accomplish tasks. In the next section, the two repair strategies, clarification and paraphrasing, are discussed in more detail and relevant examples are presented.

Repair Strategies

When failures in communication occur, the repair strategies of clarification and paraphrasing play a critical role in the classroom environment. For example, the intent of a teacher may be to explain, describe, compare, or assess, but when that effort breaks down, the instructional intent is continued through the repair of the previous utterance(s). As stated previously, clarification may be used to repair a language function through restatements, elaboration, or further specificity. Paraphrasing may actually be used as a repair strategy for clarification itself or may be used to repair one of the oral language functions alone.

These two types of repair strategies are categories on the ALEC and observers looked for evidence of them during observations. During data analysis, the language functions that the repair strategies support were identified. The nature of the two repair strategies in conjunction with their oral language functions is discussed

below. Then, a detailed examination of paraphrasing is included to demonstrate that teachers do not always use paraphrasing in response to student confusion (as with clarification), but use it purposefully and strategically to help students construct linguistic meanings and avoid the need for conversational repairs. A discussion of how teachers used paraphrasing to support clarification and support student understanding across the three instructional contexts (science, academic vocabulary, and process/application instruction) is also included.

Clarification and oral language functions. Clarification was recorded on the ALEC and had the following distribution: 4th grade: 1; 4th/5th grade: 14; 5th grade: 4. Teachers used clarification to repair explanations, descriptions, assessments, and classroom management discourse directing instruction. The examples that follow demonstrate each of these four types of clarification repairs.

Clarification of explanation. The teacher of a 4th grade class led a discussion on planetary systems. She asked the students to look in their textbook and identify the names of the planets in order from the sun. Within this review of the planets in the solar system, the teacher assumed the students implicitly learned that the moon was not a planet because it was not listed as a planet in the text. Later in the lesson, the class discussed the moon landing. One student asked the teacher if the moon was the only place astronauts had visited. The teacher responded yes, and then told the students that Americans planned to visit the planet Mars. In Example #42, a student asked a follow up question:

Example #42	(4th grade)
Student:	So the moon is the only *planet?*
Teacher:	Yes, but remember, the moon is not a planet.

The teacher chose to answer the student's question while facilitating a repair. She realized her explanation of the solar system's planets contained a communication failure, so she used a repair to clarify to the class that the moon is not a planet.

Clarification of description. In a 5th grade class, students were expected to add sand samples to vinegar to see if the sand was composed of animal shells. The teacher described what would happen if the sand contained animal shells: the sand

and vinegar mixture would begin to bubble. One student mixed sand and vinegar together and noticed that the sand began to float. Example #43 shows how he described to the teacher, in the form of a question, what he observed, while simultaneously asking if it meant that his sample contained shells.

Example #43	(5th grade)
Student:	If the stuff is floating?
Teacher:	*Only* if it's bubbling.

Since the student observed a different phenomenon (sand floating) than the teacher had initially described, the student initiated a repair. In this case, the teacher's use of the marker *only* demonstrates that the initial instruction needed to be repaired with a more specific one.

Clarification of assessment. Teachers used assessment to see if students understood the task they were performing. Example #44 illustrates how a teacher used the repair strategy of clarification to correct a misunderstanding when assessments demonstrated that students did not understand tasks.

Example #44	(5th grade)
Student:	(Asking the teacher) How many times do we…
Teacher:	Time out—what is your pectoral fin?
Student:	It's right there (pointing to picture). *Right*?
Teacher:	(Looks through student's folder for fish diagram.)
Student:	The pectoral fin is the one in the front, so it'd be that one.
Teacher:	You have described it in the middle. (Clarifies where to put the answer) Look at your diagram.
Student:	(Clarifies which diagram)
Teacher:	Bingo.

The teacher asked the assessment question "What is your pectoral fin?" because she noticed that the student's work was incorrect. The student demonstrated his uncertainty by using the marker, "Right?" The teacher then took the opportunity to repair the student's understanding by specifying where the pectoral fin was located on his fish. The student's original question, however, was never fully asked or answered.

Clarification of directed instruction. The teacher in Example #45 uses direct instruction to present task directions for an activity that involves illustrating various types of plants.

Example #45	(4^{th} / 5^{th} grade)
Teacher:	Draw a desert plant.
	(The teacher wrote this instruction on the overhead and orally gave the Spanish translation.)
Student:	We already did that!
Teacher:	In your journal.

In this example, the teacher clarified how the current task (i.e., drawing a desert plant in the students' journals) was different from the previous task (i.e., watching the teacher draw a desert plant on the overhead.) In this case, the student needed the teacher to be more specific when directing instruction and, therefore, initiated a repair by objecting to the task direction until the teacher offered clarification.

In summary, clarification was used across the oral language functions when the apparent intended communication failed. Teachers used clarification to repair explanations of scientific concepts, descriptions of what should happen in scientific lab experiments, assessments of task understanding, and directed instruction of how one activity differed from previous activities. In all of the examples discussed, the teachers' intended communication failed and was not achieved until they repaired the initial utterance with clarifications. In this way, clarification was used to assist communication between teachers and students in classroom interactions.

Paraphrasing and oral language functions. The observations of paraphrasing recorded on the ALEC formed a corpus of 28 instances (4^{th} grade: 5; 4^{th} / 5^{th} grade: 15; 5^{th} grade: 8). Twenty-two paraphrases were in service of clarification; three paraphrases were in service of explanation; and three were in service of assessment. Although most paraphrases are repair strategies, data analysis demonstrates that some paraphrases are not initiated because of communication failure, but are proactively used by teachers to introduce new concepts. The examples that follow each illustrate one type.

Paraphrase in clarification. The teacher of a 5^{th} grade lesson on whale behaviors tries to elicit student responses to her question about why whales breech. When she

does not get the correct answer, she urges the students in Example #46 to describe the motion of the whale to her. A student explicitly signals non-understanding and the teacher responds by rephrasing her request to repair the communication.

Example #46	(5th grade)
Teacher:	Describe it though.
Student:	I don't understand.
Teacher:	Make me see what it is.

Paraphrase in explanation. In a 4th grade classroom, the teacher explains how the sun and the earth work together. No student response is elicited in this instance; instead, the teacher goes on to rephrase her explanation of the solar system, as shown in Example #47.

Example #47	(4th grade)
Teacher:	The sun and the earth work together. They have a relationship.

Paraphrase in assessment. In Example #48, the teacher uses paraphrase in her 5th grade unit on whales to prompt student response to her assessment of their understanding about the existence of barnacles growing on whales. She gives students multiple prompts to think about a probable answer along the lines of *what*, *why*, or *how* something comes off (i.e., *barnacles*) whales. These often rapid-fire paraphrases are the teacher's multiple attempts to get at what she feels is the correct response.

Example #48	(5th grade)
Teacher:	Where [are the] scars from? That process.
Student 1:	Try to get off.
Student 2:	When they come off....
Teacher:	They come off, but what?
Student 3:	Rubs off up against something....
Student 4:	They swim to warmer water....
Teacher:	Yeah, the change in temperature. I think cold equals [barnacles] on and warm equals off. Off, why? Or how?
Students:	(no response)

Paraphrase in-depth. In this section paraphrasing is described with much greater specificity. First, the 22 paraphrases that were used for clarification are further examined. Second, the instructional contexts of paraphrasing are examined, as well as the possible rationale and implications for the use of paraphrase by teachers.

Eight of the 22 paraphrases that were used for clarification were classified as repairing the explanation language function. For example, the following 4th / 5th grade teacher explained how scientists use whale characteristics such as fluke markings to identify individual whales. In Example #49, the teacher becomes increasingly concrete with each paraphrastic utterance as she clarifies what she means by *tell one whale from another* to the point that she makes up names for two whales:

Example #49	(4th / 5th grade)
Teacher:	How scientists tell one whale from another. Tell them apart. Josephine from Tom.

Twelve of the remaining paraphrases used for clarification originated in the assessment language function[9]. In Example #50, a 4th grade teacher working with her class on the solar system receives no response to her questioning about the effects of gravity. She rephrases her question by specifically naming the two planets which she had previously referred to erroneously as two systems, thus repairing her initial question for the class.

Example #50	(4th grade)
Teacher:	How does gravity affect these two systems?
Students:	(no response)
Teacher:	What does gravity have to do with Earth? With Sun?

Example # 50 demonstrates that the lack of a response (or an extended pause) from the listener is a way of signaling a break down in communication and alerting a speaker to initiate a repair (Schegloff, Jefferson, & Sacks, 1977).

[9] The remaining two paraphrases used for clarification were used for description and academic vocabulary instruction.

Figure 2 on page 29 shows the distribution of paraphrases across the different instructional contexts. In the context of science concept instruction, paraphrasing could be used to make complex sentence structure less demanding. In Example #51, the teacher explains how the mineral content of sand is determined.

Example #51	(5th grade)
Teacher:	Where was it found? Where did it come from? XXX Sand analysis.

The teacher's paraphrase of the first sentence (*Where did it come from?* for *Where was it found?*) may have occurred because the teacher was aware of using a passive construction in the first sentence. Passive constructions are found to be more difficult for students to process than the active voice that was used in the second sentence (e.g., Fraser, Bellugi, & Brown, 1963).

Much of the paraphrasing language function occurs in the context of vocabulary instruction when teachers introduce primarily specialized academic vocabulary implicitly via synonymous phrases. In the previous example, the teacher used paraphrasing as a way to shift from the informal expression of concepts to the more precise use of scientific language. That is, the teacher was starting with the language students were presumably familiar with (e.g., *Where did it come from?)* and shifting via rephrasing to less familiar terminology. In this example, the teacher described what "sand analysis" comprises and formulated the components that the students should be thinking about (in effect these are the questions she wants them to ask themselves) in order to analyze the sand's mineral content. In this example, the teacher completed her explanation with the precise scientific label for the type of experiment the students were attempting.

A second example of this shift from familiar to less familiar language can be found in Example #47 on page 61. Here the teacher rephrased *work together* for *relationship,* a shift from familiar to less familiar (yet nonspecialized) academic vocabulary. In Example #52, this teacher then asks the following:

Example #52	(4th grade)
Teacher:	Are they [the Earth and the Sun] a system? If they work together?

The teacher thus continued to paraphrase, further introducing the specialized academic vocabulary *system* for what she had been referring to as *working together* and *relationship* in order to teach the students that the Earth and the Sun are interconnected—each part of the solar system.

Some teachers paraphrased in the reverse direction, shifting from the formal to the more familiar, especially if they had no response from students or if students asked explicitly for clarification. In Example #46 on page 61, the 5th grade teacher tried to find out if her students could describe what a whale does when it breeches. She rephrased a more formal use of language (nonspecialized academic *describe)* into the more colloquial and presumably familiar *make me see* in an attempt to clarify what she meant for the student to do.

As already mentioned, paraphrase was evident in the third instructional context only one time. This context focuses on the skills that students need to carry out their science activities and this paraphrase was used by a 4th grade teacher to make sure her students understood what counted as evidence in their experiment to show the Earth revolves around the Sun. In this example, she assessed students with questions that they must be asking themselves about the planetary systems. In particular she had the students focus on aspects of the planetary systems that they were already sure about, which is best characterized as presenting a strategy to help students accomplish their task. She repeatedly used a variation of the phrase, *know for sure*, in guiding the class discussion, as illustrated in Example #53.

Example #53	(4th grade)
Teacher:	What do we know about the sun, planets, and space?
Student:	No ending to space.
Teacher:	*What do you know for sure?*
	(Discussion on space continues.)
Teacher:	Is there gravity on Earth?
Student:	Yes, because we stay on the ground.
Teacher:	*Know that for sure?*
	(The discussion focuses on the sun.)
Student:	Solar eclipse.
Teacher:	What is it? *Know for sure?*

In summary, paraphrase appears to occur most often for two distinct purposes: (1) when a teacher has either overestimated student knowledge and then rephrases in more familiar terms what was initially expressed with formal academic (nonspecialized or specialized) language as in Example #49 above, or (2) when the teacher begins with informal familiar language for a new science concept and then shifts to rephrasing the concept using precise scientific or nonspecialized academic language as in Example #47 and its continuation in Example #52. The first purpose of paraphrasing appears to be a compensatory approach. When meaning-making has failed, teachers have to rephrase their utterances to find a level of familiarity that will enable students to understand what they are talking about. The second purpose suggests teachers are acting proactively, using language they gauge students will comprehend before introducing terminology for a new concept. This practice follows the constructivist (Vygotskian) approach to teaching that uses such strategies as a form of scaffolding to enable student participation in scientific discussion (see also Gibbons, 1998). Paraphrasing in this manner is not simply a repair strategy but rather it functions to scaffold instruction, the goal being to take students from the familiar to the unfamiliar in incremental steps. This approach while including students in the process could serve to build concept knowledge in incremental steps as well. However, as documented elsewhere (Cazden, 1988; Goodlad, 1984), few occasions were observed for students to participate in extended discourse of this type. For ELLs especially, this lack of opportunity to engage in extended academic discourse is problematic (Ramirez & Merino, 1990).

Summary of Structural Features Found in Teacher Talk

In this section, the structural features of the communicative intents found in teacher talk are summarized.

Explanation. Teachers generally used short declarative sentences to explain a scientific concept or task. First, the general topic or type of task was introduced; then teachers used short sentences to explain the details. Occasionally, teachers reread the text of a worksheet to highlight the task direction they were explaining.

Description. Short declarative sentences were also used in description. Often, multiple sentences were used to describe one scientific concept, task, or anecdote.

When describing a concept, teachers used the simple present and future tenses. Similes were used for description and generally involved the use of the connector *like*.

Comparison. There were two types of overarching comparison structures used by teachers. One, teachers compared two scientific concepts from the same lesson (e.g., herbivores and omnivores) to highlight similarities and differences. Two, teachers compared new scientific concepts with previously taught concepts (e.g., plant reproduction to the previous unit on whale reproduction). This type of comparison is more linguistically difficult because in order to understand the new content material, a student must recall language that was taught some time ago. Generally, teachers used short declarative sentences to compare two concepts, but a few instances of simile use *like* and parallel sentence constructions (e.g., "What you see, *not what you* did") were observed.

Assessment Teachers used simple interrogatives to assess student knowledge. Interrogatives often began with which, how, what, and can.

Clarification. Teachers clarified scientific concepts and tasks by using parallel structures: two adjacent sentences without connectors (e.g., instead, because, etc.). For example, the first sentence often was a negation (e.g., "We're not studying the ocean.") and was followed by a parallel clarification (e.g., "We're doing a model."). Teachers also clarified concepts by using sentence starters that were familiar and routine. The starters included, "You're supposed to…," "It must be...," and "Only do..." By using familiar starters, teachers alerted students to pay attention to the directive. Clarifications generally involved short declaratives, but some teachers were observed using short interrogatives as well.

Paraphrasing. Teachers used a variety of sentence structures when they paraphrased their utterances. On the one hand, they could paraphrase a simple sentence that contained a potentially unfamiliar specialized or non-specialized academic word and rephrase the sentence using longer sentences and more complex syntax but familiar lexical items. On the other hand, they could take a complex sentence and rework it by using just a sentence fragment from the original sentence.

Directing instruction. Directing instruction involved short declarative sentences in the simple present and future tenses. Teachers used discourse connectors to make clear the sequencing of tasks. These connectors were often numerical (e.g., step one, step two, etc.).

Directing behavior. Teachers directed behavior in short declarative sentences in the simple present tense. The use of specialized academic vocabulary was not observed in directing behavior.

Student Exposure to Print Materials

Although the main focus of this study was on teacher talk, print materials are included as one part of "academic language input" to students. In this section, selected print materials from the science classes are analyzed. The majority of classes observed included student reading activities at both visits. Two classes included student reading at just one of the two observations; one class had no student reading activities at all. The amount and nature of the reading activities varied considerably among classes, though the overall amount was relatively minimal. In addition to textbooks, students used worksheets, graphs, and charts with varying levels of teacher support. On occasion, individual students read passages from print materials aloud to the whole class or to their neighbor.

As stated earlier, four print materials representative of different writing styles were selected and analyzed in this report. The discussion of these materials follows. The analyses focused on ALMC categories which broadly cover sentence structure, academic vocabulary, and language functions and specifically include: (1) average sentence length, (2) complexity of sentence structure[10], (3) language functions utilized[11], (4) nonspecialized and specialized academic vocabulary, and (5) the number and type of visual aids used. In addition, brief summaries of how the print materials were used within the context of classroom instruction are provided.

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[10] Simple declarative or interrogative sentences contain a subject and a predicate (e.g., Whales are mammals). When embedded clauses or additional modifiers are added, the sentence becomes more complex, typically presenting greater challenges to a reader (e.g., In the ocean, there are many mammals, including whales) (Lord, in press).

[11] The language functions used to analyze print materials are the same as those detailed in the teacher oral talk section.

The first selection is taken from the 4th grade text *Discover the Wonder* (Heil et al, 1993). Students read from a passage of the text entitled *Systems in Space.* The following is a randomly chosen paragraph from this passage:

> Selection #1
>
> The moon and Earth are also very different from one another. And they too form a system. Notice in the picture how the Earth and moon system is similar to the sun and Earth system. The moon is smaller than Earth, and it orbits Earth. Month after month the moon keeps orbiting Earth, even as Earth is orbiting the sun. Why does the moon orbit the Earth? Why does Earth orbit the sun? The answer to both of those questions is gravity (p. 11A).

Sentence Length

The sentence length of the paragraph ranges from six words to 18, with an average length of 10 words per sentence.

Sentence Structure

The syntactic structure of many of these sentences is complex. For example, the sentence, "Month after month the *moon* keeps *orbiting Earth*, even as *Earth* is *orbiting* the *sun*" contains an embedded clause, "even as Earth is orbiting the sun." In addition, the phrase "month after month" in the beginning of the sentence may pose difficulty for the reader.

Language Functions

Sentences within this passage serve the oral language functions of explanation, description, and comparison. The first sentence, "The *moon* and *Earth* are also very different from one another" alerts readers that this paragraph will explain the differences between the moon and Earth. The paragraph concludes with the answer or explanation for the questions, "Why does the *moon orbit* the *Earth*? Why does *Earth orbit* the *sun*? The answer to both of those questions is *gravity*." The moon is described as "*orbiting Earth."* In addition, the moon is compared to Earth, "The *moon* is smaller than *Earth,* and it *orbits Earth."* The comparison is implicit in the second sentence, "And they too form a system."

Academic Vocabulary

Selection #1 contains nonspecialized vocabulary (*similar, form, notice*) as well as specialized academic vocabulary (*system, gravity, orbit*). The term *orbit* is used five times within the selection in three different forms (i.e., *orbits, orbiting, orbit*). If a student did not understand the specialized term *orbit*, it would be very difficult to comprehend the paragraph.

Visual Aid

One visual aid is included in the text to help readers: a picture of the moon orbiting the earth with the caption, "The *sun* and *Earth form* a *system*, and *Earth* and the *moon form* another *system*."[12]

Instructional Use of Print Materials

Throughout the lesson the teacher provided support of new content information presented in the text by asking questions, repeating information, activating student prior knowledge, and building upon student comments. The teacher also used semantic maps or flow charts (including one from the text) to illustrate how systems, such as the solar system, work. Before students began reading, the teacher called their attention to the title and subtitles of the chapter. After an individual student had read a section aloud to the class, the teacher asked questions about the textual information (e.g., "What two *systems* did they [the textbook] name that are affected by the *force* of *gravity*?"). The teacher also took the opportunity to extend the lesson on gravity and the solar system when discussing how a student's solar powered radio works. Later in the lesson, students were asked to repeat, or more specifically "cover and retell," what they had read, and share this information with a partner.

The second selection contains directions for creating a Microsoft Excel[13] file. The worksheet with the directions was created by a teacher for her 4^{th} / 5^{th} grade students. In this instance, print materials served as direct instruction for accomplishing a task. Students worked in pairs to create Excel graphs of "Ocean temperatures and depths." The teacher gave them the following worksheet as a

[12] Capitalization is as presented in text.
[13] Teacher adapted from "ClarisWorks for Teachers: Elementary Edition."

guide. Instead of full paragraphs, the worksheet contained a list of computer tasks required to create a graph. Certain words were highlighted, such as the computer file names[14]:

> Selection #2
> **Creating Your Graph**
> (1) Open **Microsoft Excel** (spreadsheet)
> (2) In column A, write down the temperatures, putting one temperature in each cell starting with cell 1
> (3) In column B, write down the ocean depths, putting one temperature in each cell starting with cell 1
> (4) Take your cursor and **highlight every cell with information** in the A and B column
> (5) Click on the icon that is a graph
> (6) Click on **XY (scatter**) graph then click on **Finish**. A scatter graph will appear on your spreadsheet
> (7) Click on the **line graph icon** next to the scatter graph (without the dots) and click **Finish**. The dots (points) on your graph will be connected

Sentence Length

The length of the numbered items varies from four words, "Open *Microsoft Excel* (spreadsheet)," to 18 words, "In column B, write down the *ocean depths*, putting one *temperature* in each cell starting with cell 1." The average length of the numbered items is 13 words.

Sentence Structure

Although the language in the numbered items is explicit, several of the sentences are complex and contain embedded clauses. Frequently sentences contain more than one command or imperative. For example, "*Click* on *XY (scatter) graph* then *click* on Finish." In addition to the numbered lists of computer tasks, there are several open-ended questions on the opposite side of the worksheet that students must answer while doing the activity. These questions concentrate on student understanding of the lesson's content knowledge; their conceptual understanding of "what's under the water." Directions are given within this section as well; however, in contrast to the list of computer directions, students must also process content material in order to perform the task.

[14] These words are bolded within the examples.

Language Functions

The worksheet provided direct instruction or a list of tasks that students must follow in sequential order to complete the task of creating an Excel graph.

Academic Vocabulary

Within this example, students are called upon to process two types of specialized academic vocabulary: (1) technical or computer related terms, such as *click and drag, icon*, and *spreadsheet*, (2) science terms such as *temperature* and *ocean depths*.

Instructional Use of Materials

Initially the teacher led a whole-class discussion about the ocean temperature at different depths. Next, the teacher introduced the graphing activity by telling her students, "We will *graph* on the computer using a program you haven't used before called *Excel*." Students read the numbered directions aloud as the teacher demonstrated how to create the Excel graph. Most computer specialized terms were not highlighted since students appeared to already know the terms and use them easily. However, the teacher provided a definition for *cells* pointing to the screen and stating, "These *individual* things here are called *cells*." The teacher discussed both content material and computer tasks during the demonstration. Throughout the Excel demonstration, the teacher asked for information from the worksheet in order to check whether students were following along, such as saying, "Can someone tell me what my first direction is?" After the teacher had finished the graph, she showed her students how to save the document, then circulated around the classroom as students started working on their own graphs.

The third selection was taken from a 4^{th} / 5^{th} grade science activity text, *Earth's Oceans* (Atwater et al, 1993). The introductory paragraph to the unit, *Movement of Ocean Water*, was selected for analysis:

> Selection #3
>
> In the last lesson, you discovered that ocean water is different from fresh water. Ocean water contains dissolved minerals and salts, which make it salty. Some ocean water has more salt than other ocean water. There are other differences as well. Ocean waters near the equator are warm, while polar waters and deep ocean waters are colder. Differences in temperature are one reason ocean water

> moves. In this lesson, you will explore the ways that ocean water moves over Earth. (p. 25)

Sentence Length

The shortest sentence in this paragraph contains six words, while the longest contains 16. The average sentence length is 11 words.

Sentence Structure

Five out of seven sentences have embedded clauses. The sentence, "Ocean water contains dissolved minerals and salts, which make it salty," is a complex sentence where the phrase "which makes it salty" serves as a subordinate clause to the main sentence. This passage also contains comparatives, such as *more salt* and *colder*.

Language Functions

Sentences within this passage served the oral language functions of explanation, description, and comparison. The sentence, "Differences in temperature are one reason ocean water moves" acts as an explanation. Ocean water is described as "salty." This passage also compares ocean water at two areas of the globe by describing their difference in temperature, "Ocean waters near the *equator* are warm, while *polar* waters and deep ocean waters are colder."

Academic Vocabulary

This passage contains both nonspecialized and specialized terms, including variants forms (e.g., salt, salty). The nonspecialized terms are *discovered*, *contains*, and *explore*. The specialized terms are *dissolved*, *minerals*, *salts*, *equator*, *polar*, *temperature*, and *Earth.*

Instructional Use of Materials

The teacher introduced the lesson by reviewing prior material on ocean properties. Students took turns reading aloud from the text. The teacher summarized passages of the text after they were read by individual students, such as, "They gave us one of the *factors* (or) causes of why ocean water moves…" After reading the introduction to the unit, the teacher demonstrated an experiment using hot and cold water. The steps for the experiment were described within the text,

although the teacher did not explicitly read from these pages. Students were then given a teacher created worksheet to record their observations while conducting the experiment. The teacher modeled how to answer questions from the worksheet. For example, as the teacher circulated the room she told the class, "If this were my lab, I would stop and record what I see." During the last few minutes of class, students who had finished the lab were able to view a website that discussed ocean temperatures.

Often, teachers compiled packets of information to give to students to complement a lesson. Many of these materials were derived from outside sources such as institutions (i.e., university web sites, museums) texts, or other teachers. Occasionally these packets contained materials from multiple sources. Print materials originating from outside sources had not necessarily been created with a certain student age group in mind or for the purpose of classroom instruction. Therefore, these materials might present additional or unfamiliar language demands for students.

One 5th grade teacher gave her students a packet of materials about sea life. The first page of the packet entitled Tidepools[15] explained what a tidepool was and described the sea life found there. The fourth selection was taken from the sea life packet:

> Selection #4
>
> Animals and plants live in different areas of the rocky shore according to their needs. Animals that must always be wet, like sea anemones and sea urchins, live below the low tide mark. Others, like the periwinkles and mussels, hold water in their shells and can live in areas uncovered at low tide. Crabs and sea stars move to follow the tide or hide among the seaweeds and under rocks to stay wet.

Sentence Length

The shortest sentence within Selection #4 contains 15 words while the longest contains 20. On average, sentences are 18 words long.

[15] This packet of materials included the selection on *tide pools* provided courtesy of the New England Aquarium (no date given).

Sentence Structure

Although the paragraph contains only four sentences, those sentences contain numerous modifiers and embedded clauses.

Language Functions

Sentences within Selection #4 served the oral language functions of explanation and comparison. Readers learn why certain sea creatures live in different areas. In addition, the passage uses the function of comparison to further explain the habits of different sea creatures stating, "Animals that must always be wet, like *sea anemones* and *sea urchins,* live below the low *tide mark.* Others, like the *periwinkles* and *mussels,* hold water in their shells and can live in areas uncovered at *low tide*."

Academic Vocabulary

Selection #4 contains a large number of specialized terms, specifically the names of sea creatures such as *periwinkle* and *sea anemones*. In addition, nonspecialized academic vocabulary such as the term *according* is used instead of a simpler synonym such as *by*.

Visual Aid

Next to the paragraph on tidepools, there is an illustration that shows the various tidal levels or zones. These zones are delineated from one another. Within this same picture, sea creatures similar to those described in the paragraph above are illustrated. The picture is labeled using the terms: *intertidal zone, high tide, and low tide.*

Instructional Use of Materials

Students used the packet of materials as a resource in creating crossword puzzles. It is assumed that students had used this packet or read the materials prior to this lesson, although observers were unaware of the context of any prior interactions. The teacher began the lesson by discussing the components of crossword puzzles. Students discussed "what they noticed" on a sample crossword puzzle. Then the teacher assigned students to make a crossword themselves using the sea life packet and their notes for ideas. The steps for creating a crossword were written on the blackboard: "Step 1. You have to pick ten *vocabulary* words. Step 2.

Once you pick a *vocabulary* word, you have to write a *clue."* The teacher gave a description of the word *clues* in the form of a definition, "Clues—kind of a secret, not exactly an answer."

Summary of Print Materials Analysis

The four print selections analyzed above were used within the context of classroom instruction. Each presented linguistic challenges for the student, in that all excerpts used complex sentences, containing embedded clauses and multiple modifiers. In addition, each excerpt contained both nonspecialized and specialized academic vocabulary. These print materials were all used in conjunction with teacher talk and classroom conversation.

Student Talk Observed During Science Lessons

In this section the data collected on student oral language production is examined. These data were not extensive because of the procedural limitations mentioned above. However, using the ALEC items as a guide and the instructional contexts identified in the section on teacher talk above, student language is characterized in terms of language functions, repair strategies, and pragmatic uses of language in the classroom.

Figure 3 is a matrix representing the intersection of language functions, repair strategies, and classroom management across the three instructional contexts of student talk. As with the Figure 2 teacher talk matrix, the numbers in the shaded cells are rough gages only of the amount of student talk within any given category and should only be interpreted relative to one another. A number of features make this student talk matrix different from the teacher talk matrix. The instructional contexts themselves needed modification to be aligned with the student perspective on instruction, that is, their learning. These contexts are best described then as (1) science learning, (2) acquisition of academic vocabulary by providing definitions, synonyms, examples, and repetitions as requested by the teacher, and (3) process/application learning, as well as process/application instruction that was directed towards peers or the teacher.

Communicative Intent	Context of Learning								
	Science Learning	Academic Vocabulary Acquisition				Process/Application Instruction/Learning			
	Concept Learning	Requested to provide definition	Requested to provide synonym	Requested to provide example	Requested to provide repetition	Presents and ensures peer understands task	Presents instructions/ techniques to peer or teacher	Presents materials needed to peer	Presents a strategy to help peer or teacher
Oral Language Functions									
Explanation	14	1	6[a]						
Description	10	1							
Comparison	12					6			
Substantive Question	2								
Comment	2								
Repair Strategies									
Requesting Clarification	14								
Providing Clarification	12						5		
Classroom Management									
Responding to teacher question	7				6				
Proposing instructional procedure							1		

Note. This matrix is an outgrowth of the matrix of teacher talk (Figure 2). Future research will need to refine/expand these categories as more student talk data becomes available.

[a] All of these instances are cross linguistic paraphrases (i.e., Spanish paraphrase of the initial English utterance).

Figure 3. Working draft matrix of individual instances of student talk observed during 4th & 5th grade science lessons

Within communicative intents, two additional language functions were added: asking substantive questions (e.g., science content), and making comments. While the assessment language function was not observed being used by the students in this study, it is possible that peer and student self assessments are used in other science classrooms. In the repair strategies category, clarification was divided into requesting and providing clarification. Classroom management for students also differed from those of teachers. In general, students simply answered teacher

questions. On one occasion, a student even proposed instructional procedures to the teacher.

Science Learning.

Much of the student talk observed was concentrated in the context of science learning. In this context, students used five oral language functions and two repair strategies. The language functions were predominantly explanation, description, and comparison of science concepts. Example #54 illustrates a student providing an explanation to a teacher query. In this instance, the degree to which the student's response reflects an adequate understanding is unclear. The student does not elaborate in the relationship between *density* and *salinity* and could, therefore, be appropriating these terms with little or no understanding of how ocean water differs from salt water (W. Sandoval, personal communication, December 4, 2001).

Example #54	(4^{th} / 5^{th} grade)
Teacher:	What makes ocean water different from salt water?
Student:	Ocean water has greater density because of salinity.

Example #55 provides a student description of a jar that contains different colored water.

Example #55	(4^{th} / 5^{th} grade)
Student:	Orange on top. Yellow on the bottom. The two colors are cut in half. Different color liquids.

In Example #56, a student compares a parasite to a video.

Example #56	(4^{th} / 5^{th} grade)
Teacher:	Raise your hand if you know what a parasite is.
Student:	A parasite is like the desert video we watched.

Students sought clarification primarily when the teacher was explaining science concepts and / or process application procedures to them, as in the student's second question in Example #57.

Example #57	(4th grade)
Student:	Is the moon the only place astronauts visited?
Teacher:	Yes, we're trying Mars.
Student:	So the moon is the only planet?

To a much lesser extent students asked substantive questions. The first student question in Example #57 illustrates this rare type of student talk. Also infrequently, students made comments that related the science they were learning to their own personal experiences such as one student in a 4th / 5th split grade classroom who said, "I have something like that," referring to the clear putty used for holding an aquarium together.

Students were rarely asked by the teacher to provide clarification of their oral language functions for the teacher. In the area of classroom management, the students were responsive to teachers' questions.

Academic Vocabulary Acquisition.

Just three students were observed providing their own original oral definitions in response to a teacher request for a specialized or non-specialized academic word. All three words were used in service of the explanation language function. For example, when asked to explain gravity, a student said, "Means it stops us floating around." As mentioned earlier, requests for students to provide a definition by reading from the text provided were also observed.

In the classroom with the high percentage of ELL students, six synonyms for academic words were provided during explanations. Those synonyms were verbatim translations of English terms into Spanish and vice-versa. Especially in the classroom containing a high percentage of ELL students, choral repetition was used to practice specialized academic words such as *photosynthesis, xylem*, and *pollen*.

In one case a student unsuccessfully asked a peer for clarification of a specialized academic vocabulary term. In Example #58, an English-only student and an English language learner are working together during a science lab.

Example #58	(4th / 5th grade)
EO:	Where's the *slide*?
	(The ELL mistook the EO's word *slide* for *slice*.)
ELL:	I don't know what *slice* is.
	(The EO student ignores the ELL's request for clarification.)
EO:	(The EO then asks the teacher his question.) Are those the *slides*?

Although the ELL asked the EO student what the term *slice* was, he did not receive clarification of the term.

Process/Application, Instruction/Learning.

Students were observed providing clarification in the context of helping their peers accomplish a science activity. The student in Example #59 spends a lot of time tutoring a peer on an activity about fish morphology.

Example #59	(4th grade)
Student:	[Draw] just the body, not the fins. Don't draw the fins, just the body.…Listen, listen don't do that. The pectoral fin is the one on the side, so draw that one big. Big.

In one instance, a student provided the teacher with a suggestion for how to conduct an activity. Specifically, the student proposed that they all have a partner because he felt it would make the task procedure easier to handle.

In conclusion, much of the observed student talk was confined to explaining, describing, comparing, and seeking clarification of science concepts. There were no occasions observed in which students practiced the use of academic vocabulary by being requested to produce their own synonyms or examples, discounting the requested translation equivalents. (See Figure 3, Footnote a, p. 76) There was also little evidence of students instructing their peers across the multi-faceted aspects of science activities, despite the frequent use of collaborative grouping used as an instructional technique by the teachers.

Student Production of Academic Language in Writing

In an attempt to explore how academic language emerges within student writing (the fourth research question for this study), samples of student essays, tests,

and letters were analyzed. Writing samples were collected from two 5th grade science classes and were analyzed in terms of sentence length and complexity, language functions, use of classroom talk and materials, and use of nonspecialized and specialized vocabulary. All classes observed included writing activities during at least one visit. The amount and nature of the writing in the classes varied greatly. The types of writing activities ranged from simply filling in labels on worksheet flow charts or diagrams, to essays about fish morphology. In between these two extremes were writing tasks that required students to describe science objects, take lab notes, and formulate a formal hypotheses.

Student writing as illustrated in the conceptual framework (Figure 1, p. 17) is a form of academic language production or output. The examples below provide some indication of the influence of teacher talk and print materials in student production of academic language (through the content and style of their writing). This section serves as an initial study of student academic language production. While the findings are tentative, the analyses and discussion illustrate possibilities for the further study of student writing.

Participants.

The examples below of student work were taken from two 5th grade classrooms within the same school. Students from the two classrooms were combined for math and science classes, according to their math skill level. Their classroom teachers on occasion brought the two classes together for science instruction. Three of the students included in this study are ELLs who are highly proficient in reading and writing in English, according to their teachers.

Both classrooms were visited on two occasions. During three of the four visits, lessons covered oceanography and included such activities as creating crossword puzzles, conducting experiments, and quizzing students as a way of preparing them for the unit test. The following sections show how the topic of whale blubber is covered in print materials, introduced in class, and written about by students.

Print Materials.

Print materials for the unit were collected, including a packet of handouts on tide pools and sea life, a packet on whales, a math worksheet that incorporated

vocabulary from the unit, and a copy of the unit test. The topic of *blubber* was covered to some degree in all of these materials.

Classroom Instruction.

One of the two teachers led a discussion about the properties of blubber before students participated in an experiment that involved placing their hands in cold water with and without a glove of *blubber*.

The teacher wrote a descriptive list of whale characteristics on the board: (1) Warm-blooded, (2) Hair, (3) Mammary glands, (4) Live birth, and (5) Breathe air. After discussing this list, the teacher described the blubber experiment. During the experiment, the teacher assigned students to write a paragraph, instructing them to review their notes. Students had several pragmatic questions about the essay, asking the teacher for specific details about the task. The teacher provided strategies for students as they wrote their essays.

Student Essays.

Twelve student essays selected by participating teachers were analyzed and reflect a range of student language levels. Students utilized the language functions of explanation, description, and comparison in their essays. Sentence length and complexity varied greatly among students. In general, students utilized a mixture of declarative, interrogative, and more syntactically complex sentences (e.g., use of multiple embedded clauses, etc.). For example, almost all of the students explained that blubber was a type of fat. Some students wrote a simple sentences, while others included multiple clauses. Many students also incorporated more formal academic phrasing in their writing. Students utilized many of the characteristics discussed in class and/or listed on the board to help explain as well as describe what blubber is and why whales might need it.

Student Tests.

The unit tests for twelve students were analyzed in this study, although not necessarily for the same twelve students who had written blubber essays.

As expected, student writing on the test was more explicit and direct than in student essays. In general, sentences were simple declaratives. In addition, many student definitions were broad, perhaps due to their perception of definitions as having limited detail or length. Snow (1990) theorized that students' skill in writing formal definitions was heavily influenced by their exposure to dictionary definition models and their ability to practice writing such definitions. Several students (in this study) adopted a dictionary definition style for the unit test. The following illustrates this style:

> X is a _____ [superordinate] that _____ [complement clause, describing specific characteristics].

A fictitious definition illustrating this structure is:

> Blubber is a type of fat that keeps sea mammals warm in cold waters.

Before giving the unit test on oceanography and whales, the teacher reviewed test items with the class in the form of a game. On the test, students were given a list of terms and asked to "define and use each word in an appropriate sentence," including the word blubber.

Student Letters.

Students wrote letters at the end of the unit telling their teachers what they had enjoyed most about the unit, what they had learned, and what they would like to study in future science classes. Although none of the sample letters contained an explicit reference to blubber, students discussed various whale facts. Students also described the steps they had taken in researching their reports. In future studies, such descriptions may shed light upon students' own reflections in the writing process.

Summary.

Firm conclusions cannot be made concerning the influence of teacher talk, print materials, or level of language demand upon academic writing from a single study. The analyses here show that students utilized both nonspecialized and specialized

terms in their work. Without additional independent assessment of student conceptual knowledge, however, it is not possible to be certain if the students have the conceptual knowledge suggested by the use of the terms. Student use of the terms may simply reflect recall of the vocabulary encountered in class. In addition, different types of writing should be used for different assignments. For example, students created written definitions for the unit test using abbreviated dictionary style as well as paraphrasing. When writing letters to their teacher, students were much more informal, using the format for a friendly letter.

The widest range in writing style and complexity appeared in student essays rather than in the tests, letters, and other writing samples students produced. The variety of style in the essays may have been due in part to their length. Some students explicitly stated the main topic of the essay (provided a topic sentence) while others simply "listed" facts that they had learned from the unit.

Discussion

The work reported here examined the use of academic language in 4th and 5th grade science classrooms. The analyses took a functional approach to describing the language to which students were exposed and thus needed to process and understand. The conceptual framework (Figure 1, p.17) that helped shape this effort provided broad data collection categories that will continue to guide CRESST's long-term research agenda for ELLs. To help ascertain the most meaningful units of analyses for the type of data collected, an inductive approach was taken which led to the development of a matrix of teacher-produced academic language within three instructional contexts (Figure 2, p. 29). Broad communicative functional categories emerged from the data. This work was exploratory and the data limited in that fieldnotes rather than audio or video recordings were used. Thus, the focus on salient language functions rather than fine-grained linguistic analysis allowed for a broad descriptive representation of the uses of academic language in the classrooms visited. This approach provides solid evidence of the use of specific language functions in 4th and 5th grade science classrooms as well as initial, though unsystematic, glimpses of lexical usage. In-depth data analysis of syntactic structures was not possible, given the methodology used.

Findings related to the major research questions follow along with implications for further research. These implications include additional in-depth study of academic language exposure across grades and content areas, as well as curriculum development and the development of language tests based on functional notions of academic language.

Answers to Research Questions

In this section, each of the research questions is revisited and the major findings summarized.

1. How are the language functions used by science teachers within different instructional contexts?

The conceptual framework for this research provided a structure for characterizing and analyzing academic language found in science classrooms. Academic language, receptive and productive, was conveyed through multiple language functions used by teachers in science instruction. A matrix (Figure 2) was developed to illustrate teacher talk as it intersected different contexts of instruction with language functions, repair strategies, and classroom management.

During science lessons, teachers exposed students to academic language within a range of instructional contexts. It was possible to characterize the primary instructional contexts as science instruction, academic vocabulary exposure or instruction, and process/application instruction. In each of these three contexts, teachers used all four language functions and both repair strategies. Regardless of context, the students were predominantly exposed to the language of explanation and description. Use of the classroom management categories by teachers was almost entirely confined to process/application instruction, rarely surfacing in the context of academic vocabulary instruction and not at all in the context of science instruction. In sum, students were required to attend to multiple functions across all instructional contexts during science lessons.

(a) The context of science instruction—developing basic conceptual understanding

Instruction fell into just four functional categories—explanation, description, comparison, and assessment—though additional categories such as synthesis and

summation might be expected in the science classroom. Of the repair strategies, very little clarification was observed around conceptual instruction. For whatever reasons, students did not seem to signal the need for clarification of science concepts. There were, however, isolated cases of paraphrasing that emerged as repair avoidance (e.g., Examples #47 and #52, pages 61 and 64, respectively).

(b) The context of academic vocabulary instruction—developing nonspecialized and specialized academic vocabulary

A range of nonspecialized and specialized academic vocabulary was observed during science lessons. Frequently, teachers used academic vocabulary without any apparent support. However, when teachers did highlight academic vocabulary, the supports of definitions, synonyms, examples, and repetition were used. Overt instruction of specialized vocabulary occurred more often than nonspecialized vocabulary, and frequently took the form of examples in the process of providing description, explanation, and comparison of science concepts. The use of definitions repeatedly required teachers to clarify, and the use of synonyms often required teachers to paraphrase whole sentences. In addition, some terms were found to have precise scientific meanings as well as non-academic discourse usage (e.g., for the word *cross, cross pollination* is an example of a scientific use versus *to cross the street*, which is an example of a non-academic use). It could be that it is the non-academic meaning of the word that is often more familiar to students (Stevens, et al, 2000; Bailey, 2000a) and thus requires the teacher to overtly introduce the academic meaning of the word. Gibbons (1998) notes that students' familiarity with everyday language should be seen as a conduit for developing "the unfamiliar registers of school" (p.99) and that indeed by a teacher introducing a more scientific term for a word used by a students to talk about an observation or phenomenon, the two co-construct concepts allowing the student to acquire more specific scientific terminology in the process.

(c) The context of process/application instruction—engaging students in classroom learning activities

Most teachers incorporated both constructivist and direct instruction practices in their teaching. Strategies such as K-W-L charts, choral response, and

collaborative work were observed. Frequently, students shifted tasks at least once during the lesson (i.e., lecture to group work, video to discussion). Many of the tasks had an interactive component, whether it was a game to illustrate a scientific concept or the collaborative use of microscopes in a lab.

Although levels of student participation were not systematically measured during observation, there appeared to be large differences in the style and amount of student response elicited by teachers. In some classrooms, students felt free to call out questions or answers, while in other classrooms students were required to raise their hand or wait to be called upon for a response. In addition, some lessons appeared to promote more discussion and student interest than others, perhaps due to subject matter, relevancy to students, or teacher / student style of interaction.

There was evidence of all language functions, repair strategies, and classroom management categories occurring with at least one of the four process / application categories. Of the process / application categories, teacher instructions / techniques to accomplish a task were most frequently observed, whereas talking about the materials needed to accomplish these same tasks was the least observed.

Although certain strategies (i.e., K-W-L) were used to guide classes through lessons, efforts to present outlines for and summations of lessons rarely occurred. In addition, review of prior lessons was typically done in an incidental manner as part of the on-going instruction.

2. What academic language is used in print materials selected by teachers?

Teachers used a diverse and eclectic mix of print materials in their instruction. These materials ranged from textbook entries to websites to video documentaries. Materials had varying levels of linguistic demand as measured by syntactic complexity, sentence length, and amount of academic vocabulary. Print materials contained multiple language functions and embedded academic vocabulary (both nonspecialized and specialized) similar to that observed in teacher talk. In addition, most of the print materials provided some sort of visual aid, from explicit graphs or diagrams to purely aesthetic pictures. While some materials required the student to react in writing, most simply provided information.

The level of support given to students when using materials differed among classrooms. In general, print materials were used as supplemental tools that reinforced content knowledge during lessons. Students were not ordinarily asked to read new selections and process new material on their own without teacher talk or group discussion.

Several of the materials used during observations were created by outside sources other than textbook publishers (e.g., museums, websites). Print materials from these outside sources had not necessarily been created for a specific grade level, or even for instructional purposes. These materials tended to be more challenging possibly due to the use of a greater amount of academic language.

3. What evidence of academic language emerges in student talk?

Student talk data revealed five predominant functions of language in the classroom. As with teacher talk, students were mainly explaining, describing, and comparing scientific concepts. They also asked the teacher questions of scientific substance and added commentary in isolated cases. In terms of repair strategies, students both requested and provided clarification, and showed understanding of classroom management by their appropriate responses to teacher questioning. Much of the student language occurred during science concept learning.

Students were rarely required to be actively involved in the acquisition of academic vocabulary. On occasion, a teacher would ask individual students to provide a definition of a specialized academic word. A teacher would also occasionally ask students to make a choral response in order to practice the pronunciation of a word. Students were not observed supplying synonyms or examples. Students seldom talked in the process/application context when they were actively involved in carrying out a scientific experiment or task. In the latter context, the students were heard to at least provide clarification of instructions/techniques when requested by their peers—perhaps as a consequence of the collaborative nature of many of these tasks. It is feasible that much of the interaction in the context of process/application learning was nonverbal in that students were not required to talk if they understood the nature of a task and the guidelines to accomplish it. In addition, the data collection procedure made it very

likely that much peer-peer conversation during individual and small group activities occurred unobserved and unnoted by the researchers.

4. What evidence of academic language emerges in student writing products?

A small number of student writing samples (essays, test answers, and letters) from two 5th grade classes were also analyzed. The skills and level of academic language found in student writing varied across samples. In general, students used different styles of writing for different tasks (e.g., using a distinctive dictionary style in writing definitions.) Students also used multiple language functions within their writing, primarily explanation and description. In addition, academic vocabulary, mostly specialized, appeared in student samples. Student writing also illustrated student misunderstanding or erroneous attempts to generalize what had been learned within a lesson. For example, several students used the concept of blubber to describe human fat.

Students exhibited varying skill in utilizing and adapting academic language from print material in their essays. Occasionally, students used the exact same sentences, presumably taken from print materials, within their work. Certain examples of teacher talk noted during observations (e.g., the teacher comparison of whale blubber to wetsuits), appeared across student writing samples. The student essays did not have a uniform organizational structure (i.e., beginning or thesis statement, middle, end). This may reflect less of an emphasis on writing composition in science classrooms than in language arts. Keys (1999) has argued for increased opportunities for students to practice writing across the specialized communicative genres pertinent to science (e.g., explanation, reporting). These genres in part echo the speech functions documented here; for example, the report genre includes descriptive writing. Other genres, such as exposition (that involves arguing a position) and experiment (that involves interpretation of data), offer possible fruitful avenues for expanding the list of speech function categories in future research. Moreover, the closer examination of the role of student writing and particularly its integration with on-going classroom discourse is suggested by the results of a recent study by Rivard and Straw (2000) who found that students who

both orally discussed and wrote about science concepts out-performed students who either only discussed concepts or only wrote about them.

Implications for Future Research

The work reported here is a descriptive study of functional academic language use in 4th and 5th grade science classrooms. Although the effort was exploratory, the results are fundamental to refining a conceptual framework for future analyses of academic language. Indeed, an ideal future matrix of observed talk in science classrooms would expand Figures 2 (p. 29) and 3 (p. 76) by including the following:

(1) Where relevant, additional communicative intents and the unique linguistic features (discourse, syntax, and vocabulary) necessary to carry out the intents.

(2) Additional instructional/learning contexts that focus on the explicit teaching and acquisition of both discourse and sentence level aspects of academic language to complement the existing work on vocabulary in this study. Although overt teaching of these two linguistic areas went unobserved or happened incidentally in this study, they are essential elements of academic language within all content areas and thus would need to be a part of a comprehensive description of the construct.

(3) Refinements of the matrices to ascertain whether the intersection between certain contexts and certain communicative intents are possible. It is feasible that some of the empty cells in the current matrices could never be filled. For example, teachers may never introduce new academic vocabulary while directing student behavior.

While the need remains to more fully describe and characterize the language of the science classroom (and other content-area classrooms as well), this study documented teacher behavior primarily at a functional level and may suggest a direction for proposing effective communicative strategies for teaching/reinforcing academic language. Some teachers were observed using multiple language functions to solidify concepts and then finally assess student understanding. The description below shows how a teacher might systematically move through language functions to teach a science concept:

> To teach students about the process of photosynthesis, a teacher could explain that plants take light from the sun and turn that energy into food that helps them to grow. To ensure the students understand the new concept, the teacher would then describe how a plant would die without sunlight. Next, a teacher could use comparison to describe why so few plants grow in caves while many plants grow in sunny gardens. Finally, the teacher may choose to assess students, asking them to verbalize their knowledge, in order to ensure that students understood the scientific concept being taught.

In this example, the language functions of explanation, description, comparison, and assessment are used to teach the process of photosynthesis. Perhaps teachers who organize their use of language in this manner can be more effective in teaching content area material than those who do not. This issue warrants further empirical study.

Teaching and Testing Academic Language as a Second Language

Implicit in this work is the belief that academic language development is or should be within the purview of content area teachers as well as language arts teachers and, in the case of ELLs, ESL specialists. Future work describing academic language should be extended to other grades and other content areas. As future research builds on the base established here, it will be possible to identify academic language features that cut across content areas and those that are specific to a particular content area. Curriculum development and the development of language test specifications that focus on both oral and written academic language could then follow.

ELLs are particularly in need of instruction that focuses on academic language development. If the language taught in the ESL classroom is overly simplified or does not include academic language, ELLs will be less able to successfully transition out of ESL services to mainstream classrooms. Also, the creation of academic language proficiency assessments will help prevent ELLs from exiting ESL services until they have sufficient academic language skill to negotiate grade-level content material and assessments.

Concluding Remarks

While no conclusive recommendations are possible at this time, the functional approach to academic language taken here has provided an initial means for characterizing teacher language, and to a lesser extent student language, in one specific content area. To provide a more complete picture, future studies utilizing audio and video recordings would allow for detailed transcript analysis of verbatim speech. This methodology would yield data amenable to complementary formal linguistic description. These types of analyses would then allow for an extension of knowledge about academic language use in classrooms, thereby promoting an understanding of both the purposes of language use (functional approach) and the forms the language takes (formal linguistic approach) within and across content areas. The long-term CRESST research agenda calls for the use of this information in developing curricula and language tests that support the teaching and learning of academic language across content areas in U. S. schools. These efforts would ideally benefit both EO and ELL students.

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APPENDIX A

Academic Language Exposure Checklist (ALEC)

Academic Language Exposure Checklist

Part I: Observation of Academic Language in Classroom Settings

Date: _____

Observer:_____ Observation Focus: Teacher / students

Grade:_____ Teacher:_____ Rm #:_____

Teacher E-mail/Contact Number:_____

School and District:_____

Content Area:_____ Duration in minutes:_____

Topics:_____

Classroom Activities

1.1 Describe main activities observed (e.g., group instruction, individual problem solving, silent reading, small group collaborative work)

1.1a List any materials used (i.e., text, web site, work packet)

1.2 Different groupings of interlocutors addressed by teacher and/or teacher aides:

☐Whole Class ☐Small Groups ☐Pairs ☐Individuals

Examples:

1.3 Different groupings of interlocutors addressed by students

☐Teacher ☐Whole Class ☐Small Groups ☐Pairs ☐ Individuals

Examples:

Teacher's Language Use in Instruction

2.1 Language demonstrated by teacher

Oral Language

☐Explanation

☐Description

☐Comparison

☐Clarification

☐Direction

☐Other _____

Listening

☐Verbal response (e.g., asks another question, gives oral feedback, uses rewarding words)

☐Nonverbal response (e.g., nods in agreement, uses facial expression)

Reading

Writing

2.2 Does teacher ask similar questions (e.g., paraphrase) in different ways?
☐Yes ☐No

Examples:

2.3 Teacher's use of academic vocabulary

Definition **S**ynonyms **E**xamples **R**epetition **O**ther

Nonspecialized words:

_____

_____

_____

_____

_____

Specialized words:

_____

_____

_____

_____

_____

_____

2.4 Does the teacher sustain the "theme" of lesson? ☐Yes ☐No

Examples:

3. Students' Language

3.1 Language produced by students

Oral Language

☐Explanation

☐Description

☐Comparison

☐Other _____

Listening

Reading

☐Oral

☐Silent

Writing

3.2 Do students echo the teacher's syntactic structures and vocabulary?

☐Yes ☐No

Examples:

3.3 Students' use of academic language

Nonspecialized words:

Specialized words:

3.4 Do students signal their lack of understanding?

☐Never ☐Occasionally ☐Often ☐Very Often

Justification:

3.5 How do students signal their lack of understanding?

☐Ask for repetition of given information

☐Ask for another example

☐Ask for additional definition

☐Ask peers for help

☐Overtly state lack of understanding

☐Other _____

(4) EO vs. ELL practices

Number/Proportion of ELL students in class:_____

English proficiency level of the students (i.e., ELD level) :_____

4.1 Does teacher use different language for addressing ELL students vs. EO students?

☐Uses ELL's native language

☐Simplifies explanations/provides further explanation

☐Uses synonyms

☐Uses additional examples/counter-examples

☐Changes discourse (explicit vs. implicit)

☐Other _____

4.2 Do the students use different language practices depending on whether they are grouped as all EO, all ELL or mixed EO/ELL students? ☐Yes ☐No

Examples:

APPENDIX B

Academic Language in Materials Checklist (ALMC)

Academic Language Exposure Checklist

Part II: Academic Language in Materials Checklist

(attach copy of materials where possible)

Date: _____

Reviewer: _____

Teacher: _____

School: _____

1. Textbook(s)

1.1 Title and publishing information

1.2 Describe the language level (e.g., designed for ESL, ELD, original target grade level, etc.).

♦ **Choose a random paragraph to answer questions 1.3-1.8**
If the textbook is used in the class, select a paragraph from the lesson.

1.3 What is length in words of the shortest and longest sentences?

shortest _____ longest _____

1.4 What is the average sentence length? (Total number of words in paragraph divided by total number of sentences).

1.5 List nonspecialized words (Give examples in original sentence context)

1.6 List specialized words (Give examples in original sentence context)

1.7 Describe language functions

- ☐ Explanation
- ☐ Description
- ☐ Comparison
- ☐ Direction
- ☐ Definition
- ☐ Other _____

1.8 Describe number and type of visual aids (e.g., timeline, graphs, pictures)

2. Worksheets/handouts

2.1 Give number and purpose of all worksheets and handouts

2.2 Describe language level (e.g., designed for ESL, ELD etc.)

♦ **Choose a random paragraph to answer questions 2.3 – 2.9**

2.3 What is length in words of the shortest and longest sentences?
shortest _____ longest _____

2.4 What is the average sentence length? (Total number of words in paragraph divided by total number of sentences).

2.5 Give examples of the range of syntactic structures

☐ simple declarative/interrogative

☐ multiple embedded clauses

2.6 Describe the language functions:

☐ Explanation

☐ Description

☐ Comparison

☐ Direction

☐ Definition

☐ Other _____

2.7 List academic nonspecialized words (Give examples in original sentence context)

2.8 List academic specialized words (Give examples in original sentence context)

2.9 Describe number and type of visual aids (e.g., timeline, graphs, pictures)

3. Students' Journal or Homework

3.1 Give examples of the range of syntactic structures

- ☐ simple declarative/interrogative
- ☐ multiple embedded clauses

3.2 Describe language functions

- ☐ Explanation
- ☐ Description
- ☐ Comparison
- ☐ Direction
- ☐ Definition
- ☐ Other _____

3.3 List the academic nonspecialized words (Give examples in original sentence context)

3.4 List academic specialized words (Give examples in original sentence context)

3.5 Describe number and type of visual aids (e.g., timeline, graphs, pictures)

4. Reaction to Classroom Materials

4.1 What kind of difficulties do the students encounter while working on a specific text / worksheet / handout? (e.g., word meaning, instruction, etc.)

4.2 How often and how do students signal their lack of understanding?

- ☐ ask for teacher to read the material
- ☐ ask for explanation or definition
- ☐ ask peers for help
- ☐ overtly state lack of understanding
- ☐ Other _____

Other Comments:

APPENDIX C

NUD*IST Example

Q.S.R. NUD*IST Power version, revision 4.0.
Licensee: UCLA Center Study of Evaluation.

PROJECT: **Fifth - Fourth Split**, User 2.4 ELL, 10:57 am, Jun 20, 2001.
CREATED BY: C.L.
****
***
Teacher's Language Use/Language Demonstrated by T/Oral Language/**Explanation**
++++++++++++++++++++++++++++++++++++++
+++ ON-LINE DOCUMENT: 02A OBS2
+++ Retrieval for this document: 3 units out of 203, = 1.5%
*Explanation / definition / example:
56
++ Text units 58-60:
++++++++++++++++++++++++++++++++++++++
+++ ON-LINE DOCUMENT: 02B OBS 2
+++ Retrieval for this document: 2 units out of 154, = 1.3%
*Explanation
47
++ Text units 49-50:
Explained that class was going to model something that happens naturally outside of the classroom.
49
++++++++++++++++++++++++++++++++++++++
+++ ON-LINE DOCUMENT: 02B OBS 4
+++ Retrieval for this document: 1 unit out of 185, = 0.54%
*Explanation
56
++ Text units 57-57:
++++++++++++++++++++++++++++++++++++++
+++ ON-LINE DOCUMENT: 02B OBS 5
+++ Retrieval for this document: 2 units out of 237, = 0.84%
++ Text units 74-75:
++++++++++++++++++++++++++++++++++++++
+++ ON-LINE DOCUMENT: 09A OBS 2
+++ Retrieval for this document: 2 units out of 87, = 2.3%
*Explanation
50
++ Text units 51-52:
Teacher explained that the process is called "crossing" when a scientist takes two flowers of the same type but different colors and produces the same type of flower but of a third color.
51
++++++++++++++++++++++++++++++++++++++

APPENDIX D

Classroom Activities Observation Summary

OBSERVATION: 2-B
OBS. DATE: 12/05/00
PREPARED BY: C.L.
DATE PREPARED: 04/26/01

SCHOOL: 01
TEACHER: 02
GRADE: 4/5
CONTENT AREA: Science

TOPICS: Geography / Water movement

CHECKLIST QUESTION NUMBER : 1.1, 1.2, 1.3

I. CLASSROOM ACTIVITIES

SUMMARY:

1. Whole class instruction, reviewing what had been covered.
***Teacher to whole class**

2. Individual student reading aloud to whole class as audience from textbook.
***Teacher to whole class**

3. Discussion and small number of student posed questions
***Individual to teacher**

4. Teacher led whole class instruction and direction for lab experiment.
***Teacher to whole class**

5. Pair work and some small groups perform lab experiment through collaborative work.
***Individual to small group**

6. Individual work on lab notes.
***Teacher to individual**

7. If students had completed lab work, students allowed to do supplemental individual work viewing on website.