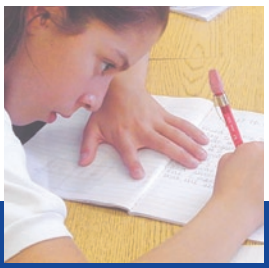
A California Science Project Publication



Essential Elements of

Effective Science Instruction for ENGLISH LEARNERS

2nd edition

Fred Dobb

Essential Elements of

Effective Science Instruction for ENGLISH LEARNERS

2nd edition

Fred Dobb

A California Science Project Publication

California Science Project
3806 Geology Building, UCLA Los Angeles, CA 90095-1567

Suggested Citation:
Dobb, Fred (2004) *Essential Elements of Effective Science Instruction for English Learners,* 2nd edition. California Science Project: Los Angeles, CA.

Additional copies of this publication are available from: California Science Project, 3806 Geology Building, UCLA, Los Angeles, CA 90095-1567. It also can be found online at http://csmp.ucop.edu/csp

Cover photographs courtesy of California Science Project sites: Bay Area Science Project and Imperial Valley Science Project.

Foreword

"Science education is intended for all students. Academic instruction must be designed so that each student has the opportunity to master science standards that provide systematic and coherent access to this challenging subject…Instruction for English Learners in the academic language of science is critical and must be specifically designed, planned, and taught."

Science Framework for
California Public Schools:
Kindergarten Through Grade Twelve
2003

As the Science Framework for California Public Schools points out, science education must reach the more than one quarter of our student population classified as English Learners (EL). Among the many challenges facing teachers of EL, at all grade levels, are the purposeful development of scientific written and oral discourse, science-specific academic language, and standards-based understandings. With these skills EL will succeed in the all-English classroom, eventually be reclassified as fluent English proficient (FEP), and graduate from high school prepared for postsecondary study and careers.

Designing and implementing effective science instruction for EL has been a major emphasis of the California Science Project (CSP) through its university/school district partnerships across the state. This publication reflects the crucial issues addressed by CSP in its professional development activities conducted by university scientists in collaboration with EL specialists, and staff development experts. Among the topics examined, debated, and addressed in depth by CSP are modifying instruction, assessment, developing academic language, and the use of textbooks.

In this, the second edition of Essential Elements of Effective Science Instruction for English Learners, our English Learner Specialist Dr. Fred Dobb examines the special challenges to sci-

ence teachers working with EL and the proposition that science teachers can be highly effective language teachers. Response to the first edition of this publication from within California, the United States, and from other countries, has been encouraging and enthusiastic. Fred Dobb's work has now been used extensively by teacher credential programs at universities, school district professional development events and, of course, by the CSP regional sites. Demand for more copies has resulted in this updated second edition, which includes expanded resources, a revised Sheltered Science Instruction Observation Protocol, and the addition of a graphic organizer for instructional planning, "Targeting Academic Language Development for English Learners Through Scientific Investigation and Experimentation," in Appendix III.

Finally, the CSP network has embraced the development of the academic language of science for English Learners through its setting of priorities and the allocation of resources. I wish to thank the following CSP statewide office staff members for their many contributions to the development of this publication: Shan Boggs and Michelle Gamboa-Huitron, for their meticulous editing, Alex Ko, for his technical work, and Suzanne Nakashima for collaborating with the author on science content issues. In addition, I wish to thank the following regional site educators for their suggestions for enhancing this edition: Sonia Jaramillo, Monterey Bay, Jeff White, Redwood, and Yolanda Guerrero, Olga Amaral, and Mercedes Durón-Flores, Imperial Valley.

María Alicia López-Freeman
Executive Director
California Science Project

Contents

Introduction

In planning activities affecting EL and their teachers, it is worth restating those key factors that are often lost during political battles over language minority education in California and the nation. Once we understand and maintain awareness of the complex political, social, and economic reality of these students, we establish a firm foundation to assess the appropriateness of competing pedagogical philosophies and approaches. Effective science teachers view their educational practice within the context of the lives of their EL.

For those of us considering the impact our professional development activities may have had, we need to reflect on just how strongly we have presented the case for needed change. An upgrading of services to the EL population will arrive when we, as a community, are personally and professionally committed to work toward that which we would accept for our own children. Despite abundant evidence of our educational system's failure to assure educational success for all students, our system has yet to respond with authenticity and quality implementation.

When we restate the key factors of working with EL, we acknowledge that teaching demanding science content is not the same as teaching an English proficient student and we acknowledge that reaching EL involves approaches that go beyond "just good teaching." Let's examine these two factors more closely.

First of all, the U.S. Supreme Court, other federal courts, and the voters of California have identified EL as students requiring specialized instruction. At a minimum, schools must select appropriate approaches, implement those approaches, and monitor student progress. To ignore the language proficiency of EL is to violate their civil rights and doom them to academic failure. Extraordinary means, such as specialized English instruction and use of the primary language, are called on to avoid and/or make up for educational deficits.

In California, the possibility of teaching science through

the primary language has largely been foreclosed by state and local decisions to teach and test in English only. In science, we need only refer to the results from recent testing to see that very few EL, at the high school level, scored at or above the 50th percentile.

During professional development activities involving instructional strategies for EL, we often hear that these "are just good teaching practices." Certainly these strategies may be effective with other students, but omitted in the comment is what the EL brings to the pedagogical encounter. Whereas for other students the approach may further clarify a concept, for the EL the same approach may be an instructional life raft, which rescues the student from an otherwise incomprehensible science lesson. We need to remind ourselves that EL often find themselves overwhelmed by a language not their own, in an unwelcoming school environment where they are reluctant to participate actively. Also, we acknowledge that second language development is a personal and idiosyncratic journey in which the science classroom can provide motivation and situations to use English for meaningful communication.

Finally, in restating and reexamining key factors affecting the teaching of science to EL, we accept the challenge to plan professional development activities that will create positive teaching and learning situations. The CSP has committed itself to brighter academic futures for EL. Through this publication, with its delineation of ten essential elements of effective science instruction, we share what we have learned on the road to equity for these students.

Essential Element #1

Academic Language Through Science Instruction

Among the many challenges facing the teachers of EL is the purposeful development of academic language through science instruction in both self-contained and departmentalized settings. For EL to succeed in the all-English classroom, to eventually be reclassified to fluent English proficient (FEP), and to graduate from high school, they need discipline-specific and appropriate language.

At present, in most educational organizations resources are dedicated to the earliest stages of English Language Development (ELD) where the student needs are the most obvious. Newcomers and beginning ELD students learn survival and classroom coping skills. Once oral social language is present, students' needs for more demanding academic language can be masked by short answers, smiles, nodding heads, and barely getting by in academic subjects. Limited resources and extra help may be withdrawn in order to serve those at the lower proficiency levels, or withheld because it is seen as unnecessary for academic progress.

As a consequence, large numbers of EL reach the early intermediate and intermediate level of English proficiency, and stay there. (See Appendix III for complete proficiency level descriptions.) Statewide these students number in the hundreds of thousands; they do poorly academically and receive little specialized instructional attention. They struggle, but never excel or thrive in the classroom. Their mastery of science content standards is inadequate and leaves them unprepared for higher education. In some districts, these are known as "the students waiting to be reclassified as FEP." Some leave high school after many years as

EL, with or without a diploma. With increasing graduation requirements, "without the diploma" will become the norm unless we strengthen services to EL in science as well as the other core subjects.

A linguistic profile of these EL reveals social speaking skills, but not the skills needed to persuade, debate, or give oral presentations. Decoding skills may mask a lack of comprehension of complex text. Students get the main idea of a lesson, but miss important technical details and nuances. The specialized scientific meaning of everyday words goes unperceived. Writing a few sentences on a test does not extend to completing a lab report.

The science teacher, at all grade levels, plays a pivotal role with these students. It is the science teacher who can provide a language-rich environment where EL can create and express understandings. Regardless of changing policies and practices, it is indisputable that science instruction has a distinct place in the development of academic language. Within the CSP we work to recognize, understand and implement this vital role of subject matter instruction in academic language development. Our work is guided by two fundamentals:

1. Inquiry science provides shared experiences. In other words, it offers an arena in which the EL can try out their maturing ideas about scientific phenomena using their expanding second language skills. It is only through expressing oneself about "something" that another language adheres to our lives and becomes part of our identities. Science content becomes that "something." What is learned in science through English remains as part of one's understanding of the universe and represents a step in one's growth into a second language. Thus, the student who plans, plants, observes, and records growth of her garden in English brings purpose

and significance to both life science and all ELD skills.

2. There is a direct correspondence between the steps in the scientific process, with its incremental demands for an ever-expanding vocabulary and literacy skills, and the levels of English language proficiency contained in the California ELD Standards. Throughout the process, the students' goal is to use contextually appropriate language that is accurate, precise and objective. For example, the oral or written descriptions of experiments expose EL to a sequence of steps different in presentation style from other listening and reading experiences. Language structures expressing causal relationships need to be understood, tried out, and eventually incorporated into the linguistic repertoire of the EL.

Appendix IV of this publication consists of a graphic organizer entitled "Targeting Academic Language Development for English Learners Through Scientific Investigation and Experimentation." It is designed for use in professional development programs in order to analyze the relationship between expermentation and investigation and English language developement, to plan instructional units. and to examine instructional materials.

As we continue to evolve as a provider of professional development, we sharpen our focus on the academic success of EL by:

1. Capitalizing on the potential of each step in the scientific process for academic language development at each level of proficiency in listening, speaking, reading, and writing.
2. Promoting changes in the learning environment of the science classroom to make it more supportive of EL success.
3. Incorporating into instruction what we have learned from case studies of former EL who have become science professionals.
4. Exploring the unique relationship between the sciences and the EL population — history, trends, desired goals, and international perspectives.

5. Sharing among regional sites and efforts in other states an array of materials focusing on successful approaches.
6. Developing assessment items appropriate for students at various grade levels and diverse ELD proficiency levels.
7. Collaborating with regional leadership teams to strengthen our knowledge base and professional development delivery capacity regarding EL.

Essential Element #2

Affective Factors

It is worth pondering what would happen in California science classrooms today to that famous screen beauty and inventor, Hedy Lamarr, and other scientists for whom English was not a first language. Would their talents in the sciences be recognized and encouraged or would they be advised to take less demanding courses? Would their lack of academic English skills result in poor grades and discouragement?

Often over looked in the articulation of quality science teaching is the affective domain so essential in making a positive connection with EL. Without that connection, standards-based content, high quality materials, and teacher preparation have little impact.

Consider the 1998 California Standards for the Teaching Profession, developed by the California Department of Education and the Commission for Teacher Credentialing, in light of connecting with EL. As with most general statements and generic words of guidance geared to the broadest of educational audiences, a teacher has to amplify and stretch these standards to see the ties to the needs of EL. If one wished to make the tie, it is possible. If one wishes to ignore the tie, it is also possible. It is not sufficient to merely mention "all students," or "individual needs," or "making subject matter accessible." One must also consider the perspective of the EL in the science classroom and what affective factors encourage EL engagement.

While trying to receive, interpret and explain science content, EL frequently ask themselves a series of questions in our classrooms. Probably, most of our standards for teaching do not

come close to addressing them. New and experienced teachers will likely find some resonance in these questions. Here are a few examples:

- Does this teacher know who I am?
- Does this teacher care about me?
- Does this teacher want me to succeed?
- Does this teacher realize that I am not intellectually limited, even though I am not able to express myself completely in English?
- Does this teacher understand the fear of ridicule and embarrassment I must overcome every time I open my mouth to speak, participate in a group, or hand in written work?
- Does this teacher see me as a potential contributor to scientific knowledge?

These are very relevant concerns of students who need to be assured and reassured that their teachers are aware of the issues behind each question and are willing to reach out to each EL.

Science teachers who are able to connect to these students are successful in communicating that students are not alone in their struggle to participate, that support is available, and that former EL have succeeded in the science program. Equally important, on the part of the instructors, is the outward recognition that the EL population is diverse. Instructors avoid making false, defeating assumptions about demanding science content knowledge, academic English, and career goals and the futures of EL.

Next time we use our cell phones, think of former EL Hedy Lamarr, whose patent makes possible such wireless communication and think of those other EL we see in our classrooms. The next important inventors and scientists (and movie stars) are before us.

Essential Element #3

Classroom Talk

As new California Science Standards Tests are gradually introduced, they will join the constellation of standardized tests designed for English proficient students, but inappropriately given to EL. The difficulties of adequately assessing the science knowledge of EL in English have been extensively documented by Solano-Flores, Sexton, and others. In response to this situation, CSP has been developing K–12 science standards-based measures that take into account the developing English proficiency of these students. (See Essential Element #10.)

Nevertheless, the new statewide science testing activity has caused science to re-enter the elementary school curriculum, at least at grades four and five, on whose science standards the test is based. Looking at the blueprint for the test, we see that students will be expected to "know and express" and "show" their knowledge of specific scientific concepts from the fourth and fifth grade standards on a written multiple choice test using scientific terms, discourse and conventions. The test blueprint is located at: *http://www.cde.ca.gov/ta/tg/sr/blueprints.asp*

There is now a greater likelihood that EL will receive science instruction. In the process of planning science instruction, it is expected that teachers will consult both the *California Science Content Standards* and the *English Language Development Standards* to capitalize on the advantages of teaching content to develop academic language. A hands-on science classroom can be a rich, highly motivating language laboratory. The key to building on EL experiences and leading them to reading and writing about science is engaging them in purposeful, guided instructional conversations about their lessons.

A groundbreaking article by one of the pioneers in content and language scaffolding theory and practice, Pauline Gibbons, shows just how productive this teacher and student talk can be in moving from everyday comments on scientific phenomena to academic discourse. (Unless otherwise noted, all quotations in this section come from "Mediating Language Learning: Teacher Interactions in a Content-Based Classroom," by Pauline Gibbons, TESOL Quarterly, Vol. 37, No. 2., Summer 2003. *http://www.tesol.org/*)

Gibbons' article describes what she observed in two fourth and fifth grade classrooms working on magnetism and how effective strategies for instructional conversations resulted in student growth, both in English as a Second Language and in science. The article includes samples of science-based conversations on magnetism and analyses of how teachers artfully used student responses to keep the dialogue moving to higher levels of scientific understanding and discipline-appropriate language.

According to Gibbons, significant student growth results when the following conditions exist:

1. Teachers and their EL students form a partnership through guided conversations in which the students gradually appropriate the language of the discipline and use it to express their understandings. While there is "considerable linguistic and conceptual distance" between science teacher and students, teachers make "discourse and linguistic choices" to contract that distance.
2. Teachers assist EL "in moving from registers expressing their firsthand experience in oral language to those expressing academic knowledge in writing." In other words, teachers move EL along a continuum of oral social English to the school world of written language, from inter-personal talk to school valued expository text.
3. Teachers are skillful at signaling a need for clarification of EL talk and providing clues for modifying their language. EL,

not teachers, restate their words in more academic terms. "The teacher hands over to the student the responsibility for clarification, which results in increasingly explicit information from the student …comprehensible output." In effect, teachers are stretching student language to conform to conventions of the discipline.

4. EL take responsibility for making themselves understood to teachers who are motivated and interested in developing effective speakers who can describe, explain, question, hypothesize, and persuade.
5. Instructional conversations represent a rehearsal for scientific writing in lab reports or science journals.

In summary, Gibbons reminds us that in preparing EL to take the written fifth grade science test and future tests at other grades, we must reconsider and effectively employ the oral instructional conversation in order to move EL from personal experience to academic English, from detailed oral expression to factual writing, and from a superficial to a deep understanding of science.

Essential Element #4

Vocabulary Development

Science vocabulary development represents a continuing thread of academic growth for EL as they progress through the levels of English proficiency from "beginning" toward "advanced." Here, we look at science vocabulary development from three perspectives: its importance in over-all academic achievement; its role in student use of the academic language of science; and the powerful instructional use of high frequency science terms and academic vocabulary lists.

Research shows a strong relationship between an extensive student vocabulary and over-all academic achievement. Standardized tests favor students with well developed vocabularies. During science instruction, EL must rely on their second language vocabulary not only to understand concepts, but also to generate written explanations of their readings, experiments, and observations for themselves, their teachers, and fellow students. Higher levels of academic achievement accompany an ever-expanding vocabulary for EL.

In a refinement of his work on second language development, Cummins states in "Reading and the ESL Student," that EL progress in their academic careers from acquiring conversational fluency by adding the most frequently used spoken words to their linguistic repertoire, to learning discrete language skills in order to comprehend new vocabulary, to the ultimate goal of general and science-specific academic language. At this stage in their science study, vocabulary principally from Greek and Latin roots can represent a significant challenge. Science reading ma-

terials become more complex, technical, abstract, and beyond students' social experiences. Extensive reading of science materials, however, provides exposure to Greek and Latin-based words, a richness not generally found in oral language.

Because a basic core of approximately 2,000 high frequency words accounts for most words in academic writing, effective science teachers can provide direct instruction of vocabulary to benefit EL through a variety of activities.

In Accelerating Academic English: A Focus on the English Learner, Scarcella advises that these activities target not just meaning, but also such related issues as parts of speech, frequency, appropriateness in scientific writing, which words are commonly used with the word, and pronunciation.

There are many well researched, high frequency word lists available, ranging from general academic language, to general science, to science discipline specific. *The Corson University Word List: The Most Frequently and Widely Used 150 Words*, represents the first type of list and contains words like "environment," "affect," "select," and "species," which first appear in the kindergarten science class. The *Academic Word List* contains 800 words arranged alphabetically from all disciplines. *Bar-Tzur's Vocabulary List for General Science* contains 357 terms, many of which first appear in early science instruction and continue through university. Finally, an Internet search reveals specific vocabulary lists for biology, geology, environmental science, chemistry, and physics. Examples of science specific words are: *http://www.theinterpretersfriend.com/tech/vocab/vl/science.html* and *http://www.uefap.co.uk/vocab/select/sp_env.htm*

In their practice, the instructors need to be conscious of these word lists, gauge their importance for EL, and emphasize those words with the greatest likely benefit to the students. Key to profitable use of student study time is placing instructional spotlight on words likely to reappear regardless of grade, science course, or textbook. These words should be used in lesson planning, used consistently in class in different lessons, and should appear in student speech and written work.

Not only do words and expressions have different meanings from everyday usage, but also for EL, the common usage itself may be unfamiliar. In summary, instructors can pay attention to teaching vocabulary within the scientific context, not in isolation, and avoid memorization of vocabulary lists without content support.

Essential Element #5

The Science Textbook

It is useful to examine the recommended ways of working with EL and their science textbooks. Among the many challenges faced by the science teacher is the effective use of textbooks developed with little consideration for the EL. Clearly, teachers must explore new ways to use the textbook to reach EL for both the learning of science content and proficiency in the academic language of science. It is through this examination that science teachers also better understand their role as facilitators of second language development.

Using science textbooks with EL presents the instructor with a pedagogical dilemma. On one hand, the use of the same textbook as that used with English proficient students assures that the EL student will be exposed to the same standards-based content. Eventually, the student will face this same content in standards-based examinations written in English. Here, too, is a great potential source of academic language about real world phenomena. The textbook provides the student with a written reference full of colorful illustrations, charts, and graphs. On the other hand, because the text assumes proficiency in academic English, it is obvious that the EL will not derive the same benefits from the textbook without teacher intervention and guidance. In her landmark work, *Teaching Science to Language Minority Students*, scientist and second language acquisition specialist Judith W. Rosenthal explains why.

Rosenthal asserts that the factual and direct style of scientific writing can be dull, impersonal, and decidedly harder to understand than narrative fiction. The English classroom, where

the most direct teaching of language occurs, rarely exposes the EL to expository writing with complex content. In the textbook, content is often unfamiliar, and new vocabulary is introduced rapidly and constantly. Details are usually presented before general ideas and concepts. Dense passages require rereading. There is infrequent repetition or restatement of information.

When faced with fact-packed textbooks and the necessity to slow down and reread material, even the most motivated EL complain of fatigue and frustration. Students with strong academic preparation in their primary language may need two or three times as long to read the textbook as they would to read the same material in their stronger language. Without careful instruction, their engagement with the text and comprehension tend to be low. Frequently, they miss the major science concepts and find little positive reinforcement in their attempts to keep up.

A thorough review of materials, focusing on the challenges presented to EL by their science textbooks, yields the following six groupings of instructional strategies and approaches: primary language support, reading comprehension activities, attention to study skills, vocabulary development, attention to scientific discourse patterns, and the use of supplementary materials.

1. Primary language support is appropriate for EL at various levels of proficiency development. Depending on the instructional objectives of the program, primary language utilization ranges from classes taught in the other language to the use of bilingual instructional assistants, to purchasing bilingual dictionaries to including other language editions of the textbook and tests. The appropriate grouping of students with a common primary language often facilitates the inclusion of primary language support.
2. Reading comprehension activities for individual students and groups appear in compendiums of teacher directed strategies. Typical of these activities are those that focus on important habits such as previewing material, recognizing chapter

headings, identifying introductions, reading every first sentence in a paragraph, understanding visuals and graphs, summarizing, and answering end of chapter questions. Activities emphasize the importance of allowing students to show their understanding of written materials in a variety of ways.

3. Attention to study skills often includes the study of the textbook as a genre with definite characteristics of expression. Cautions are shared about such unfortunate textbook practices as placing visuals at a distance from related text or including interesting, but extraneous material in chapters. In this grouping, we also find an examination of comprehension strategies used by successful science students in mastering the material of each chapter.
4. Vocabulary development focuses on the multiple meanings of words frequently found in science textbooks. Scholars have developed multiple lists of high frequency academic words and words appearing in science materials. Science word lists include: *http://www.theinterpretersfriend.com/tech/vocab/vl/science.html* and *http://www.uefap.co.uk/vocab/select/sp_env.htm*

   Key to profitable use of student study time is placing instructional spotlight on words likely to reappear often during the EL years in class, regardless of grade, science course, or textbook. Not only do words and expressions have different meanings from everyday usage, but also for EL the common usage itself may be unfamiliar. Attention is paid to teaching vocabulary within the scientific context, not in isolation. Memorization of vocabulary lists without content support is avoided. (See Essential Element #4.)
5. Attention to scientific discourse patterns is crucial in getting EL to recognize and understand the differences between expository text and narrative. Students need to get practice reading, listening to the material, and using such common linguistic structures as "if _____, then_____," linking words

such as "then," "next," "finally," "after," the explanation of events or phenomena using a logical sequence, or the inclusion of a concluding statement in oral and written reports.

6. Use of additional supplementary materials, to strengthen EL understanding of major concepts or to link their prior experiences to new science classroom experiences, is frequently suggested. In cases where the student does not comprehend the textbook material, these materials provide alternative avenues to the material. A comprehensive list of such materials for science is found at the California Department of Education website at: *http://www.cde.ca.gov/ci/sc/ll/*

In summary, the challenges presented to EL by their science textbooks can be addressed by the instructor through a variety of approaches that both add depth to scientific understandings and further the development of academic English. Resources, representative of each of these six groupings of ways to work with EL and their science textbooks, are found in the Pedagogy section of Appendix I.

Essential Element #6

Science Textbook Teachers' Guide

Essential Element #5: the Science Textbook identifies a variety of effective textbook-based strategies in the second language acquisition literature specific to working with EL: (1) primary language support; (2) vocabulary development; (3) attention to study skills; (4) reading comprehension activities; (5) attention to scientific discourse patterns; and (6) use of supplementary materials. Nevertheless, even a limited review of science textbook teachers' guides, finds that few of these strategies have been adapted for chapter topics or as ways of approaching reading comprehension.

It appears that the number of excellent resources filled with instructional strategies for working with EL have had only limited impact on science textbook writers and publishers. In order to maximize the usefulness of science textbooks for EL and their teachers, many textbook publishers have added sections to their teachers' guides explicitly for EL similar to sections for gifted and compensatory education students. In all cases, these sections are welcome and long overdue. Now that EL and their teachers are included, it is time to consider the nature and quality of this inclusion. Regrettably, in some cases, the inclusion of these strategies seems forced and not grounded in the major science concepts presented in the student textbook.

Here we look at typical science textbook teachers' guides suggestions and find that these suggestions fall into the following six broad categories: (1) use of primary language; (2) word

origins/pronunciation; (3) study skills; (4) link to prior knowledge; (5) interactions with other students; and (6) visual representations. Our review contains abbreviated examples of each category with commentary.

1. *Use of primary language* — Examples: "Ask students for the word for 'lead' in their native languages." "Have students write down the types of rocks in their native language in a journal." Comment: Not addressed are how teachers are to use these student-generated words in instruction, especially when the teacher does not know these other languages and when primary language instruction in science is not offered. Students may not have the scientific vocabulary required in their primary languages.
2. *Word origins/pronunciation* — Examples: "Mention that the word 'X' is of Greek origin and means 'Y.' " "Point out that when words with two or more syllables end with a 'y,' the 'y' sound is usually like a long 'e.'" Comment: There are more "telling about the word" sections than significant vocabulary development activities. There is a need for stronger connections between the use of the words within the unit and more student use of the new words in speaking and writing.
3. *Study skills* — Examples: "Challenge the student to use the dictionary to look up 'Z.' " "Have students make up their own memory devices to remember science facts." Comment: There is a need to explain how teachers can help students build on the language skills they have to review and write about what they have learned. There is little attention to the textbook as a specific genre with reading challenges or on how to understand the information as it is presented in different forms.
4. *Link to prior knowledge* — Examples: "Have EL prepare topographical maps of the area in which they were born or immigrated from." "Visit a construction site where machines are used and discuss observations in the classroom."

Comment: There is an absence of systematic ways of acknowledging student prior experience and knowledge and sharing it with others. Prior knowledge is not examined and valued fully as key to deeper comprehension of print.

5. *Interactions with other students* — Examples: "Pair EL up with English proficient students to discuss the results of the experiment." "Request students describe their experimental procedures with the class." Comment: More guidance is needed in establishing roles and expectations for EL participation in heterogeneous groupings.
6. *Visual representations* — Examples: "Challenge students to draw and label the parts of a volcano." "Arrange chairs in the classroom to reflect the solar system." "Ask students to draw two word webs." Comment: These activities are adequate beginnings that should be used to expand student language in all skill areas; however, more detailed instructions to the teacher are needed.

In comparing these two sets of categories — one from methodological sources, the other from science teachers' guides — there appear to be some similarities for items one through three. Nevertheless, to fully operationalize these strategies the guides need further development. Take, for example, the first three areas. Primary language support exists when the teacher can understand and react to what the EL student has produced in the other language. Vocabulary development in science is successful when EL can incorporate new vocabulary accurately into their oral and written production. Study skills result in independent learners. Regarding the other three areas, the teachers' guides fall far from the mark. For example, reading comprehension would ideally focus on those challenges presented by the content of the textbook itself. Further, there is very little attention to the patterns of written and spoken scientific discourse. Supplemental materials other than those associated with the various textbook series that could be of importance to EL are usually omitted.

However well intentioned teacher guide suggestions may be, in some cases, they are incomplete paths to the development of the academic language of science or the understanding of science concepts.

It still falls to the instructor to combine her pedagogical knowledge of EL strategies with her science content knowledge to assure quality instruction. Following the teachers' guide alone will not lead to the mastery of standards. In most teachers' guides, the same series of suggestions are repeated regardless of the scientific topic presented in the chapter, the prior science studies of the students or English proficiency level. In general, there is a lack of emphasis on student comprehension of major concepts and a focus on discrete parts of the material in the textbook.

In evaluating the overall seriousness and quality of a science teachers' guide and whether or not to employ the proposed strategies, teachers should ask a few of these questions:

1. Is there a means for checking EL comprehension of the unit content? If students didn't get it, what do I do?
2. Do these strategies utilize and lead to the independent use of science process skills?
3. What correspondence exists between the strategies and the ELD levels of my students?
4. Are strategies consistently placed throughout the teachers' guide?
5. Are the activities equal in rigor and challenges to those for all students?
6. Are strategies provided for scaffolding instruction in the introduction of new materials?
7. Are strategies provided which lead to an instructional conversation between EL and their teacher?
8. Do the activities capitalize on the visual and physical properties of science experiments and demonstrations?

Essential Element #7

Professional Development

This is a consumers' guide developed in order to assist teachers in making an informed selection of professional development programs. All CSP regional sites address the needs of EL explicitly and in detail through written proposals of professional development focusing on areas of critical importance in instruction. Whatever their level of expertise and history of commitment to EL issues, each site is challenged to rethink its services to EL and under performing schools, and include well planned activities based on a firm theoretical base in their program designs.

Several years of building expertise and capacity have paid off with all proposals addressing academic language in the science curriculum for EL, and with various degrees of sophistication and precision.

Among those instructional issues that are receiving further CSP attention, through additional resources to sites and technical assistance, are the following:

1. The special challenges of scientific spoken and written discourse, and vocabulary that need to be included in instructional design.
2. Incrementally adding rigor to academic language as students progress to higher levels of English Language Development (ELD).
3. Assuring that the specific needs of EL are addressed not just at the earliest stages, but until they have mastered the literary conventions of science and can communicate effectively within the discipline.
4. How state-adopted and supplementary materials can most effectively be used with EL.

5. Efficient and supportive ways to provide feedback to students on their written and oral work within the context of science instruction.

In planning professional development programs, each CSP site faces significant challenges. Consulting standard references in science education provides no help as they largely ignore the issue of language minority students. On the other hand, publications by the Teachers of English to Speakers of Other Languages (TESOL) organization frequently call for essential collaboration with subject matter teachers. Consequently, CSP sites survey teacher needs and adapt from their previous experiences in developing action plans.

In any case, here are a several questions to ask. No program will probably include all these features. The programs will also probably cover additional topics, concerns, and issues. While this list is not all-inclusive, it does provide some guidance in making decisions about professional development for those teaching science to EL.

1. To what extent is the program based on the development of academic English for science?
2. Is there a demonstrated understanding of the relationship between ELD and science?
3. Do activities focus on activities designed to move students to the next higher level of English proficiency?
4. Is there a strong focus on providing a rigorous science standards-based curriculum for EL?
5. Does the program make informed connections between ELD and the science standards?
6. Does the program acknowledge the needs of EL at all levels of developing English proficiency?
7. Is there attention to ways of providing feedback to students in all language skill areas, especially writing?

8. How well does the program address the science-specific academic language challenges for EL?
9. Does the program assist teachers in the use of state-adopted materials and supplementary materials with EL.

Essential Element #8

The Sheltered Science Instruction Observation Protocol

The world of sheltered instruction for EL and their teachers has taken a huge step forward with the start of training sessions offered by the Center for Applied Linguistics in support of the Sheltered Instruction Observation Protocal (SIOP). California State University, Long Beach, (CSULB) was the site of the first SIOP Training of Trainers attended by an international group of instructors and representatives from the CSP. Many future trainings are planned around the world. The trainers were the creators of SIOP: Dr. Deborah Short, Center for Applied Linguistics; Dr. Mary Ellen Vogt, CSULB; and Dr. Jana Echevarria, CSULB.

CSP involvement with SIOP has continued with the adaptation of the instrument and training to the specific needs of standards-based science instruction. As commonly implemented, Sheltered Instruction (SI) or Specially Designed Academic Instruction in English (SDAIE) is a means for making grade-level academic content accessible to EL, while at the same time promoting their English language development. Science teachers skilled in SI use strategies such as visual aids, demonstrations, pre-reading activities, graphic organizers, and adaptation of textbooks to make the content comprehensible. These teachers develop the academic language of science through specially designed activities in listening, speaking, reading, and writing. They purposefully work to include the discourse of science in the linguistic repertoire of their students.

The SIOP is a tool for self-monitoring and/or peer coaching in the effective delivery of content to EL. The document focuses on the following areas of teaching and learning: preparation, build-

ing background, strategies, interaction, practice/application, lesson delivery, and review/assessment. Complementing the SIOP is the SIOP Lesson Planning Guide. Both documents lead us in the careful combination of English Language Development Standards and science standards.

The CSP statewide office now offers Sheltered Science Instruction Observation Protocol (SSIOP) training to its regional sites for replication in schools, districts, and science departments. Each regional site receives a comprehensive training manual, publications developed by SIOP, including a training video and *Making Content Comprehensible for EL: The SIOP Model*, the adapted SSIOP, and follow-up consultations for implementation.

The following is the text of item #15 taken from the instruction section of the CSP adapted SSIOP that can be rated by the instructor or others observing the science lesson.

> The teacher engages students in a **scientific conversation, which moves students from personal experience and everyday language to generalizations expressed in discourse patterns specific to the discipline**.
>
> The teacher includes the use of question types and strategies, which specifically promote science process skills (e.g. observing, classifying, measuring, using numbers, communicating, inferring, predicting, collecting, recording and interpreting data, and identifying and variables, defining operations, making hypotheses, and constructing and using models).

The complete SSIOP is found in Appendix II of this publication.

Further information on SIOP, articles on the accomplishments of the project, and research focused on sheltered instruction is available on the SIOP web page: *http://www.cal.org/projects/si*

Essential Element #9

Lesson Study

Regional sites have participated actively in including the Lesson Study process in their professional development activities. The process lends itself to a closer examination of instruction as teachers discuss their planning and attempts to reach all students. Each step in the organization of Lesson Study, such as focusing on goals and content, planning study lessons, teaching and observing lessons, discussing instruction, revising and reteaching, and filing the lesson study report — provide opportunities for observing EL and their work and constructing improved instructional strategies. At each point, we consider the short and long term progress of our science students.

Within the CSP, we work to meet the challenge of making standards-based instruction comprehensible to EL and to provide the opportunity for these students to develop the academic discourse to succeed in the science curriculum. As we consider individual standards, we may lose sight of larger goals for EL. Lesson Study asks us to consider how close we are working toward these larger goals for EL.

What do we mean by these larger goals? Specifically, for these second language learners, this means gradually developing English proficiency that approximates that of their English-speaking peers, that permits successful participation in the school's academic program, and provides students with skills to meet most course needs. Students can then read, comprehend and write to meet most academic demands of the discipline at grade level. It means being reclassified as fluent English proficient using multiple criteria, and graduating from high school.

In addition, we want these students to be scientifically literate and capable of building connections between science, technology and society.

For example, in working with EL at the intermediate level of proficiency on a unit on ecosystems, we expect students to explain how energy flows through the system. In order for students to explain in both oral and written form, a lesson must contain specific content and second language instructional characteristics. Thus, before we ask students to explain to classmates or answer essay questions about ecosystems, we need to review the nature of the instruction they are receiving. More specifically, we might ask the following questions:

1. Have students been able to make the connections between the concept of ecosystem with their own life experiences?
2. Have students been exposed to sufficient material to draw upon for their explanations?
3. Do students have the command of patterns of oral and written organization to be able to successfully share what they know?
4. Have students had the opportunity to perform the role of teacher or guide to peers or adults?
5. Has corrective feedback been provided to students before performance is formally evaluated and graded?
6. Have students begun to feel comfortable as explainers of scientific phenomena?
7. Through their classroom activities have students added the vocabulary specific to ecosystems such as food, energy, flow, and interdependence to their active personal vocabulary?

In summary, the Lesson Study process provides us with an opportunity to improve our instruction by purposefully examining, along with our colleagues, the long-range goals for EL in science and seeing if our incremental, daily instructional steps will lead us to fluent English proficiency.

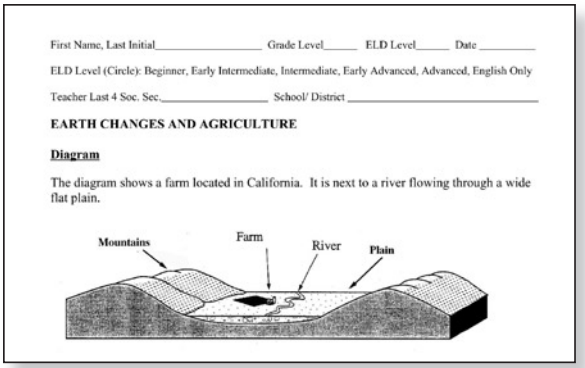
Essential Element #10

Assessment

CSP has been developing and field-testing a set of criterion-referenced measures for EL based on the California Science Content Standards over the last three years. During this period, the California English Language Development Test (CELDT) has become the established statewide-standardized instrument for initial EL identification and measuring annual English language growth. There now exists a commonly used set of descriptors of EL proficiency levels: beginner, early intermediate, intermediate, early advanced, and advanced. A more complete description of these levels is included in Appendix III of this publication and on line at: *http://www.cde.ca.gov/ta/tg/el/*

Teachers have also become increasingly sophisticated in their use of all testing results in planning instruction. The CSP/EL items provide additional subject-specific information on the development of academic language. The items also function as intermediate steps in preparing EL to take standardized tests in science and other subjects that have been designed for the general English proficient population.

The CSP's commitment to this project arises from both extensive classroom experience and a thorough review of the research showing just how difficult it is to get an accurate picture of what EL get from science instruction conducted through their second language. In addition, the CSP recognizes the complexities of working with two sets of standards: science and English Language Development (ELD), and has come to capitalize on the relationship between doing and experiencing science and talking and writing about it using the topic appropriate discourse pat-



First Name, Last Initial_____ Grade Level_____ ELD Level_____ Date _____

ELD Level (Circle): Beginner, Early Intermediate, Intermediate, Early Advanced, Advanced, English Only

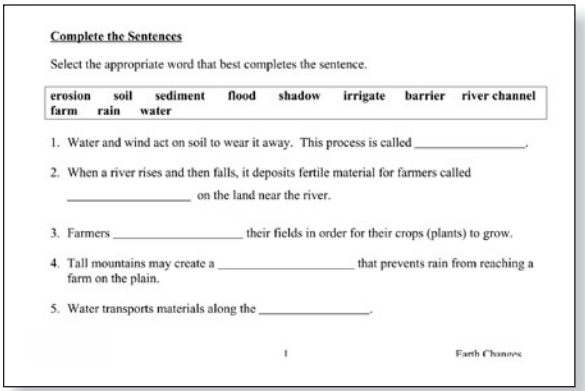
Teacher Last 4 Soc. Sec._____ School/ District _____

EARTH CHANGES AND AGRICULTURE

Diagram

The diagram shows a farm located in California. It is next to a river flowing through a wide flat plain.

Fig. 1



Complete the Sentences

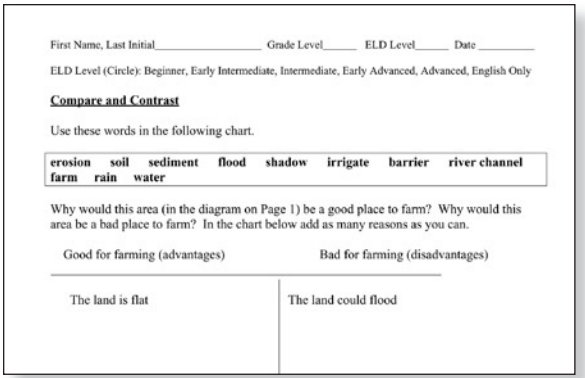
Select the appropriate word that best completes the sentence.

erosion	**soil**	**sediment**	**flood**	**shadow**	**irrigate**	**barrier**	**river channel**
farm	**rain**	**water**					

1. Water and wind act on soil to wear it away. This process is called _____.
2. When a river rises and then falls, it deposits fertile material for farmers called _____ on the land near the river.
3. Farmers _____ their fields in order for their crops (plants) to grow.
4. Tall mountains may create a _____ that prevents rain from reaching a farm on the plain.
5. Water transports materials along the _____.

1 Earth Changes

Fig. 2



First Name, Last Initial_____ Grade Level_____ ELD Level_____ Date _____

ELD Level (Circle): Beginner, Early Intermediate, Intermediate, Early Advanced, Advanced, English Only

Compare and Contrast

Use these words in the following chart.

erosion	**soil**	**sediment**	**flood**	**shadow**	**irrigate**	**barrier**	**river channel**
farm	**rain**	**water**					

Why would this area (in the diagram on Page 1) be a good place to farm? Why would this area be a bad place to farm? In the chart below add as many reasons as you can.

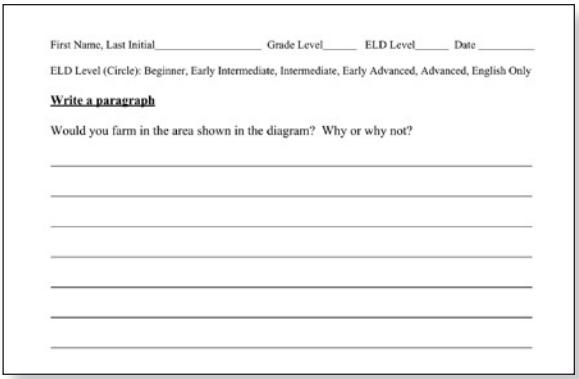
Good for farming (advantages)	Bad for farming (disadvantages)
The land is flat	The land could flood

Fig. 3

terns and vocabulary for each grade level. Finally, and most importantly, the CSP firmly believes that effective science teaching provides EL with a contextualized, interactive opportunity for academic language development. Explicit teaching of the science process skills — observing, classifying, measuring and using numbers, communicating, inferring, predicting, and collecting, recording, and interpreting data — pays off in EL growth in both science and English.

Briefly described, the test items address a variety of K–12 standards in a format and style designed to minimize student confusion and maximize performance. Topics include: ecosystems, evolution, earth changes and agriculture, the food web, and the water cycle. Each item contains the following sections: completed and

labeled diagram (See Fig. 1), "sentence completion with word bank" (See Fig. 2), "complete the visual organizer" (See Fig. 3), "write a paragraph" (See Fig. 4), and an optional "talk about it" (See Fig. 5). Students are encouraged to draw upon information from all sections of each item, as well as their classroom instruction to provide their answers. Teachers and scorers are provided with separate rubrics for judging student responses for science content and English language development. At this point in the field test, over one thousand students have participated.

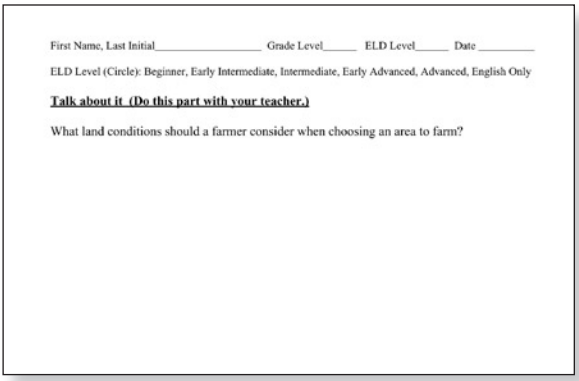

First Name, Last Initial_____ Grade Level_____ ELD Level_____ Date _____

ELD Level (Circle): Beginner, Early Intermediate, Intermediate, Early Advanced, Advanced, English Only

Write a paragraph

Would you farm in the area shown in the diagram? Why or why not?

Fig. 4


First Name, Last Initial_____ Grade Level_____ ELD Level_____ Date _____

ELD Level (Circle): Beginner, Early Intermediate, Intermediate, Early Advanced, Advanced, English Only

Talk about it (Do this part with your teacher.)

What land conditions should a farmer consider when choosing an area to farm?

Fig. 5

Developers, scorers, and field test teachers have increased their learning in a number of areas. Among the declarative statements we can make, based on preliminary analyses of student responses, are the following:

1. Rubrics alone are inadequate for scoring. In making determinations about content and ELD, it still takes an experienced and sympathetic scorer and a rubric to make reasonable judgments about EL responses.
2. Students need to be taught to take advantage of and use all the information presented to them. They should learn that it is not cheating to copy words, phrases and ideas presented

within the test items. Test taking skills and strategies need to be taught explicitly.

3. In writing directions for examiners, we cannot be too explicit. For example, it must be clear that students are to tell about the process happening in a picture, not to just describe the superficial features of a picture.
4. In science and language instruction, extensive input and practice are needed to result in even small amounts of student production.
5. Writing is key to communicating understandings and the most difficult test of academic language and scientific understanding. EL students who can communicate their observations and understandings in an accurate, simple and clear manner have a solid base for more challenging work in the sciences.
6. Words used within a science context do acquire a meaning often quite different from their common definitions in social conversations. In an ecosystem, for example, the relationship between plants and animals differ from that established between teachers and students. Consequently, we need to do more to introduce scientific vocabulary within the context of the experiment, observation, or presentation.
7. Directions to the examiner must be clear, simple, and to the point.

This developmental project, based on science testing research and best practices in second language learning, offers a model for other subject areas to assess EL progress in the mastery of standards and the development of academic language.

In Summary

Designing and implementing effective science instruction for EL has been a major emphasis of the California Science Project. As a statewide project, we have sought to capitalize on the logical connections between the richness of the science curriculum and the stages of second language proficiency development for the benefit of the EL population. Implementation continues through a network of committed regional sites. Many questions about effective practices remain to be answered. This publication has presented the essential elements to be considered by professional development planners and teachers as they present standards-based science content to English Learners: the effective use of textbooks, guiding instructional conversations, developing academic language, scaffolding instruction, instructional planning, and assessment. As the CSP evolves, it will continue to refine its approaches to assure educational equity to language minority students in science, from kindergarten through grade twelve and beyond.

Appendix I

Resources

Assessment

Council of Chief State Schools Officers. Limited English Proficient Student Projects. Science and Math Projects. *http://www.ccsso.org*

Gibbons, B. Supporting Elementary Science Education for English Learners: A Constructivist Evaluation Instrument. Journal of Educational Research; 7/1/2003.

Hakuta, K. (ed.) (2000) Testing English-Language Learners in U.S. Schools: Report and Workshop Summary. Washington, DC: National Academy Press.

O'Malley, J.M. (1996) Authentic Assessment for English Language Learners: Practical Approaches for Teachers. Reading, MA: Addison-Wesley.

Rivera, C. The Effects of Linguistic Simplification of Science Test Items on Performance of Limited English proficient and Monolingual English-Speaking Students. *http://www.doe.state.de.us/aab/aera linguistin simplification.pdf - 84k-*

Sexton, U. (1999) Guide to Scoring LEP Student Responses to Open-Ended Science Items. Washington, DC: Council of Chief State School Officers.

Solano-Flores, W. Cultural Validity in Assessment Project: Publications and Related References, June 2, 2001. *http://www.edgateway.net/cs/cvap/print/docs/cvap/pub_1.htm*

Solano-Flores, W. Examining Language in Context: The Need for New Research and Practice Paradigms in the Testing of English Learners. AERA. Educational Researcher, Vol. 32, No 2, pp3–13.

Diversity

Faltis, C. and Wolfe, P.M. (editors) (1999) *So Much to Say: Adolescents, Bilingualism, and ESL in Secondary School*. Teachers College Press.

Howard, G. R. (1999) *We Can't Teach What We Don't Know: White Teachers, Multicultural Schools.* Teachers College Press: NY, NY.

Igoa, C. (1995) *The Inner World of the Immigrant Child*. Lawrence Erlbaum Associates. Mahwah: New Jersey.

Lee, E. and others (editors) *Beyond Heroes and Holidays: A Practical Guide to K–12 Anti-Racist, Multicultural Education and Staff Development*. Teaching for Change: Washington, DC. *www.teaching_for_change.org*

Nieto, S. (1999) *The Light in Their Eyes: Creating Multicultural Learning Communities*. Teachers College Press: NY, NY.

Pedagogy

Barton, M.L. (2001) Teaching Reading in Science. Aurora, CO: McRel.
http://www.ascd.org

Bassano, S. (1997) Life Science: Content and Learning Strategies (Science Through Active reading Series). Addison-Wesley.

Bernhardt, E. (1995) Science Education and the Second Language Learner. Columbus, OH: National Center for Science Teaching and Learning.

Billmeyer, R. (1998) Teaching Reading in the Content Areas: If Not Me, Then Who? Aurora, CO: McRel.
http://www.ascd.org

Brinton, D. (1997) New Ways in Content-Based Instruction. Alexandria, VA: Teachers of English to Speakers of Other Languages.

Calderon, M.E. (1999). Promoting Language Proficiency and Academic Achievement through Cooperation. Washington, DC: ERIC Clearinghouse on Languages and Linguistics.

California Department of Education (1999) English Language Development Standards for California Public Schools, K–12.

California Department of Education. (2000) Strategic Teaching and Learning: Standards-Based Instruction to Promote Content Literacy in Grades Four Through Twelve. Sacramento: CDE Press.

California Science Project Newsletter Articles on English Learners. *csmp.ucop/csp/news/connection.html*

California Science Teachers Association (2003) California Journal of Science Education, English Language Learners: Informing Our Practice. Volume lll, Issue 2, Spring 2003.

Cary, S. (1997) Second Language Learners. Sternhouse: York, MN.

Cary, S. (2000) Working with Second Language Learners: Answers to Teachers' Top Ten Questions. Portsmouth, NH: Heinemann.

Center for Applied Linguistics (CAL). (2002) Integrating Language and Content in Secondary School. Washington, DC: CAL.

Center for Applied Linguistics (CAL) (2002) The SIOP Model: Sheltered Instruction for Academic Achievement. Washington, DC: CAL.

Chamot, A.U. (1994) The CALLA Handbook: Implementing the Cognitive Academic Language Learning Approach. Reading, MA: Addison-Wesley.

Christison, M.A. (1992) Earth and Physical Science: Content and Learning Strategies (Science Through Active Learning Series). Addison-Wesley.

Connolly, R.R. (ed.) (1989) Writing to Learn Mathematics and Science. New York: Teachers College Press.

Crandall, J. (ed.) ESL Through Content Area Instruction: Mathematics, Science and Social Studies. Englewood Cliffs, NJ: Prentice Hall Regents.

Echevarria, J. (2000) Making Content Comprehensible for English Language Learners: the SIOP Model. Needham Heights, Mass.: Allyn and Bacon.

Echevarria, J. (1998) Sheltered Content Instruction: Teaching English Language Learners with Diverse Abilities. Needham Heights, MA: Allyn & Bacon.

Echevarria, J. (1998) Teaching Language Minority Students in Elementary Schools. Santa Cruz, CA and Washington, DC: Center for Research and Education, Diversity and Excellence.

Echevarria, J. (1999) Teaching Secondary Language Minority Students. Santa Cruz, CA and Washington, DC: Center for Research on Education, Diversity and Excellence.

Fathman, A.K. (1989) Science for Language Learners. Englewood Cliffs, NJ: Prentice Hall Regents.

Fern, V. Active Learning and the Limited English Proficient Student Directions in Language and Education, National Clearinghouse for Bilingual Education, Vol. 1 No. 2. *http://www.ncela.gwu.edu/ncbepubs/directions/02.htm*

Freedman, R. (1999) Science and Writing Connections. Dale Seymour.

Scaffolding for English Learners: What's a Science Teacher to Do? Tomas Galguera. *www.deltaeducation.com/foss/newsletter/spring2003.pdf*

Gibbons, P. (1993) Learning to Learn in a Second Language. Portsmouth, NH: Heinemann.

Gibbons, P. (2002) Scaffolding Language, Scaffolding Learning. Portsmouth, NH: Heinemann.

Herrell, A.L. (2000) Fifty Strategies for Teaching English Language Learners. Upper Saddle River, NJ: Merrill.

Hampton-Brown. Language Transfer Issues for English Learners. *http://www.hampton-brown.com/*

Keyerleber, J. (1990) Communicative Math and Science Teaching. Washington, DC: Center for Applied Linguistics.

Kinsella, K. (2002) Reading in the Content Areas: Strategies for Reading Success. Upper Saddle River, NJ: Globe Fearon. *http://www.pearsonlearning.com/globefearon/globefearon_default.cfm*

Kinsella, K. (2001) Science Reading Strategies. Upper Saddle River, NJ: Globe Fearon.

Knox, C. and Flanders, A. (2001) Literacy Scaffolds for English Language Learners. Redlands, CA: O.W.L. Associates, Inc. *http://www.cde.ca.gov/standards*

Marzano, R.J. (2001) Classroom Instruction that Works: Research-Based Strategies for Increasing Student Achievement. Alexandria, VA: ASCD.

McCargo, C. Address the Needs of English Learners in Science and Math Classrooms. ERIC Review: Volume 6, Issue 2. *http://www.eric.ed.gov/resources*

New Jersey Department of Education (1998) New Jersey Science Curriculum Framework Chapter 9, Part B. *http://www.state.nj.us/njded/frameworks/science*

North West Regional Laboratory. The Inclusive Classroom: Teaching Mathematics and Science to English-Language Learners, November 1999. 41 pages. (Available in PDF Format [700K] and HTML Format.) *http://www.nwrel.org/msec/resources/justgood.html#ell*

Oshima, A. (1998) Writing Academic English. Addison-Wesley.

Peregoy, S.F. (2000) Reading, Writing And Learning ESL: A Resource Book for K–12 Teachers. Addison-Wesley.

Portland Public Schools. The 12 Cs for School Success: Developing Language Through Content *http://www.alliance.brown.edu/programs/eac/lncblt_v3-4.shtml*

Reid, J.M. (1993) Teaching ESL Writing. Pearson ESL.

Rosenthal, J.W. (1995) Teaching Science to Language Minority Students: Theory and Practice. Clevedon, Great Britain: Multilingual Matters.

Samway, K.D. (1999) Myths and Realities: Best Practices for Language Minority Students. Portsmouth, NH: Heinemann.

Science for Linguistic Inclusion: A Project of WestED. *http://www.wested.org/cs/wew/view/pj/99*

Short, D.J. (2002) How to Integrate Language and Content Instruction: A Training Manual. Washington, DC: Center for Applied Linguistics.

Snow, M.A. (1997) The Content-Based Classroom: Perspectives on Integrating Language and Content. White Plains, NY: Longman.

Stead, T. (2002) Is That a Fact?: Teaching Non-Fiction Writing K–3. Portland, ME: Stenhouse.

Stoddart, T. (2000) Integrating Language, Literacy and Science Instruction for English Language Learners: An Annotated Bibliography. Santa Cruz: UC Accord.

UNITEC in SCHOOLS. Suggestions for Adapting Units. New Zealand. Background readings on science for EL. *http://schools.unitecnology.ac.nz/writers/nesb/suggestions.html*

University of Texas Learning Center. Reading in the Sciences. *http://www.utexas.edu/student/utlc/handouts/2419.html*

Walqui, A. (2000) Access and Engagement: Program Design and Instructional Approaches for Immigrant Students in Secondary Schools. Arlington, VA: Center for Applied Linguistics.

Walqui-van Lier, A. (2002) A Scaffold for Change: Professional Development for Teachers of English Language Learners. San Diego: San Diego County Office of Education.

Policy Papers

Abedi, J. Challenges in the No Child Left Behind Act for English Language Learners, CRESST Policy Brief, Winter 2004 *http://cresst96.cse.ucla.edu/products/newsletters/policybrief7.pdf.*

AERA. English Language Learners: Boosting Academic Achievement AERA Research Points. Winter 2004. Vol.2, Issue *1www.aera.net/pubs/rp/RP_Winter04.pdf*

California Association for the Teaching of English to Speakers of Other Languages Position Statement on Specially-Designed Academic Instruction in English (Sheltered Instruction) 1992. *http://www.catesol.org/shelter.html*

Scarcella, R. (2003) Academic English: A Conceptual Framework. UC Linguistic Minority Research Institute Technical Report 2003–1. *http://lmri.ucsb.edu*

Schifini, A. (1999) Reading Instruction for Struggling Readers. Pacific Resources for Education and Learning (PREL) Briefing Paper. Honolulu:PREL. *http://www.prel.org*

Schwartz, W. Parent Guide to Teaching English and Science Together. ERIC Clearinghouse on Urban Education: Washington, DC. *http://eric-web.tc.columbia.edu/pg/pg07.asp*

Solomon, J. Conceptualizing Academic Language, Center for Applied Linguistics: Washington, DC. National Center for Research on Cultural Diversity and Second Language Learning. *http://www.ncela.gwu.edu/miscpubs/ncrcdsll/rr15.htm*

Sutman, F.X. (1986) Learning English Through Science: A Guide to Collaboration for Science Teachers, English Teachers, and Teachers of ESL. Washington, DC, National Science Teachers Association.

Sutman, F.X. (1993) Teaching Science Effectively to Limited English Proficient Students. — An ERIC Clearinghouse Urban Education Digest. *http://eric-web.tc.columbia.edu/digest/dig87.asp*

Professional Development

Anstrom, K. Preparing Secondary Education Teachers to Work with English Language Learners: Science. NCBE Resource Collection Series, No 11, December 1999.
http://www.ncela.gwu.edu/ncbepubs/resource/ells/science.htm

Wong Fillmore, L. and Snow, C.E. (2000) What Teachers Need to Know About Language. Washington, DC: ERIC Clearinghouse on Languages and Linguistics Special Report.

LAB at Brown University (2002) The Diversity Kit: An Introductory Resource for Social Change in Education Parts: Human Development, Language, Culture.
http://www.lab.brown.edu

National Association for Bilingual Education (2002) Professional Development for Teachers and Administrators Working with English Language Learners. Washington, DC: NABE.

Project Guided Language Acquisition Design.
http://www.projectglad.com/glad.html

Parsons, S. Making Sense of Literacy Through Science (LTS): A Model for Professional Development. Electronic Journal of Literacy Through Science. Volume 1, Issue 2 (Spring 2002)
http://sweeneyhall.sjsu.edu/ejlts/archives/scientific_literacy/pmq.htm

Research

Amaral, O., Garrison, L. and Klentschy, M. *Helping English Learners Increase Achievement Through Inquiry-Based Science Instruction*, Volume 26, Number 2, Summer 2002, Bilingual Research Journal, A Journal of the Center for Bilingual Education and Research and the National Association for Bilingual Education.
http://www.ncela.gwu.edu/miscpubs/nabe/brj/v26.htm#26.2

Bailey, A.L. and Butler, F.A. (2001) Towards the Characterization of Academic Language in Upper Elementary Classrooms. CRESST/UCLA: Los Angeles.

Bravo, M. and E. Garcia. "Learning to Write Like Scientists: English Language Learners' Science Inquiry & Writing Understandings in Responsive Learning Contexts." Paper presented at AERA Annual Meeting, 2004. *http://www.ncela.gwu.edu/enews/2004/0713.htm#ScienceLiteracy*

Cummins, J. (2000) Language, Power and Pedagogy: Bilingual Children in the Crossfire. Clevedon, Great Britain: Multilingual Matters.

Cummins, J. (2001) Negotiating Identities: Education for Empowerment in a Diverse Society. Los Angeles: California Association for Bilingual Education.

Effective Instruction for English Language Learners: A Discussion Sponsored by the California Education Policy Seminar and the CSU Institute for Education Reform. Includes papers by R. Scarcella, T. Wiley, M. Lavadenz, and L. Siegel.

Fradd, S.H. (2001) Promoting Science Literacy with English Language Learners Through Instructional Materials Development: A Case Study. Bilingual Research Journal. *http://brj.asu.edu/content/vol25_no4/html/art5.htm*

Gallard, A. NARST Research Matters to the Science Teacher Creating a Multicultural Learning Environment in Science Classrooms. *http://www.enc.org/topics/equity/articles/document.shtm?input=ACQ-111327-1327*

Gibbons, B. Supporting Elementary Science Education for English Learners: A Constructivist Evaluation Instrument. Journal of Educational Research; 7/1/2003.

Gibbons, P. (2003) Mediating Language Learning: Teacher Interactions with ESL Students in a Content-Based Classroom, TESOL Quarterly, Vol 37, No 2. Summmer 2003.

Hampton, E. (2001) Inquiry Science in Bilingual Classrooms. Bilingual Research Journal. *http://brj.asu.edu/content/vol25_no4/html/art4.htm*

Minicucci, C. (1996) Learning Science and English: How School Reform Advances Scientific Learning for Limited English Proficient Middle School Students. National Center for Research on Cultural Diversity and Second Language Learning: Washington, DC.
http://www.ncela.gwu.edu/miscpubs/ncrcdsll/epr17.htm

Roseberry, A.S. Appropriating Scientific Discourse: Findings From Language Minority Classrooms. NCRCLSLL Research Report 3.
http://www.ncela.gwu.edu/miscpubs/ncrcdsll/rr3/index.htm

Schleppegrell, M.J. (2002) Developing Advanced Literacy in First and Second Languages: Meaning With Power. Mahwah, NJ: Lawrence Elbaum Associates.

Solomon, J. Conceptualizing Academic Language. Center for Applied Linguistics.
http://www.ncela.gwu.edu/miscpubs/ncrcdsll/rr15.htm

Third National Research Symposium on Limited English Proficient Students: Focus on Middle and High School Issues. Science and Math.
http://www.ncela.gwu.edu/ncbepubs/symposia/third

Valadez, J. Dispelling the Myth: Is There An Effect of Inquiry-Based Science Teaching on Standardized Reading Scores?
http://sustainability2002.terc.edu/invoke.cfm/page/729

Valdés, G. (2001) Learning and Not Learning English: Latino Students in American Schools. New York: Teachers College Press.
http://www.csus.edu/ier/reports/bilingual.pdf

Web links

Bilingual Research Journal Online
http://brj.asu.edu

California Association for Bilingual Education
www.bilingualeducation.org

California Department of Education: Standards and Assessment Division: California English Language Development Test.
www.cde.ca.gov/ta/tg/el/

California Teachers of English to Speakers of Other Languages
www.catesol.org

California Tomorrow Publications
http://californiatomorrow.org/publications

Council of Chief State Schools Officers. Limited English Proficient Student Projects. Science and Math Projects.
http://www.ccsso.org

Dr. Cummins' ESL and Second Language Learning Web
http://www.iteachilearn.com/cummins/index.htm

Dr. Kenji Hakuta's Home Page
http://faculty.ucmerced.edu/khakuta

Dr. Mora's Cross-cultural Language and Academic Development CLAD Website
http://coe.sdsu.edu/people/jmora/

Electronic Journal of Literacy Through Science
http://sweeneyhall.sjsu.edu/ejlts

Intercultural Development Research Association (IDRA)
http://www.idra.org

James Crawford's Language Policy Web Site & Emporium
http://ourworld.compuserve.com/homepages/JWCRAWFORD/

National Association for Bilingual Education
www.nabe.org

Office of English Language Acquisition, Language Enhancement, and Academic Achievement for Limited English Proficient Students - National Clearinghouse for English Language Acquisition and Language Instruction Programs.
http://www.ncela.gwu.edu

Resources for Bilingual Education and Other Programs for the Education of English Learners in California.
www.cde.ca.gov/sp/el/er/

"Schooling English Learners for 21st Century Success," Various Presentations by Francisca Sánchez, Assistant Superintendent, San Bernardino County Superintendent of Schools.
http://ci.sbcss.k12.ca.us/ci/downloads.htm

Science Content Standards for California Public Schools, Kindergarten Through Grade Twelve. Translated into Spanish by the California Science Project.
http://csmp.ucop.edu/csp/standards/index.html

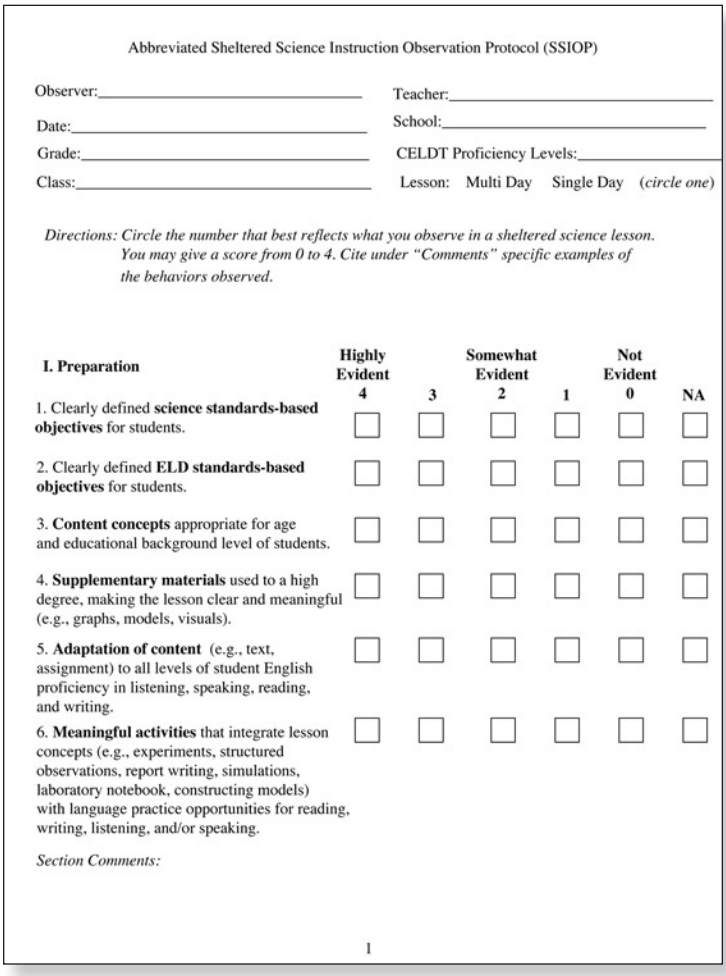
Teachers of English to Speakers of Other Languages.
http://www.tesol.org/index.html

University of California Linguistic Minority Research Institute
http://lmri.ucsb.edu/address/tocaddres.htm

U.S. Department of Education, Office for Civil Rights, English Language Learner Resources.
http://www.ed.gov/about/offices/list/ocr/ellresources.html

Appendix II

Sheltered Science Instruction Observation Protocol (SSIOP)



Abbreviated Sheltered Science Instruction Observation Protocol (SSIOP)

Observer:_____ Teacher:_____

Date:_____ School:_____

Grade:_____ CELDT Proficiency Levels:_____

Class:_____ Lesson: Multi Day Single Day *(circle one)*

Directions: Circle the number that best reflects what you observe in a sheltered science lesson. You may give a score from 0 to 4. Cite under "Comments" specific examples of the behaviors observed.

I. Preparation	**Highly Evident** 4	3	**Somewhat Evident** 2	1	**Not Evident** 0	NA
1. Clearly defined **science standards-based objectives** for students.	☐	☐	☐	☐	☐	☐
2. Clearly defined **ELD standards-based objectives** for students.	☐	☐	☐	☐	☐	☐
3. **Content concepts** appropriate for age and educational background level of students.	☐	☐	☐	☐	☐	☐
4. **Supplementary materials** used to a high degree, making the lesson clear and meaningful (e.g., graphs, models, visuals).	☐	☐	☐	☐	☐	☐
5. **Adaptation of content** (e.g., text, assignment) to all levels of student English proficiency in listening, speaking, reading, and writing.	☐	☐	☐	☐	☐	☐
6. **Meaningful activities** that integrate lesson concepts (e.g., experiments, structured observations, report writing, simulations, laboratory notebook, constructing models) with language practice opportunities for reading, writing, listening, and/or speaking.	☐	☐	☐	☐	☐	☐

Section Comments:

1

This is an adaptation of the original abbreviated Sheltered Instruction Observation Protocol (SIOP) presented in training by the Center for Applied Linguistics.

II. Instruction

Building Background	**Highly Evident** 4	3	**Somewhat Evident** 2	1	**Not Evident** 0	NA
7. **Science concepts explicitly linked** to students' background experiences.	☐	☐	☐	☐	☐	☐
8. **Links explicitly made** between past learning and new concepts.	☐	☐	☐	☐	☐	☐
9. **Key vocabulary emphasized** within its scientific context and significance. Compared and contrasted with everyday meaning (e.g. introduced, written, repeated, and highlighted for students for students to see). Attention given to high frequency scientific terms.	☐	☐	☐	☐	☐	☐

Section Comments:

Comprehensible Input	4	3	2	1	0	NA
10. **Speech** appropriate for students' proficiency level (e.g., slower rate and enunciation, and simple sentence structure for beginners).	☐	☐	☐	☐	☐	☐
11. Clear **explanation** of academic tasks.	☐	☐	☐	☐	☐	☐
12. Uses a variety of **techniques** to make science concepts clear (e.g., modeling, visuals, hands-on activities, experiments, models, maps, computer assisted simulations, demonstrations, gestures, body language).	☐	☐	☐	☐	☐	☐

Section Comments:

Strategies	4	3	2	1	0	NA
13. Provides ample opportunities for students to use **strategies**.	☐	☐	☐	☐	☐	☐
14. Consistent use of **scaffolding** techniques throughout lesson, assisting and supporting students understanding (e.g., think-aloud).	☐	☐	☐	☐	☐	☐

	Highly Evident 4	3	Somewhat Evident 2	1	Not Evident 0	NA
15. Teacher engages students in a **scientific conversation which moves students from personal experience and everyday language to generalizations expressed in discourse patterns specific to the discipline**. Includes the use of question types and strategies which specifically promote science process skills (e.g.,observing, classifying, measuring, using numbers, communicating, inferring, predicting, collecting, recording and interpreting data, and identifying and controlling variables, defining operationally, making hypotheses, and constructing and using models).	☐	☐	☐	☐	☐	☐

Section Comments:

Interaction	4	3	2	1	0	NA
16. Frequent opportunities for **interaction** and discussion between teacher/student and among students, which encourage elaborated responses about lesson concepts.	☐	☐	☐	☐	☐	☐
17. **Grouping configurations** support language and science objectives of the lesson.	☐	☐	☐	☐	☐	☐
18. Consistently provides sufficient **wait time for student responses**.	☐	☐	☐	☐	☐	☐
19. Ample opportunities for students to **clarify key concepts in L1** as needed with aide, peer, or L1 text.	☐	☐	☐	☐	☐	☐

Section Comments:

Practice/Application	4	3	2	1	0	NA
20. Provides **hands-on** material and/or manipulative for students to practice using new science knowledge.	☐	☐	☐	☐	☐	☐
21. Provides activities for students to **apply science and language knowledge** in the classroom throughout the steps of the scientific investigation and experimentation cycle.	☐	☐	☐	☐	☐	☐

3

	Highly Evident 4	3	Somewhat Evident 2	1	Not Evident 0	NA
22. Uses activities that integrate all **language skills** (ie. reading, writing, listening, and speaking).	☐	☐	☐	☐	☐	☐

Section Comments:

Lesson Delivery

	4	3	2	1	0	NA
23. **Science standards-based** objectives clearly supported by lesson delivery.	☐	☐	☐	☐	☐	☐
24. **ELD standards-based objectives** clearly supported by lesson delivery.	☐	☐	☐	☐	☐	☐
25. **Students engaged** approximately 90% to 100% of the period.	☐	☐	☐	☐	☐	☐
26. **Pacing** of the lesson appropriate to the students' ability level.	☐	☐	☐	☐	☐	☐

Section Comments:

III. Review/Assessment

	4	3	2	1	0	NA
27. Comprehensive **review** of key science vocabulary.	☐	☐	☐	☐	☐	☐
28. Comprehensive **review** of key science concepts.	☐	☐	☐	☐	☐	☐
29. Regularly provides **feedback** to students on their output (e.g., language, content, work).	☐	☐	☐	☐	☐	☐
30.Conducts **assessment** of student comprehension and learning of all lesson objectives (e.g., spot checking,group response) throughout the lesson.	☐	☐	☐	☐	☐	☐

Section Comments:

Appendix III

Targeting Academic Language Development for English Learners Through Scientific Investigation and Experimentation

Purpose

Designed for use **in professional development programs** with the California Science Project Publication *Essential Elements of Effective Science Instruction for English* (*http://csmp.ucop.edu/csp/index.php*) as a tool for:

1. Analyzing the correspondence between scientific investigation and exploration at all grades in the California Science Standards, K-12, and the second language functions required of English Learners at each step in the process.
2. Planning instructional units for English Learners based on both the California Science Standards and the California English Language Development Standards (*http://www.cde.ca.gov/ci/*).
3. Examining science textbooks, curriculum units, and other instructional materials for a comprehensive treatment of English Learner challenges.

Common Scientific Language Functions

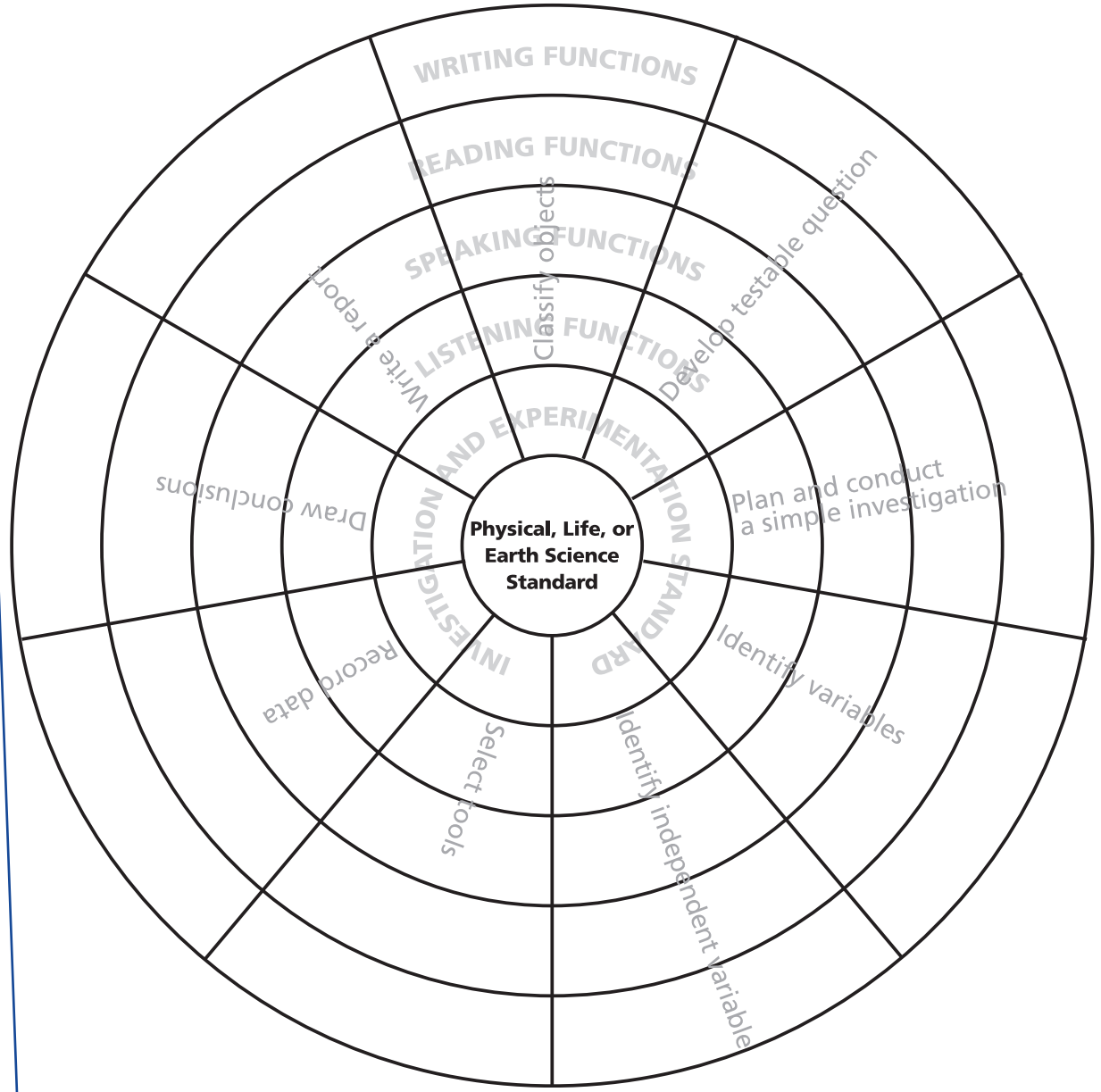
- Analyze
- Anticipate
- Calculate
- Challenge
- Cite discrepancies
- Cite information
- Classify
- Compare
- Conceptualize
- Conclude
- Confirm
- Construct charts and graphs
- Consult multiple sources of information
- Contrast
- Copy
- Defend a position
- Demonstrate
- Describe
- Design
- Determine
- Disagree
- Discuss
- Distinguish cause from effect
- Distinguish constants from variables
- Distinguish fact from opinion
- Document
- Estimate
- Experiment
- Explain
- Explore
- Formulate
- Hypothesize
- Identify
- Identify physical attributes
- Identify properties
- Identify relationships
- Illustrate
- Infer
- Inquire
- Interpret
- Investigate
- Investigate cause/effect relationships
- Justify
- List
- Make a claim
- Measure
- Observe
- Organize
- Outline
- Persuade
- Plan
- Predict
- Propose
- Provide evidence
- Provide rationale
- Question
- Read
- Recognize
- Record
- Reflect upon
- Reformulate
- Replicate
- Report
- Request and provide assistance
- Request and provide directions
- Revise
- Sequence
- Solve
- State
- Strategize
- Suggest
- Summarize
- Support with facts

Common Scientific Language Functions

Please see page 64 for a list of common scientific language functions.

Steps For Completing The Graphic Organizer

1. Select as your topic for investigation and exploration a standard from either physical sciences, or life sciences, or earth sciences for the grade level of your choice. Insert that standard in the center circle. For example, one fifth grade standard might be: "students know the origin of the water used in their communities."
2. In the "experimentation and investigation" circle insert the steps appropriate for the grade level of your choice and apply the steps of the scientific process to the content standard you have selected. For example, at fifth grade one of the nine steps would read: "students classify sources of water according to the size and location."
3. In the outer circles identify the language functions needed. For example, in the listening circle: "students listen to information presented orally and take notes on the size and location of water in their community."
4. Note that from kindergarten through grade 12 the number and complexity of steps in the investigation and experimentation cycle increase. The example presented here is for the fifth grade.



Appendix IV

California English Language Development Test Proficiency Standards (CELDT)

California English Language Development Test Proficiency Standards

Proficiency Levels	Listening and Speaking Standards	Reading Standards	Writing Standards
Advanced Students performing at this level of English language proficiency communicate effectively with various audiences on a wide range of familiar and new topics to meet social and academic demands. In order to attain the English proficiency level of their native English-speaking peers, further linguistic enhancement and refinement are necessary.	Students who perform at this level typically hear and repeat all beginning, medial, and ending speech sounds in context, as well as identify words that are identical in sound. They are able to use complex vocabulary and give the opposites of more difficult words. They can follow more complex instructions. They can tell a story using fluent sentences and details.	Students who perform at this level typically are able to interpret more complex figures of speech, as well as decode words with more difficult beginning or medial sounds. They can identify root words, synonyms, and the number of syllables in a word. They can read a more complete story and sequence events, draw inferences, and make predictions and generalizations.	Students who perform at this level typically are able to write a relevant sentence in response to a picture prompt. The sentence has no mechanical or syntactical errors. They can use sequenced pictures and a sentence starter to write a well-organized story that contains relevant details and accurate transitions. The story may contain a few minor errors in grammar and mechanics.
Early Advanced Students performing at this level of English language proficiency begin to combine the elements of the English language in complex, cognitively demanding situations and are able to use English as a means for learning in other academic areas.	Students who perform at this level typically hear and repeat most beginning, medial, and ending speech sounds in context. They are able to use more difficult vocabulary, give the opposite of a word, and use more complex verb forms to describe a picture prompt. They can follow complex instructions. They are able to tell a story in a logical sequence, using details and basic sentence construction.	Students who perform at this level typically are able to match complex vocabulary words to pictures, use regular plurals, and identify the number of syllables in a word. They can use context to complete the sentences of a short passage. They can read a story and answer more difficult questions that involve sequencing, generalizing, drawing conclusions and making simple predictions.	Students who perform at this level typically are able to use contractions, possessives, superlatives, and prepositions. They can write complete sentences that contain no grammatical, syntactical, or mechanical errors, and that are appropriate to a picture prompt. They can write a story with a beginning, middle, and end using fluent sentences and well-organized ideas.
Intermediate Students performing at this level of English language proficiency begin to tailor the English language skills they have been taught to meet their immediate communication and learning needs.	Students who perform at this level typically hear and repeat many beginning, medial, and ending speech sounds in context. They can use difficult vocabulary, as well as various verb forms, to describe a picture prompt. Students can follow simple instructions. They are able to tell a story using at least one complete sentence.	Students who perform at this level typically are able to match sound patterns and identify compound words. They can recognize common abbreviations. They are able to use the context of a sentence to fill in the blanks with the correct words. They can read a story and answer literal questions.	Students who perform at this level typically are beginning to use writing conventions, such as subject and verb agreement, compound subjects, verb tenses, and regular and irregular verb forms. They can write simple sentences appropriate to a picture prompt, although the sentences may contain several errors. They can write a story by listing events or ideas in response to sequenced pictures.
Early Intermediate Students performing at this level of English language proficiency start to respond with increasing ease to more varied communication tasks.	Students who perform at this level typically hear and repeat a few beginning, medial and ending speech sounds in context. They describe a picture prompt using common vocabulary. They are able to follow simple commands. They tell a story using incomplete sentences.	Students who perform at this level typically are able to match simple vocabulary words to pictures. They can hear a word and select its printed form from a choice of similar words. They are able to identify contractions and recognize some basic semantic categories. They can read simple stories and recall a few details.	Students who perform at this level typically are beginning to use some writing conventions, such as spacing, punctuation and capitalization. They can write sentences appropriate to a picture prompt. The sentences include at least one English word spelled correctly. They can write a story in response to sequenced pictures. The story may list events or ideas, and contains at least one complete sentence.
Beginning Students performing at this level of English language proficiency may demonstrate little or no receptive or productive English skills. They may be able to respond to some communication tasks.	Students who perform at this level may demonstrate no receptive or productive skills, or may hear and minimally repeat some speech sounds in context. They may describe a picture prompt using common nouns. They begin to follow a few simple commands. They tell a story using isolated words or the English words.	Students who perform at this level may demonstrate no receptive/productive skills, or they may be able to identify the letter that corresponds to the initial sound of a simple spoken word. They may be able to match commonly used nouns to pictures. They begin to recognize some basic groups of related words. They may be able to read simple stories and recall minimal details.	Students who perform at this level may demonstrate no receptive/productive skills, or they may begin to use a few standard writing questions. They can write some isolated English words. They may attempt to write stories in response to sequenced pictures, but the writing is minimal and contains unrelated fragments.

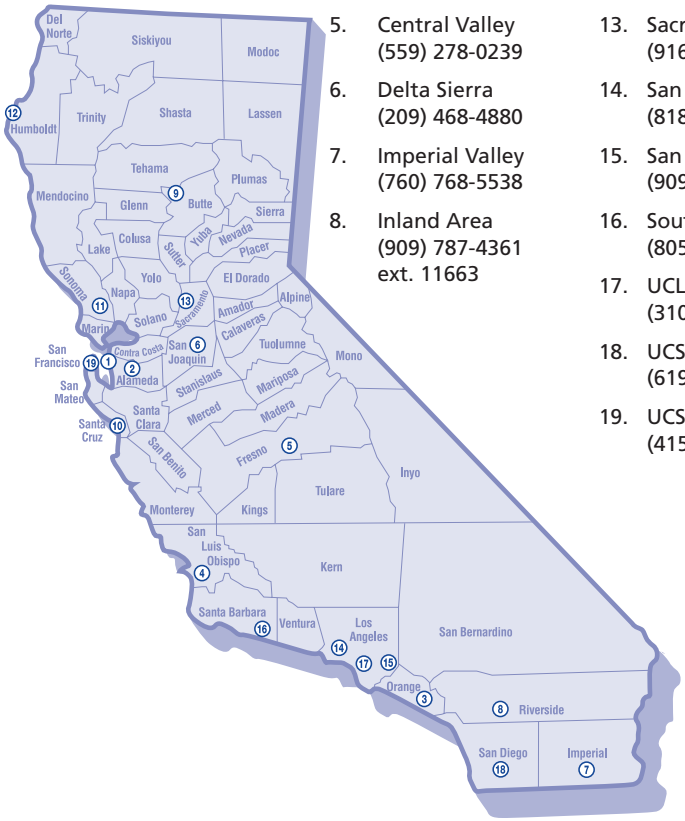
Test Date: Summer/Fall 2001

Standards and Assessment Division of the California Department of Education
http://www.cde.ca.gov/ta/tg/el/

Appendix V

Map of California Science Project Sites

1. Bay Area
   (510) 643-3478
2. BEST Institute
   (510) 885-3438
3. CSP at Irvine
   (949) 824-6390
4. Central Coast
   (805) 756-0292
5. Central Valley
   (559) 278-0239
6. Delta Sierra
   (209) 468-4880
7. Imperial Valley
   (760) 768-5538
8. Inland Area
   (909) 787-4361
   ext. 11663
9. Inland Northern
   (530) 898-5539
10. Monterey Bay
    (831) 459-2001
11. North Bay
    (707) 664-2157
12. Redwood
    (707) 826-5551
13. Sacramento Area
    (916) 278-5487
14. San Fernando Valley
    (818) 677-3543
15. San Gabriel Valley
    (909) 869-4743
16. South Coast
    (805) 893-5663
17. UCLA
    (310) 825-1109
18. UCSD
    (619) 849-2204
19. UCSF
    (415) 514-0588



About the Author

Fred Dobb (Ph.D., Stanford University), English Learner Specialist for the California Science Project, has spent his career in language minority programs as a bilingual teacher, administrator, and staff development specialist. He has been California Department of Education Director of Bilingual Education and State Supervisor of International Language Programs. Before joining CSP, he collaborated on the California English Language Development Test. He teaches courses in linguistic and cultural diversity, and second language acquisition, at San Francisco State University. He is the recipient of the California Language Teachers Association President's Award. A Fulbright scholar to Brazil, he has taught at post-secondary institutions in Puerto Rico, Nicaragua, Mexico, and Spain, and has trained science teachers from Chile and Argentina at the University of California, Davis.

California Science Project
3806 Geology Building, UCLA
Los Angeles, CA 90095-1567
csmp.ucop.edu/csp

"Science education is intended for all students. Academic instruction must be designed so that each student has the opportunity to master science standards that provide systematic and coherent access to this challenging subject…Instruction for English Learners in the academic language of science is critical and must be specifically designed, planned, and taught."

Science Framework for
California Public Schools:
Kindergarten Through Grade Twelve
2003