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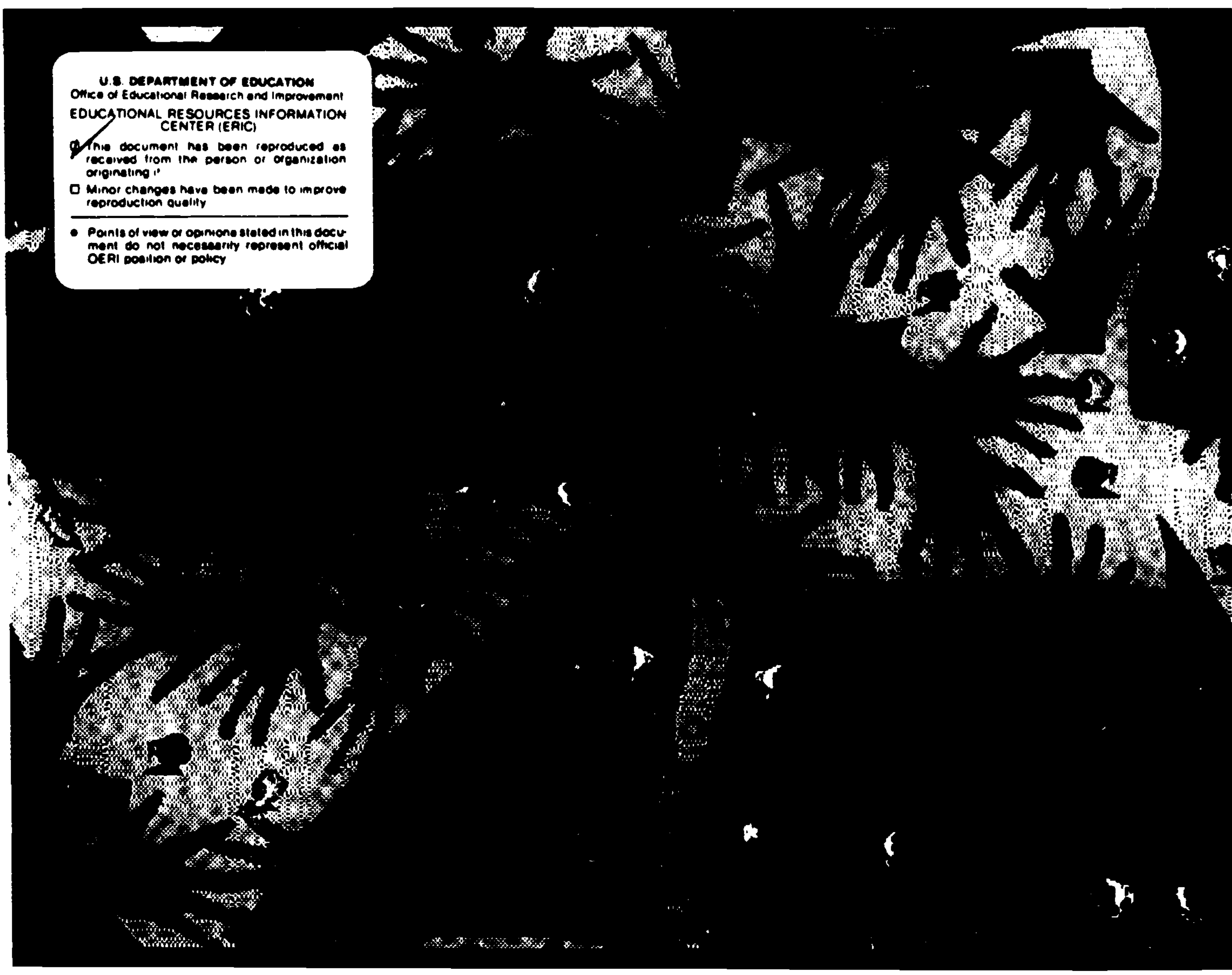
ABSTRACT

This monograph is a rich resource of information designed to strengthen science and basic skills teaching, and improve learning for limited English proficient (LEP) minority student populations. It proposes the use of hands-on science investigations as the driving force for mathematics and English language development. The materials included in this book are based upon the understanding that science and the English language can be effectively learned together, and that teachers of LEP students need not place excessive emphasis upon the first language; although the availability of teachers and aides who have knowledge of LEP students' first language can enhance instruction through its judicious use. Chapters include: (1) "Science and Language Instructional Goals for Limited English Proficient (LEP) Minorities"; (2) "Grades N-6; Science and Language Instruction for LEP Students: The Integrated Activity Learning Sequence (IALS)"; (3) "The Nature of Science Driven Instruction for LEP Students"; and (4) "Supporting Reform in Science Driven Instruction for Diverse Student Populations". Two appendices include resources for science teachers, educators, policymakers and others for improving science instruction for LEP students and an integrated activity learning sequence in science for grades 9-12. Contains 54 references. (JRH)

Improving Learning in Science and Basic Skills Among Diverse Student Populations

Francis X. Sutman & Ana Guzman



ERIC Clearinghouse for Science, Mathematics, and Environmental Education

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Francis X. Sutman has taught sciences and mathematics in public schools and has continued this commitment through the National Science Foundation's school outreach program as well as through the Rowan College of New Jersey's Curriculum Development Council. He has been a research chemist for Exxon Science and Engineering Laboratory and has served as a professor of science and science education at a number of institutions of higher education in several countries, Puerto Rico and in the United States. At NSF, he served as Program Director for the Assessment of Student Learning Program in science and mathematics. He is also Senior Scholar in Science Education at Temple University. Sutman was Dean of the College of Education at Fairleigh Dickinson University, and has served as President of the National Association for Research in Science Teaching and as Regional President of the Association for the Education of Teachers in Science. He has been a U.S. delegate to the Organization of American State's Council on Science, Education, and Culture, and was the first recipient of the Governor of New Jersey's Albert Einstein Award in Education for "contributions to innovative classroom practices especially for minorities." The Hispanic Congress of Pennsylvania has recognized his educational contributions as Director of the Multicultural/lingual Education Resource Information and Training Center (MERIT Center) at Temple University.

Sutman is also senior author of *Learning English Through Science*, published by the National Science Teachers Association and Educating Personnel for Bilingual Settings published by the American Association of Colleges for Teacher Education.

Ana (Cha) Guzman is a Fellow to the Chancellor of the Texas A and M University System and Program Director for the Alliance for Minority Participation Program supported by the National Science Foundation. She was Director of Regional Programs at the Thomas Jefferson High School for Science and Technology in the Fairfax County (MD) Public Schools where she established admissions criteria that would expand the pool of minority applications for this science oriented school. In this role she coordinated efforts designed to develop science curricula that could be exported to other comparable student populations. She served as Director of the Bilingual Program for the Baytown Texas schools, a program that has been identified as exemplary at state and at national levels. She served as President of the Texas Association for Bilingual Education (TABE) and currently serves on the Board of Directors of the Mexican American Legal Defense Fund, the Board of the Council on Basic Education, and the Board of the ERIC Center for Urban Education. Presently, Guzman is Vice-President for Development, Austin Community College System. Her experience with LEP populations places her in demand to set the tone for regional and national meetings that address the special needs of this population of students.

Acknowledgment

Special thanks to Katherine Goodman, Editor at the Educational Testing Service Atlanta Field Office, for her careful review of this monograph.

Foreword

Improving Learning in Science and Basic Skills Among Diverse Student Populations is a rich resource of information designed to strengthen science and basic skills teaching and improve learning for limited English proficient minority student populations. The use of hands-on science investigations as the driving force for mathematics and English language development, proposed herein, is an instructional principle whose time has arrived. Research indicates that it works well for all students; but especially for limited English proficient students at lower grade levels. To be effective, this teaching strategy must be supported by teachers who have reasonable familiarity with content – in this case, science and mathematics content. Therefore these two subjects must be a significant component of the education and training of all teachers; and teachers-in-preparation, in addition, require experience in the teaching strategies embraced in this monograph. This experience is essential because, as the authors state, the usual lecture approach to instruction appears to be more natural, so teachers require less experience in the use of lecture than they do with what is herein referred to as the inquiry approach.

It is especially useful that this monograph attends to instructional materials in science developed through National Science Foundation support. A number of these materials, some now commercially available, have been designed to offer students ample opportunities for the kinds of hands-on investigative science instructional experiences that will improve science learning and enhance basic skills development.

I recommend this monograph to all school teachers, administrators and others as they work toward making science instruction more meaningful and rewarding for all students, including minorities, attending schools throughout the nation.

Luther B. Williams
Assistant Director
National Science Foundation
Directorate for Education and Human Resources

Preface

This monograph considers the latest understandings concerning effective teaching and learning of science for diverse populations including limited English (language) proficient (LEP) students in the nation's schools. The monograph is intended to serve as a resource for teachers, school administrators, parents, school board members, and college or university level faculty members who are responsible for the future well-being and advancement of the next generation of students across the United States and elsewhere.

The materials included herein are based upon the understanding that science and the English language can be effectively learned together, and that teachers of LEP students need not place excessive emphasis upon the first language; although the availability of teachers and aides who have knowledge of LEP students' first language can enhance instruction through its judicious use.

Considerable research has shown the direction for the reform encouraged and supported in this monograph. The Appendices contain an extensive annotated listing of references to instructional and other materials beyond those referenced throughout the narrative.

We dedicate this monograph to those who have committed themselves to improving educational opportunity for all students including the LEP population. Their efforts are critical in assuring that all students are prepared to contribute effectively to the needs of society, especially in the areas of science and technology. The continued efforts of these dedicated educators, combined with the approaches proposed throughout this monograph, will not only well serve the nation, but also the self image and personal accomplishments of the nation's most valuable resource: its students.

F.X.S. & A. G.

Chapter 1

Science and Language Instructional Goals for Limited English Proficient (LEP) Minorities

As reported in the *Fairleigh Dickinson University Alumni News*, the National Association for Bilingual Education honored Robert Pettingi as the Bilingual Teacher of the Year. Pettingi, at the time of this recognition, was a science teacher at the Martin Luther King Jr. School in Upper West Side Manhattan in New York City. This school, like many urban schools, enrolls students comprising many cultures including a sizeable percentage who are classified as limited English (language) proficient (LEP). Historically these students, referred to as bilingual students, are from a variety of cultures with varied language backgrounds whose native languages are other than English. However, these students are among many who vary in their degree of limited English language proficiency.

The formal announcement of the Bilingual Teacher of the Year Award indicated that 90% of Pettingi's students had taken the New York State Regents Examination in biology and chemistry, and had passed these rigorous tests; an amazing result since 85% of the students had arrived in this country from the Dominican Republic over the past two years or less. Of these students, 90% successfully completed high school and entered some form of higher education.

Roberto, himself an immigrant from Uruguay, achieved such recognition as a master teacher of science to LEP students because he understands both the importance of science to society and that science is an excellent vehicle for teaching and learning the basic skills of both mathematics and the English language. Aside from academic learning, he is concerned "for developing students' self worth and assisting them to develop control over their own destinies." He attributes his success in teaching to both an excellent education in the sciences and training in teaching approaches appropriate for bilingual student populations.

Pettingi, a motivated professional, had earlier been employed as a dishwasher, machine operator, garment cart pusher, and NASA summer education fellow. He utilizes many of the strategies described throughout this monograph: professional practices, he states, that were learned in part from his experiences as a graduate student in a program at Fairleigh Dickinson University designed to prepare master teachers of science and related subjects specifically for bilingual school settings. These learned strategies emphasize the importance of approaching teaching so that LEP students become proficient in English language through instruction in science.

Supporting others who seek the level of success attained by Roberto Pettingi in teaching science to LEP students is the primary purpose of this publication. All students, including those who are limited in English language proficiency, deserve the best education available; all students must be enabled to play an ever increasing role in moving the nation's science and technological enterprise forward.

Through the strategies proposed and examples given throughout this monograph, teaching and learning in the sciences and related subjects can be enhanced for LEP students. The increase in learning will not only result in improved standardized test scores in basic skills and science, but also in personal understandings of science and its applications. Improvement in instruction will improve attitudes about science among this population, as well.

Discriminatory Tracking

The message conveyed by two reports published by the Rand Corporation, *Lost Talent* (Oakes, 1990a) and *Multiplying Inequalities* (1990b) was not news to the LEP population. Both publications present data indicating that in schools having large numbers of minority students, LEP students and other disadvantaged youth are clustered disproportionately into "low ability" classes. Oakes reported in *Multiplying Inequalities* (1990b) that these clustered students usually are low-income individuals who are pre-judged by their teachers to have low academic ability, especially in math and science. At schools with racially mixed student bodies, the proportion of classes judged to be of high ability significantly diminishes as minority enrollments increase. This practice, referred to as "discriminatory tracking," has assisted in producing the long-term effect of severe underrepresentation of minorities in advanced science and math courses and eventually among science and math-oriented professionals in general. The practice of discriminatory tracking must not continue for moral reasons. Practical reasons include the fact that African Americans and Hispanics, each constitute only about 2% of the scientific workforce, even though presently African Americans constitute 10% and Hispanics 7% of the total professional workforce. This disproportionate representation of minorities in science is damaging not only to the future well-being of the scientific enterprise, it also negatively impacts the nation's competitive edge in the global economy.

School Science and College Science Enrollments

The 1992 edition of *Indicators of Science and Mathematics Education* presents data indicating that gains in science on the National Assessment of Educational Progress (NAEP) were similar for H panic and non-Hispanic European American students, ages 9 and 13 years, from 1977 to 1991. No gain in scores occurred for either group at age 17. The National Center for Educational Statistics publication, *Condition of Education* (U.S. Department of Education, 1992), indicates that the percentages of minorities compared to non-minorities enrolling in colleges as science and engineering majors *appeared* to have improved slightly from 1977 on. However, the apparent increase is misleading, resulting from a substantial decrease in the percentage of white students enrolling in science and engineering majors.

The NAEP test data and college-level science major enrollment data are corroborated by the poor showings of U.S. students in sciences and mathematics on international measures, such as those administered by The International Assessment of Educational Progress (IAEP, 1992). On the latest IAEP test, "U.S. 13 year-olds, on average, scored lowest among the major thirteen industrialized nations both in mathematics and science proficiency."

Special Need for Experiential Science During the Early Years

Data from a number of sources indicate that, on average, nearly three students out of every 20 in a typical school classroom lives with a drug dependent parent, is hypersensitive due to poor diet, or is afflicted with other challenges to learning. These figures are higher in classrooms having larger numbers of minority students, especially in urban schools. The identified conditions deter students from learning in school. Procedures designed to address the needs of children who come to school with these kinds of impediments to learning are considered in publications such as *Prenatally Exposed Kids in School* by Odum-Winn and Dunagan (1994). Learning experiences must both address the identified challenges to learning and provide motivation to learn.

Preschool students from various backgrounds, including LEP students, can be positively influenced by an immediate environment that includes live animals and plants. Students learn from responding to living organisms and are motivated to acquire second as well as first language proficiency through observing and handling living-moving beings. They are naturally motivated to describe, discuss, and compare the characteristics and behaviors of living beings. At preschool ages, LEP inhibitions that students have to learning are readily overcome. They readily learn to expand their native language skills and to transfer such learning to English. The concrete experiences that require observations and descriptions based on contact with living beings provide an effective foundation for understanding more abstract ideas of later science instruction.

Learning about effective nutrition and health by observing the effects of various foods and other substances on simple living organisms facilitates understanding that mitigates against further use of abusive substances. Exposure to varied foods such as fruits and meats, in a school context, will lay groundwork for proper nutrition. Science activities, such as one illustrating that both coconut meat (fruit) and pork rind (meat) contain fat as indicated by the oily spot they produce on brown bag paper, can motivate students to want to learn more about foods. Young children can learn by experience that sweetness is not only a property of sugar from cane, but is associated with beet sugar and saccharine as well. The first two substances are called foods because they give our bodies the energy we need to move and to live.

These examples are intended to show that development of language and other communication skills can be learned through science. At the same time, such skills are essential to successful science learning. The process works in both directions. Therefore, language skill development must be a consciously planned objective of early science instruction. In both native and the English languages, that which has been observed and experienced creates a need to communicate effectively. Section II of this monograph includes a series of lessons built around a theme. The lessons emphasize science investigations that are appropriate and are designed to develop skills for young children.

The Spring issues of *Daedalus* for 1983 and 1990 give especially strong arguments for emphasizing English language development in early education. For example, Damon's article, "Reconciling the Literacies of Generations," in the 1990 issue proposes that too many young minority students are turning away from the offerings of American school classrooms, including science, not because they are functionally illiterate but because the literacies of the generations have become unlinked or disconnected. Damon indicates that to restore the essential literacy links or connections requires schools to acquire a surer feel for contemporary cultural conditions and to craft academic programs that stimulate, at early ages, the intellectual and moral development of LEP students. In his article, "Minority status and literacy in comparative perspective," John Ogbu (1983) reminded us that the cause of cultural disconnectedness may have roots in the "castelike or involuntary immigrant minority history of many at-risk students (and their families). Early intervention is more effective than later in overcoming this "disconnectedness".

Teaching and Teachers' Commitments

Many elementary level teachers argue that they have little time for science instruction because subjects like language arts (of which ESL and foreign language should be components) and mathematics require most of their available classroom instructional time. Likewise, most high school level science teachers believe that their responsibility stops at teaching science. They see no need for them to be concerned for language development. Teachers at all school levels who take these positions slight their students, especially their LEP students. Both elementary and secondary school teachers may be surprised to find that science, with its many opportunities for hands-on experiences, is an excellent vehicle for both first and second language development. High school teachers in particular need to realize that without knowledge of the language of instruction, little or no science will be understood. These realizations will occur only when more teachers gain experience learning outside of their chosen fields of study, integrating subjects, if you will, and when it becomes clear to them that the school student population has changed dramatically during the past 20 to 30 years; and it will continue to change. Using science as the "driving force" for enhancing basic skills will help more students to overcome a number of impediments to learning, impediments such as limited language proficiency. By restructuring both the curriculum and the pedagogical approach students and teachers will be rewarded by increased learning.

Deterrents to Effective Teaching

There are three major deterrents to offering quality science instruction: (a) the limited preparation in science related subjects, (b) the tendency of teachers to embrace the rhetoric of reform without changing practice, and (c) a lack of long term in-class experiences related to effective utilization of reformed pedagogical approaches. Addressing and correcting these deterrents is essential if improved-reformed teaching is to occur.

At the preservice teacher education level, especially for elementary school preparation, there is a requirement in many state certification standards that a (any) "liberal arts major" be obtained. In most cases, the requirements for these majors are neither liberal nor broad in scope. Instead, they are narrow and restrictive. As a result, standard program requirements do not enhance the competence of teachers to teach science or any other traditional subject, much less prepare them to teach science to LEP students. A liberal arts major requirement would be fruitful if it encompassed both natural and social sciences, and was complemented by experiences related to improving communications skills.

Teaching competence is hindered, also, by the commonly held erroneous belief that knowledge of content alone adequately prepares teachers to teach effectively. Extensive *experience* and *practice* with varied pedagogical approaches is essential; and individuals planning to enter teaching must learn how to effectively address the societal and personal problems that are reflected in today's school aged population, problems that will increase in number unless teachers are prepared to effectively abate them. An emphasis in teacher preparation must be given to instructional strategies other than lecture and discussion. Teachers require extensive experiences with inquiry teaching and discovery learning using a variety of resources including hands-on manipulative materials. They must learn through practice how to reduce the "density" of language in instruction and to allow students greater opportunity to construct their own knowledge. Instructional approaches that emphasize integration of science with the basic skills of mathematics and English language are essential. Preservice and inservice teachers need to actually experience the overwhelmingly positive learning that results from this approach to instruction. The approach is described in detail in an article by Romance and Vitale (1992).

Serious efforts to strengthen science teaching, and teaching overall, are presently underway. The efforts are being supported by private foundations and industries, as well as by governmental agencies, including the Education and Human Resources Directorate of the National Science Foundation and the US Department of Education's Dwight D. Eisenhower Program and Office of Bilingual Education and Minority Language Affairs. The Departments of Defense and Energy also are offering support directed twoard meeting this critical need. Some literature supporting the needed reform is provided in the Appendices.

Chapter 2

Grades N-6 Science/Language Instruction for LEP Students: The Integrated Activity Learning Sequence (IALS)

Instructional practices in science for LEP students build upon six principles that underly effective teaching of science to all students. However, the degree of English language deficiency of LEP students calls for the use of teaching strategies beyond those required for English proficient (EP) students. The exampie of a sequence of lessons included in this section are built around the application of these principles.

The first principle:

The basic education and training required of those who will teach science to LEP students is similar to that required to prepare any master teacher. There are additional components of education required to prepare these teachers to effectively address more extreme levels of deficiency in English language use among students.

The second principle:

The science content taught to LEP students should be the same as that taught to students from other cultures, language groups, and ethnic backgrounds.

Science is a humanly constructed description of the environment, and how and why the environment operates as it does. These scientific understandings and descriptions are universal! Science *content* does not belong to any single culture, ethnic group, or ability group.

The third principle:

While all science students need to know about the contributions to science by individuals from varying cultures, the examples exemplified for LEP students should come from the cultures of the LEP students.

Today's school science curriculum, overall, includes too few examples of contributions by scientists from varying cultures, much less from the cultures represented by the backgrounds of LEP students. The science curriculum, generally, is overcrowded with the vocabulary of science and the details of abstract theories and principles of science. Less theory and presentation of principles must be included in the science curriculum, and there must be more room for examples of contributions made by both the majority and minority cultures.

In particular, Hispanic and other language-cultural minorities, from all parts of the world, have made and continue to make significant contributions to scientific knowledge. Immigrants to the United States, especially, have contributed significantly to scientific and technological advancements in this country. Knowledge of such contributions assist in increasing student self esteem and tolerance. From a language perspective, inclusion of such contributions helps to reduce the density in presentation of the more technical and abstract components of science content as well as reducing the density of new technical English vocabulary. Some examples of contributions by immigrants to science and technology are included below.

Models of Excellence, published and distributed by the National Science Foundation (1991), and *Hispanics in Science and Engineering*, published by the American Association for the Advancement of Science (1992), are two examples of sources that present successes by minorities in science. One example of success is that of Dr. Alexander Cruz who grew up in the Puerto Rican section of Brooklyn, New York, where as a school age student he studied various plants and animals collected from vacant city lots. Now a Professor of Biology and a researcher at the University of Colorado, he offers minority students the opportunity to work during summers assisting with research conducted in university laboratories.

Another example of a minority's contribution to science is that of Dr. Maria Eleana Zavalia, daughter of migrant farming parents in California. As a child she watched her grandmother grow herbs and use them as medicine with sick migrant workers. Maria became interested in studying more about plants and eventually she earned a doctorate degree in botany from the University of California at Berkeley. Now, she is a Professor of Biology at the California State University at Northridge. In this role, Dr. Zavalia is active in the Society for the Advancement of Chicanos and Native Americans in Science and Engineering, which supplies minority students with information about opportunities to study and to work in the sciences.

Perhaps the most significant contributions by scientists from a single minority culture resulted from the emigration, in 1989-1990, of 40,000 students who were citizens of the Peoples Republic of China. Many of these minority students spoke little English, yet they were involved in graduate level study and research in the sciences and engineering in the United States. These LEP minorities sought, in 1989, political asylum following the Democracy Movement-Tianamin Square suppression. What a wonderful cultural example for LEP students to know about; one that integrates the natural and the social sciences.

Learning that individuals of many cultures have contributed to, and continue to participate in, the advancement of science in the United States benefits all students, particularly those of underrepresented groups, especially those with LEP backgrounds. While it is essential for minority students to become cognizant of the contributions of members of their cultures to the advancement of scientific knowledge, here and elsewhere, majority students also benefit from being informed, for it serves to foster respect, acceptance, and admiration of all who have contributed from a diversity of backgrounds.

Cultural relevance is also enhanced through teachers calling upon appropriate analogies that take into account past experiences within cultures, as well as experience with the objects that are a part of these experiences. For example textbooks in chemistry use the following analogy to describe the concept of activation energy. Activation energy can be analogized to golf balls bouncing around in the rear of a moving station wagon. Every so often a golf ball bounces far enough to go over the back of the rear seat and land on the seat. Once a golf ball gains enough energy, it will bounce over the back of the seat and fall with no further addition of energy.

For recent Hispanic immigrants, this analogy probably is not meaningful, or at least it would be far more meaningful to refer to a burro driven carreton carrying pinones. Such analogies that refer to objects from students' most recent cultures, assist in making abstract ideas or explanations of science concrete and thus more meaningful.

The fourth principle:

Science instruction is most effective when the content is organized around common themes.

The themes can be broad science concepts such as: the particle nature of matter, magnetic energy, energy transformations, chemical change, food chains, evolution, and so on. Or the themes can be societal issues such as: petroleum utilized either as a fuel or as a source of building materials; the pollution and purification of water; the impact of drugs on the physiology and behavior of living organisms; the impact of nuclear energy on society; gene identification and the impact on agricultural practice of gene splicing; or the role of science in supplying services and goods to urban dwellers.

The common theme approach to the organization of content offers several pedagogical advantages to instruction, especially for LEP students. One advantage is that this form of content organization offers more opportunities to include information that is relevant to the present and future needs of students. Second, this approach extends the time over which single topics are studied resulting in more time for students to comprehend. Even more important, is that opportunity is afforded for students to practice and to use English vocabulary and the associated syntax grammar.

The net result of the organization practices indicated above is that it supports English language development and interest which increases the probability that students will want to learn more science and language, eventually on their own. It can be seen that especially when societal issues serve as the organizational outline for science instruction the whole approach to second language instruction is practiced. When coupled with hands-on science experiences, carefully structured cooperative group instruction, and reduced dependence upon a single textbook building instruction around broad-extended areas of science significantly increases opportunities to utilize and develop all of the basic skills.

Indeed, it is difficult when building instruction around broad themes *not* to integrate traditional subjects, as indicated by the following articles: "Start with science," (Mechling, 1991), and "Establishing a research base for science education: Challenges, Trends and recommendations" (Linn, 1987).

The fifth principle:

English language development must be an integral objective of all science instruction.

While this principle is inherent in the fourth principle, especially for LEP students, English language development as an integral component of all instruction requires special emphasis.

In addressing this principle, science teachers as well as teachers of English as a second language need to cooperate in designing science instruction to insure that English language skill development is enhanced. These cooperative plans should minimize "pull out" type sessions; substituting instead opportunities for students to carry out science-driven investigations working in cooperative groups. These groups should be structured to assure that each includes students with varying levels of English language proficiency. The science investigations need to be designed so that they lead naturally and purposefully to English language activities like the following:

- Keeping a dictionary of new science terms.
- Interpreting the procedures used in carrying out each science investigation as well as writing summaries of the results of each.

- Writing to a friend about what was learned from the science investigation.
- Reporting, orally, to the class or to the cooperative instructional group the results of a recently completed science activity.
- Developing, as a cooperative group, a written summary of the results of the science investigation just completed and reporting these results orally to the entire class, using a panel format.
- Organizing and presenting a science investigation to the school as an assembly program.
- Planning and carrying out in groups science fair projects resulting from a series of related investigations.
- Developing an English language or bilingual newsletter for parents that tell about science activities carried out by the class.
- Completion of crossword puzzles that include words and definitions related to the science theme.
- Writing and acting out short plays that utilize large poster size English language prompt cards made by students.
- Drawing pictures depicting the science they have learned and writing about these pictures.

Many science trade books for children, written at appropriate levels of English competency, should be included as major holdings in the school or classroom library. (See Appendix A) Students should learn to search for appropriate books, those that address the specific science topic under discussion or study. This will require direct teacher assistance until the habit is formed and until language has developed to an appropriate level. Reading of these books can occur in groups or individually with LEP students reporting on what they have read, or through discussing what questions arose from reading about specific science topics. The books should include simply written biographies that indicate the contributions of scientists, especially about minority scientists.

Teaching strategies designed to integrate English language with science instruction also should be used again as part of the assessment of students learning in science and language. For example, students may draw a picture describing what has been learned through a science activity. This may be followed by their writing about the picture. This *communication* process then should be utilized later on as part of assessing learning. Remember that the major goal of the instruction in science is always improved English language proficiency, as well as improved communications generally.

A final principle:

> *No instructional strategy will be effective unless the teacher serves as a dynamic, caring, knowledgeable role model for learning.*

This means that teachers must show their enthusiasm for continued learning and have as positive an outlook for science instruction as they do for the more traditionally taught subjects, especially at the elementary school level.

Instructional Approach: The Integrated Activity Learning Sequence

All of the above recommendations related to instruction are incorporated in the sample Integrated Activity Learning Sequence (IALS) included in this section. What we have called the "IALS Approach" is based upon the above principles as well as on the need to reduce dependence on use of a single textbook in instruction. That kind of traditional emphasis generally does not foster an in-depth understanding of science, enhance the development of scientific processes, or offer the greater opportunity for language development.

Instruction that is dependent on a single textbook reduces the necessary flexible approach required to effectively address thematic issues as well as the use of the whole language approach in instruction. Newer curriculum materials that minimize dependence on being able to read English fluently are becoming available. The newer materials limit the dependence on new vocabulary, and they include guidelines for teachers that direct them and their students to varied sources of information for use in the inquiry teaching and discovery learning process. Examples of the newer materials include *Descubrimiento or Finding Out*, published by Santillana Publishing Co., *CheChe Konnen*, under development by the Technologies Education Research Corp; and the Projecto Futuro instructional materials from the American Association for the Advancement of Science, as well as materials from the Science/Math Integrated With Language for Elementary Schools or SMILES Project. The IALS approach is exemplified in materials produced by the SMILES Project. The materials identified here as examples are available and their effectiveness with LEP students is being studied. These materials and others are referenced in Appendix A.

This monograph includes two examples of IALS materials. In each IALS, science serves as the driving force for instruction, and lessons integrate science, mathematics, and language (English). The first of the two IALS (for the lower elementary grades) is included in this chapter, while the second (for the high school grades) appears in Appendix B.

A Science-Driven IALS for the Lower Elementary Grades

The following IALS ("How Do Living Things Behave?") includes some activities that are familiar to many lower grade teachers of LEP students. It also includes some unique and significant components such as a demonstration of the impact of drugs on living beings. This IALS can be adapted easily for use with upper elementary school level LEP students who have not had the experiences at earlier grade levels.

The two sample IALSs included here and in Appendix B present a framework for instruction, leaving each teacher the opportunity to vary the instruction based upon his/her own professional expertise and judgment. The final instruction must be based upon knowledge of the experiential and knowledge background of his or her students, and of the language readiness of the LEP students under his or her charge.

The IALS presented here begins by utilizing living animals familiar to many young children: guppies. Also notice that the initial science content is very concrete and that the level of mathematics required is very basic.

This IALS is organized into vertical columns with the following headings: *Preparation and Materials, Students' and Teachers' Activities, Assessment of Learning, Content and Process Learning Objectives*, and *Sample Questions Students May Ask*. These five columns are included to indicate the scope of information and concerns to be addressed in planning for and carrying out instruction. It will be clear from examining this IALS guide that the scope of information is significant because the proposed instruction encompasses several disciplines.

Teachers are reminded to bring together all of the required instructional materials prior to initiating the IALS. It is important for teachers who have limited experience in this area of instruction to remember that they continue to learn with their students. In this sense, they should be willing to practice unfamiliar hands-on procedures prior to introducing them to their LEP students.

The English names for the objects or materials for each investigation should be reviewed with the students prior to beginning the activity in which the object or material is first used. A way of doing this is to have students use Post-it™ Notes and a magic marker to make "home labels". Ample oral reference to the names on the stickers should be made as teacher and students carry out each action. For example, say: "I am filling the fish tank with water. The water comes from the faucet." Say this as you turn on the faucet and actually fill the tank with water. Ask students to repeat such verbal descriptions of action. Be certain that your statements are short and simple. Always use complete sentences and give emphasis to action words. The action words included in the IALS are underlined. The first two columns in addition to the actions to be undertaken by both teacher and students also includes the materials needed to carry out these actions.

The column labeled *Assessment of Student Learning* includes simple activities that, when embedded in the instruction, indicate to knowledgeable professionals, in a formal or informal way, the extent to which each instructional objective has been met. Favorable reactions by students to each activity indicate that learning is occurring; while unfavorable student responses indicate either lack of science understanding, lack of English language understanding, lack of both, or lack of overall experimental background. Knowledgeable professionals will be able to discern the cause(s) and adjust their teaching accordingly. For purposes of language development students should be offered opportunity to repeat the activity and to re-explore the language and content. It is most important that teachers *not* develop the practice of telling students what their answers should be or what they should learn. Telling is too language dependent, thus assuring that learning will be minimal. It is, however, very appropriate to assist students in summarizing, orally or in writing, what they have learned.

A very useful strategy that will enhance English learning is to assist students in orally designing their own questions and then writing these down. This should be followed by students seeking answers to the questions and writing these answers on paper. The column labeled *Sample Questions Students May Ask* is included to assist teachers in helping LEP students phrase their own questions using the English language, and in preparing for instruction.

Teachers of LEP students who use the IALS may argue or believe that they are "sacrificing" content "coverage." This is a natural reaction for more traditional teachers who are exposed to less directive approaches to teaching. Once the IALS is tried, it will become very clear that this approach to instruction leads to increased coverage of content across the disciplines as well as deeper levels of understanding across the disciplines. The paradox in teaching is that this process of "sacrificing" content, results in increases in both the amount and level of learning. That is, covering less results in uncovering more.

The column labeled *Content and Process Learning Objectives* includes statements of processes and skills associated with science, as well as with the other disciplines. The development of these processes and skills becomes an integral component of each students' experiential base; a base that is so necessary for more advanced learning.

In planning for teaching the IALS, teachers should organize students into heterogenous cooperative groups. Use of these groups in instruction fosters maximum student oral and written language development. To produce the best results, it is important that the cooperative group approach start at the beginning of the school year, because students do not respond easily to changes in classroom organization once the school year is underway.

When cooperative groups are organized in classrooms where LEP students have varying degrees of English language proficiency, or when the LEP students come from varying language cultural backgrounds, each should be structured to include substantial variation in language background and level of English competence. This will foster peer teaching of language. To assure maximum involvement of all students within each group, each student should be assigned a specific task, such as chief experimenter or scientist, assistant, equipment and materials distributor, recorder, observer, communicator of results, reader, measurer, mathematician, and so forth. These assigned roles should be rotated among the students starting with each science investigation. This procedure offers students maximum opportunity for varied experiences and enables them to make a variety of contributions. On beginning a science investigation and follow-through activities it is helpful for each student, in a group, to write down the nature of his or her assignment and to wear a tag reminding him or her of the assignment. "Translator" roles should be assigned to students who have proficiency in the primary language and/or in English. As the language proficiency of individual students improves, the role of translator should be rotated appropriately. Teachers and aides must complement the roles of students as interpreters. The increasing role of ESL specialists, classroom teachers and teaching aides as interpreters increases as the instructional group members language competence increases in language homogeneity.

Science and language competence as well as social values are learned as students cooperate in cleaning up materials following each investigation. Effort should be spent assisting students in phrasing their own questions in English. Teachers should also remember that an IALS is not intended to be prescriptive. Science results may vary and language learning will vary each time the IALS is used in instruction.

The IALS is designed to be completed in a period of 8 to 10 hours of instructional time. It is important, however, for teachers to allow additional time, if necessary, to repeat activities and to enhance instruction in other ways to ensure that the appropriate English language and math skills are developed and that science knowledge understanding occurs. The teacher should plan to divide the IALS into manageable and meaningful lessons taking into account personal classroom schedules. Teachers will discover that students will be able and willing to spend more time being involved with each activity or investigation and follow-through than was originally planned. This phenomenon *does not* indicate unusual difficulty in learning; instead it indicates interest on the part of LEP students for the hands-on investigative nature exemplified by the IALS.

For high school teachers, the second sample IALS presented in Appendix B includes substantive science and mathematics content, as well as activities designed to develop science oriented psycho-motor skills.

TEACHERS GUIDE TO AN
INTEGRATED ACTIVITY LEARNING SEQUENCE (IALS) EMPHASIZING SCIENCE FOR PRESCHOOL OR EARLY GRADES
(Adapted from Project SMILES:
Science-Math Integrated with Language for Elementary Schools materials, Temple University)

HOW DO LIVING THINGS BEHAVE?

PREPARATION AND MATERIALS	STUDENTS' & TEACHERS' ACTIVITIES	ASSESSMENT OF LEARNING	CONTENT AND PROCESS LEARNING OBJECTIVES	QUESTIONS STUDENTS MAY ASK
• 10-12 plain guppies (not guppies with fancy tails) from a pet store or from home • Two rectangular 5 gallon fish tanks (plastic is safer than glass). • Clean plastic quart milk container • Stones to place on bottom of tank • Cold tap water • Hand lens • Guppie food • 2 inexpensive air pumps • Large thermometer measuring in °C • Hand fish catcher, or strainer • Eye dropper or pipet • Small bottle of tertiary amyl alcohol (Obtained from local college chemistry department or science supply house) • straws	In carrying out this IALS it is important to emphasize actions. These actions serve as the logical structure for building English language references. To indicate the extent of action encompassed by this IALS each action word is underlined. The initial part of the IALS is a class activity. Students take turns conducting each activity. Students then become involved in groups in the language and math activities following the science investigation. • Students help to place water into the two fish tanks, counting the number of quarts of water it takes to fill each tank about 3/4 way. The class estimates how many more quarts the tank will hold. Teacher adds the final amount of water to see how close the estimates are. If a very young class, teach counting to 10. Write down numbers on chalkboard or on poster paper. Numbers must be followed by units: 1 cup or 1 quart, 2 quarts etc. • Teacher takes 2 quarts of water	• Write the names of each of the materials on the chalkboard. Ask individual students to copy each name (print) on a large card and tape each "label" to the appropriate object. • Call upon individual students, or the entire class to say each word printed on each card, and to repeat, after you, a sentence using each word. These should be action sentences. For example, "José is placing the guppy into the water." Or, "We are counting the number of quarts of water that the tank holds." • Can the students count the guppies using English language name for the numbers? Can they use each number in a correct sentence? • Can the students continue to add and subtract simple numbers - each followed by a unit of measure • Can students make up their own simple sentences? Can they	(If each objective is not met when the investigation is done for the first time then repeat it until the objective is met.) • Counting from 1 to 10. • Approximating • Learning numbers and simple counting • Learning units of volume-measurement • Measuring temperature & reading the numbers and units of °F and/or °C	

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PREPARATION AND MATERIALS	STUDENTS' & TEACHERS' ACTIVITIES	ASSESSMENT OF LEARNING	CONTENT AND PROCESS LEARNING OBJECTIVES	QUESTIONS STUDENTS MAY ASK
• plain drawing paper • pencils • colored crayons • metric and English rulers • chalk, chalkboard or marker and poster paper • "post it" note pads • marker and large index cards • masking tape • simple dictionary	out of the tank using a measuring cup, <u>pouring</u> cups of water back into a quart container, to see that 4 cups make one quart. • Children <u>determine</u> the temperature of the water when it is <u>placed</u> in the tank; (do this to the nearest degree.) Then after two days <u>count</u> the number of degrees more or less from one time to the next. (For example: 60°F on first day, 70°F on second day, 60°F is 10°F <u>less</u> than 70°F and 70°F is 10°F <u>more</u> than 60°F. If the thermometer also reads °C count differences in temperature in °C. °F = Fahrenheit, °C = Celsius.)	<u>place</u> each new word under the correct letter in their dictionary? Can they place two or more words in correct order when the words start with the same letter? (<u>Don't</u> expect proficiency in learning from the dictionary activity. This will take much more experience. But don't give up. <u>Continue</u> this activity over the entire year.) • Are students able to develop action expressions in English using basic verbs, nouns?	• Simple addition and subtraction • Introducing art (don't expect proficiency) • Describing actions orally using complete English language sentences.	• Do the measurements made by the different groups agree? (Yes, unless someone has made an error.) • Why do we use two different kinds of degrees? (°F was developed in England, °C in France.)
• 2 plastic toothbrush tubes • matches	• Place an air pump in each tank and plug it into an electric outlet	• Can students transfer the use of basic math skills from one situation to another? (If not, keep working at this. Create your own practical examples.)	• Keeping track of vocabulary in a dictionary	• What are the bubbles coming from the pump? (This is a pump for air.)
• 5 of 6 filaments of green live elodea plants (from pet shop) • 2 plastic dishes • paper towels • water (standing one or two days)	• Use strainer to <u>take</u> guppies, one at a time, from a container, <u>placing</u> them into one of the tanks. Students <u>count</u> the guppies. Stop when 2 guppies are added to the tank and ask, how many more guppies are in the tank now? Stop after 5 guppies are added. Ask, how many more guppies are in the tank now compared to when there were two guppies? Show work on board using many examples (0 guppies + 2 guppies = 2 guppies more; 5 guppies − 2 guppies = 3 guppies more, etc.) For more advanced students use more than 10 guppies.	• Can students in groups devise a way to show that a glass is not empty but rather is filled with air? (Invert the glass and push it down into the fish tank filled with water. Slowly tip the glass to one side and watch the air bubbles escape. Use two glasses and let the air bubbles collect in the second glass by placing the glass filled with water that filled with air so that the escaping air bubbles are trapped in the second glass.	• Care of living things • Food is made from once living things	• Where does the air trapped in the glass go once it escapes? (It goes back into the atmosphere.)

PREPARATION AND MATERIALS	STUDENTS' & TEACHERS' ACTIVITIES	ASSESSMENT OF LEARNING	CONTENT AND PROCESS LEARNING OBJECTIVES	QUESTIONS STUDENTS MAY ASK
	• After one guppy is placed in the fish tank ask students to draw a picture of the tank, the guppy, and the water, and color the drawing! As you add guppies have students draw additional fish. Before they draw the original guppy, develop a lesson during which the students observe and describe the guppy. Notice head, tail, fins, eyes, etc. Speak about each and ask class to repeat the sentence. "We can see the guppie's fins move," as an example. Students should label their drawing, using "post it" notes. If old enough, students write the labels.	• Exhale through a bent soda straw into a tube filled with water partly *immersed* in water. Collect the exhaled gas. Can the students determine if this gas supports the burning of a match? Is exhaled air high or low in oxygen? (low)	• Learning through art	• Do guppies need air to live? (Yes, the air contains the oxygen they need.)
	• Make a simple dictionary on the chalkboard by listing letters of the alphabet with space between them to write down new words. For example: fish tank, water. For younger children use pictures.	• Can students show that fish (animals) get the oxygen they need from dissolved air containing oxygen? (Place a glass of cold tap water on the warm window sill. Students watch, over a period of a day, to see bub : form as the water warms. This demonstration can be accelerated by using a hot plate kept on low heat. Can these bubbles be collected in an inverted plastic tube? The bubbles are air that remain dissolved in water until the temperature of the water increases.)	• Learning of English names	• They will ask questions about how to use English to express their ideas.
	• Have individual students assist in writing down words under appropriate letters. While doing this, help them to make up an action sentence, in English, using each word. e.g., The small fish swims in the water. Ask individual students - Juan, do you think that the small fish swims in the water - this exercise allows each student to practice speaking English by themselves in a comfortable environment.		• Using art to express an activity. Labeling the art with English names of objects.	

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STUDENTS' & TEACHERS' ACTIVITIES AND ASSESSMENT

- Teacher read from the dictionary the simple definition for a few of the action words like: move, place, swim.
- Be certain to show students how to feed fish, once each day (not too often), how to place stones in bottom of tank, and how to connect the air pump to supply the fish with air. As you are doing these activities, talk out what you are doing — ask students to tell you what you are doing.
- Place a few pieces of fish food on white paper, students examine this food with a hand lens. Draw these pieces of food and label the drawings.

- The next day, divide the class into two groups. Ask each group to measure the length of each side of the fish tank. Each length is different. These lengths can be labeled L_1, L_2 and L_3. Or we can use L for L_1; W or width (L_2) and H for height (L_3). The two groups can compare their measurements. Are they the same? Why are they different? How much longer is L_1 than L_2; L_2 than L_3; L_1 then L_3? How much shorter is L_3 than L_2 than L_1?
- Teacher selects one or more appropriate story books or readers from the school library and readies stories about small fish, or about guppies. A story about drugs and their negative effect on living things. Or for students from upper grades, have students read the stories and discuss them.

- For this activity or investigation take one (1) cm^3 of tertiary amyl alcohol and dilute this with 99 cm^3 of water. This makes a 1% solution of the alcohol.
- Now place only one guppy one of the fish tanks, and add drop by drop (use the eye dropper) the one percent alcohol solution to the water, stirring the water with a straw. Observe a change in behavior of the fish. (The fish will stop swimming by the time 20 drops of the alcohol are added. (Gently stir the water and alcohol after each drop is added using the straw.) Once the guppy is "sleeping" immediately take it out of the tank and place it back into the recovery tank with the other guppies. Students count the number of drops of alcohol added, and the time that it takes before any drowsiness is observed.
- Observe. The fish will "wake up." (If left too long in the alcohol contaminated water the fish will die.)

- Place the five or six filaments of the elodea plant into a fish tank containing clean water and 1/2 the guppies, disconnect the air pump in this tank and place the tank in a sunny location.
- Take one filament of elodea out of the tank and place it in one of the plastic tubes. Fill the tube with water from the fish tank. Invert the filled tube mouth down into a plastic dish containing 2 or 3 inches of water. Do this by holding your finger or a paper towel over the open mouth of the tube. Place this dish and tube in a sunny location. Repeat the above; only this time place the second tube and Elodea in water in an area of the room which receives little or no sunlight. Ask all of the students, in groups, to observe both tubes, over several days.

CONTENT AND PROCESS LEARNING OBJECTIVES

- Can students measure other L_1, L_2, L_3 in the classroom and answer how much more or less? Can they describe what they are doing and why using complete English sentences.
- For advanced students, can they measure lengths and calculate areas and volumes in both English and Metric systems? Can they express the results in English?
- Mathematics
- Language
- Introducing the topic of the negative effect of drugs on animals-humans. (Like the fish, humans are damaged by foreign substances — drugs. Sometimes humans recuperate, sometimes the do not.)
- Air contains oxygen mixed with other things. A green plant, like Elodea, when placed in sunlight, forms oxygen.
- Oxygen supports burning. Things burn in oxygen.

QUESTIONS STUDENTS MAY ASK

- Is alcohol a drug? (Yes it is. It would kill the fish if we put too much of it in the water.)
- Why can we disconnect the air pump? (Let's wait and see. Eventually the Elodea plant forms oxygen. Some of this dissolves in the water.)

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STUDENTS' & TEACHERS' ACTIVITIES

- Observe: Bubbles will form on the plant leaves, escape and rise to the top of the inverted tube. These bubbles eventually will force all of the water out of the sunlit test tube. (The bubbles will form much faster in the tube that receives sunlight.)

- For Advanced Students:

  Measure the height of each tube and determine the number of hours of time that it takes the tube to fill with gas (oxygen). Then calculate the average inches or centimeters of gas are formed each hour. The rates for each tube can be compared.

  $$\frac{\text{Total height of tube}}{\text{Total number of hours}} = \frac{\text{inches}}{\text{hour}} = \text{rate}$$

- Strike (light or *ignite* a match and observe it burn in air. Light another match and quickly thrust it into the mouth of the sunlit tube from which the water has been driven. Compare how each match burns. (The match thrust into the tube with the collected bubbles burns very rapidly producing more light than does the match burning in the air. Repeat the procedure using the tube partially filled with gas (oxygen).

  Apparently, regular air supports burning (oxygen). The tubes must contain more oxygen since the match burned more brightly in these tubes than in air. Air must contain oxygen along with other substances.

- Students may want to make drawings of the investigation and keep a written history. They also may want to write down each question that they are seeking to answer.

- Return all guppies to their correct fish tanks, add elodea to each tank and turn off the air pumps.

- Suggested Lesson Breaks

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QUESTIONS STUDENTS MAY ASK

- Are air and oxygen the same? (No, air contains oxygen mixed with other gases.)
- Does the green Elodea plant give off a gas? (Yes, see the bubbles.)
- What is this gas? (Let's wait and see.)
- How do we know what it is? (That the gas supports burning tells us it is oxygen. Supporting burning means that it allows something else to burn.)
- Is sunlight needed to form this gas? (Compare the amount of gas in the two tubes. The one in sunlight forms the gas.)
- Does this gas dissolve in water? (Yes.)
- Why are air pumps used with tanks of fish? (Fish use oxygen dissolved in water.)
- What is meant by supports burning? (Supporting burning means that it allows something else to burn.)
- What is meant by burning? (Combines with oxygen.)
- Do the guppies (do we) burn when they/we use oxygen? Why? Why not? (We sort of burn, but we do not form light. We do form heat when we use oxygen.)

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Chapter 3

The Nature of Science-Driven Instruction for LEP Students

Teaching Methodologies in the Sciences

Isidore Rabi, a famous immigrant scientist, is quoted as saying that when he was a child he came home from school each day to a mother who did *not* ask him: "What did you learn today?" Instead she asked, "What important questions did *you ask* today?" He attributes his successful science career to the wisdom of his mother. Clearly she helped to develop in her son what should be the true meaning of inquiry in school, students asking questions! But do students have frequent opportunities to ask questions in science classrooms?

As indicated in *Define your terms* (Sutman,1995), classroom science activity as generally practiced follows one of two instructional approaches called *lecture/discussion* and *inquiry/discovery*. Instruction includes the activities of both teachers (teaching) and students (learning). Lecture (teaching) and discussion (learning) are paired because they usually occur together; as is true for inquiry (teaching) and discovery (learning). The term lecture indicates the approach to teaching through which teachers convey or transmit information to students, usually the information they wish students to learn. This "telling" often is accompanied by discussion, a form of learning that should involve students in verbal interplay, that assists them in better understanding what is to be learned. In actual practice, discussion usually involves the teacher asking students questions with the expectation that they will supply the answers. "Discussion" so often takes this form that the term has become a misnomer.

Research by Mary Budd Rowe and others indicates that during most classroom "discussions" teachers ask questions and allow only a very short period of time (two to three seconds) to receive students' answers. Usually answers are not forthcoming and the teacher invariably calls upon one student and then another. Many times when no student answer is forthcoming the teacher eventually answers his or her own question!

In classrooms where teachers continually abuse the discussion process by asking all of the questions and then supplying most of the answers, there is little or no opportunity for students to pose their own questions or to discuss or debate issues. In too many classrooms, especially those including LEP students, students very rarely ask questions in either English or their native tongue. This is not the sort of environment that would have encouraged students like Isidore Rabi to ask questions.

Inquiry-oriented classrooms foster discovery learning environments in which students are supplied with a variety of resources designed to assist them in finding answers to their questions. In this environment the teacher is one of many instructional resources, including: laboratory materials and equipment to be used in hands-on investigations, the library, community-based specialists who visit classrooms, field trips, reference books, newspapers, and other media such as videotapes, films, and computer programs. Through quality discovery experiences, LEP students in particular learn to learn on their own. This should be a major long-term goal of science instruction.

The IALS presented in Chapter 2, as well as the example included in Appendix B, presents examples of effective inquiry(teaching)/discovery(learning) science lessons. They begin with a chal lenging hands-on science activity that yields unexpected or unusual results that lead students, naturally, to ask why or how?

It is useful to think of the inquiry/discovery approach to instruction as being on one end of a continuum with lecture/discussion on the other end. Table 1 indicates this continuum as well as the characteristics associated with each approach. Note as an example that when teachers emphasize lecture/discussion, they become the center of instruction, and the success of the instruction depends very heavily, especially for LEP students, on understanding language. At the opposite end of this continuum, inquiry/discovery instruction is more student-centered and successful in terms of learning because it often is much less dependent upon unfamiliar language.

Inquiry/discovery is an especially useful instructional approach to science learning for LEP students because it supports better understanding by students of their own questions, and offers opportunity for them to assist one another in phrasing answers to questions through teacher-managed discovery activities.

Teacher-Proof Curriculum

Considerable debate has occurred over many years regarding the development of curriculum materials that can force or mold teachers to emphasize an inquiry/discovery instructional approach. This forced approach is sometimes referred to as a "teacher-proof curriculum."

Many science instructional materials claim to be inquiry/discovery-based, usually because they depend very extensively on hands-on science materials. The truth is that, even with hands-on materials, science teaching can end up as lecture/discussion-directed if teachers are not conscious of how to use another approach. Special training and practice under the guidance of knowledgeable, experienced professionals are needed, in most instances, to assure that inquiry/discovery instruction is emphasized. When effectively utilized, many desired learning outcomes are enhanced.

Inquiry/discovery-based instructional materials can be ineffective with LEP students when the written materials are at too high an English language readability level. Such high levels of readability result in disinterest and little learning. This section as well as Appendix A includes information about selected science instructional materials with information about readability levels.

Inservice teacher training or professional enhancement to facilitate inquiry/discovery occur through the actual development of sample inquiry/discovery-based materials. This strategy works best when teachers cooperate with each another and with a master teacher who is experienced with this approach in a school environment that is supportive of the approach.

Examples of Recent Science Instructional Materials

Almost all of the instructional materials in the sciences for LEP students distributed to schools by commercial publishers are traditional in that they call upon students and teachers to read extensively in English. Some of these materials are also available in both Spanish and English, a practice that does not support development of English language proficiency.

Even for majority English proficient students, excessive language usage is not sound instructional practice. Below are examples of science instructional materials that better serve science, language, and mathematics teaching and learning for LEP students.

Elementary School Level

Proyecto Futuro (1992) is a source book for teachers of LEP Hispanic students developed by the American Association for the Advancement of Science. The source book contains science con-

Table 1

Some Characteristics Of Two Approaches To Science Instruction

Inquiry/Discovery <———	———> Lecture/Discussion
• Less dependent on unfamiliar language	• More dependent on unfamiliar language
• Science content is "uncovered" through activity, and the relationships among components are explored	• Science content is covered in an encyclopedic way
• Develops improved attitudes about science, scientists, and science instruction	• Destroys positive attitudes about science, scientists, and science instruction
• Increases the learning of second language skills when supported by group based classroom organization.	• Reduces the learning of second language skills. Does not lend itself to group-based classroom organization.
• Leads to greater development of both process and manipulative skills	• Leads to lesser development of process and manipulative skills
• Offers students greater opportunity to construct their own knowledge	• Leads to short-term learning of pre-designed content, with little opportunity to construct knowledge
• Allows for more experiences in the real work world	• Does not foster authentic experiences in the real work world
• Results in reduced school dropout rates	• Results in increased school dropout rate
• Results in constructive discussions among students & between students & teachers	• Results in quieter classroom environments preferred by many school administrators
• Requires a less traditional form of teacher preparation	• Requires a more traditional form of teacher preparation

tent information for the teacher as well as suggested worksheets for students, both in English and Spanish. Included are six units on related materials, as well as appropriate references. Of great value are the following introductory sections: *Hispanic culture, past and future, Integrating hands-on activities and cultural connections*, and a resource guide, *Locating hispanic science and engineering role models*.

Science for Life and Living (1990) is a textbook series developed by the Biological Sciences Curriculum Study or BSCS Inc. and published by Kendall/Hunt Publishers. This instructional program, supported by the National Science Foundation, contains many hands-on science activities related to health and social science issues. The materials are at a low readability level which makes it a useful resource. Users will want to be cautious of some content errors and of the highly prescriptive approach.

Full Option Science Study (FOSS) (1991) is a modular science program developed at the Lawrence Hall of Science (University of California, Berkeley). Funded through the National Science Foundation, FOSS was designed to be used as a supplement to traditional basal science programs for the upper elementary and middle school grades. The hands-on science investigations of the FOSS program serve LEP students effectively when used as the basis for science instruction, but only when used by teachers who are reasonably knowledgeable in science. The FOSS program, published by Encyclopedia Britannica Films Inc., is being expanded into a complete curriculum for the middle and upper elementary school grades.

Kids Network (1990), a supplemental science program, is designed for use at the middle and upper elementary grade levels. The program developed by the Technology Education Research Corporation (TERC) and published by the National Geographic Society, is an inquiry/discovery-oriented science program that utilizes computer technology. The hands-on work, cooperative sharing of data and language structure of Kids Network make it very appropriate for the English language development by LEP students. On the negative side, the program is somewhat costly to implement, requiring computers and networking capabilities.

Finding Out or *Descubrimiento* (FO/D), (1988), a supplemental instructional program designed specifically for use by LEP students, K-6, consists of a series of activities outlined on large cards, categorized by science topics. Each card includes directions and drawings to assist students in conducting measurement-oriented activities. Directions for these activities are in both English and Spanish. FO/D, developed by DeAvila and Associates and published by the Santillana Publishing Company, is especially effective in introducing science content to LEP students as well as in developing basic measurement and math skills. If the Spanish translation is used judiciously, FO/D serves effectively to develop English language among LEP students.

Science and Technology for Children, a full elementary level science program under development by the National Sciences Resources Center of the Smithsonian Institution and the National Academy of Sciences, consists of instructional thematic modules that places emphasis on hands-on investigations. Kits of science equipment and materials and written directions, are available. Free teacher training is also available when kits are purchased from the Carolina Biological Supply Company. Although not specifically directed to LEP students, this program could effectively serve academically-able LEP students at each K-6 grade level.

Project SMILES (Science/Math Integrated with Language for Elementary Schools, a science-driven instructional program designed specifically for LEP students at the elementary school level, is a series of thematic units or Integral Activity Learning Sequences (IALS). As indicated in Chapter 2, each IALS is introduced through a science activity producing unanticipated results followed by other science investigations and appropriate related activities designed to develop both math and English language skills. The activities are designed to be taught in cooperative group classroom settings. This program is being developed through the Science and Mathematics Teaching Center at Temple University in Philadelphia, PA. The format of the IALS, is at present, limited to a teacher's guide that includes directions for teachers of LEP students.

Secondary School Level

Chemistry and the Community or *ChemCom* (1988, 1992), a chemistry instructional program developed through the Division of Chemical Education of the American Chemical Society, is designed for use at the 10th or 11th grade level. The English language readability level is grade nine and the science vocabulary is not too dense. *ChemCom* includes ample hands-on investigations in both science and its social science applications. *ChemCom* has been shown to effectively serve the instructional needs of the high school level LEP student population. The program, which contains narrative and investigative activities under a single cover, is published by Kendall/Hunt Publishers

Supplementary workbook materials, developed on the Cognitive Academic Language Learning Approach, (CALLA) model, are published under the title of *Content Points A: Science, Mathematics and Social Studies Activities*. These materials, published by Addison Wesley Publishing Company, contain mostly paper and pencil activities. The few hands-on science activities included are prescriptive; limiting their use for science knowledge and language development. There is little carry-through from one lesson to the next, reducing opportunities for students to develop the scientific terminology and other related language structures.

The above analysis indicates need for additional inquiry/discovery-based science instructional materials for use by LEP students. The development of such materials should be guided by the premises proposed in Chaper 2.

Teaching Science and Language Competence

Developing both science understanding and English language skills concurrently requires special attention to how communication occurs between teacher and student. Lemke, in his book *Talking science: Language learning and values* (1990), provides examples of the poor quality of oral communication that occurs in too many science classrooms. Below is a typical direct quotation of such communication recorded during class sessions in high school chemistry:

Teacher:	This is a representation of the one S orbital. S'posed to be, of course, three dimensional What two elements could be represented by such a diagram?— Jennifer?
Jennifer:	Hydrogen and helium?
Teacher:	Hydrogen and helium. Hydrogen would have one electron somewhere in there, and helium would have — ?
Student:	Two electrons.
Teacher:	Two — This is — one S and — the white would be — Mark?
Mark:	Two S.
Teacher:	Two S. And the green would be —— ? uhh ——
Janice:	Two P. Two P
Teacher:	Janice

Janice: Two P

Teacher: Two P. Yeah, the green would be 2Px and 2 Py.

From this typical example, note that thoughts are left incomplete, that emphasis on grammar and appropriate language structure is ignored, and that very little is expected from students in terms of understanding content beyond what is to be memorized. Also, note that the only question asked by the student (Jennifer) is procedural, merely questioning her own response, and doing that in an incomplete way.

Lemke refers to this form of discourse as "question-answer-evaluation pattern" or "triadic dialogue." In ignorance, many teachers refer to this form of sloppy interaction as "discussion." Lemke indicates that this form of instructional dialogue "stacks totally against learning either science or language." He also asserts that triadic dialogue is a pattern that students quickly and easily adopt, and that its use only accomplishes maintaining some form and degree of teacher control. If this example indicates poor quality science-language instruction for majority students, imagine the poor level of instruction that its use offers LEP students.

In the above example, the teacher provided *no* assistance to students in learning how to construct workable "science sentences" and "science paragraphs." The example shows a lack of planning to teach students how to combine terms and meanings, how to speak, how to ask questions, how to argue, how to analyze, or how to write science. It "appears to take for granted that students will just catch on through a less than formal approach to instruction." Lemke pleads, "Is it any wonder that so few [students] succeed? Or is it any wonder that those [students] from social [and language] backgrounds where the structures, preferred grammar, rhetorical patterns, and figures of speech are least like those of science, do least well?"

Lemke presents several useful teaching "components" designed to improve English communications overall in science classrooms, including LEP classrooms. These components are summarized below:

- Give students more practice correctly talking science.
- Teach students how to combine science terms, first in simple sentences, then in more complex sentences.
- Teach students the minor and the major genres of science writing.
- Help students to translate back and forth between scientific and colloquial statements of the same idea.
- At advanced levels, discuss formal scientific style and the use of informal humanizing language in describing scientific content.
- Describe and demonstrate, using simple investigations, the relationships between what is observed and the explanations for what is observed (theories).
- Present science as a fallible human social activity, rather than as a superhuman infallible activity.
- Emphasize that science is a way of talking about the world. This talk need not be more difficult than talking about any other subject.
- Adapt teaching and testing to students' cultures.
- Give students practice using science to address policy issues according to their own cultural values and their more immediate interests.
- Acknowledge and then work to resolve conflicts between the curriculum and students' societal values.

Practices Emanating From the Constructivist Model

The message of this chapter, *Science Driven Instruction*, is embodied in what today is referred to as the constructivist learning theory The usefulness of this theory is supported through research indicating that most students enter school with misconceptions about both natural phenomena and the explanations for these. Research also shows that science instruction as presently practiced in schools, for the most part, does not easily eliminate the misconceptions, even among able students. Even students who perform well on standardized tests too often are unable to apply memorized facts and algorithms to correctly interpret experiences. This phenomenon compels educators to seek other than a "rote model" for instructional practice. The constructivist model is based upon the premise that the degree or extent of successful learning outcomes is dependent upon offering more opportunity for students to construct their own learning. The extent to which this construction occurs depends upon each student's personal knowledge at the time of instruction, the nature of the communication used in instruction, and the rate at which this communication occurs.

LEP students often come to science instruction with levels of experiences and personal knowledge different from the norm.. And, they come with varying levels of abilities to communicate in English. Therefore, to be successful in school, these special students must become involved through school in a rich variety of language and other stimuli; and the instruction must be structured so that the pace or rate allows for individual flexibility.

In a National Science Foundation publication, Von Glasersfeld (1988) indicated that the existence of objective knowledge, and the possibility of communicating that knowledge through language, has been taken too much for granted for all students. Faith in objective scientific knowledge has been unquestioned, and this faith has been the basis for the "failing" approach used in most of the science instruction occurring in the schools, especially science instruction for LEP students.

Teachers constrained by the traditional school structure and by the perceived need to prepare students for standardized tests expected all students to achieve the same level of learning. The need for students to perform well on standardized tests drove instruction more toward conformity or leveling.

Science instruction built upon the "constructivist theory" deemphasizes leveling and instead challenges each student to reach high expectations at his/her own level of competence.

Following is a list of instructional practices that grew directly from the acceptance of constructivism. This list, significantly revised by the authors, was first presented by Yager in The *Constructivist Learning Model* (1991), and is directed toward the instruction of LEP students.

- Seek and use questions, experiences, and ideas proposed by LEP students to guide the preparation and presentation of science directed instructional units.
- Promote cooperation over competition in instruction among LEP students.
- Use open-ended questions developed both by teachers and students, and guide LEP students so that they fully elaborate on their responses to these questions.
- Develop an environment within a planned framework that offers LEP students ample opportunities to explore their own ideas.
- Offer LEP students opportunities to challenge each other's explanations and approaches, both individually and within cooperative groups. The group approach should allow for interaction among students, as well as students with teachers and bilingual aides.
- Allow students adequate time for reflection, analysis, general problem solving, and understanding, using both the first language and English.

- Involve students in investigations that require hands-on materials, both individually and in structured groups. Investigations should be used more often to introduce topics or concepts, and less often to verify what is known.
- Utilize lectures, demonstrations, note taking, films, and so on for summarizing rather than for introducing lessons and units.
- Assure ample opportunity for student self-evaluation.
- Design instruction so that teachers and textbooks are less used as sources of information. Make available a variety of other sources of information.
- Assure that there are ample opportunities for LEP students to apply learned knowledge and skills to new situations.

It is clear that the practices stated above are consistent with those proposed earlier in relation to inquiry/discovery oriented instruction. Also, it is clear that there are similarities between practices growing out of constructivism and the whole or natural approach to language development as described in *Portraits of whole language classrooms* (Mills & Clyde, 1990). The whole language approach deemphasizes memorization of language and gives emphasis to language skill development and comprehension through its use in real world settings, such as in addressing issues that call upon science knowledge. A reference that effectively addresses these issues from another perspective is Chapter 4 of Fradd's: *Meeting the Needs of Culturally and Linguistically Different Students* (1989).

Chapter 4

Supporting Reform in Science Driven-Instruction for Diverse Student Populations

This chapter commences with a summary of the major recommended practices presented earlier in this monograph. The summary is followed by descriptions of various supports required to assure that practices can be implemented effectively with LEP student populations.

Summary of Recommended Practices

- Utilize science hands-on investigations as the driving force for mathematics and language skill development.
- Structure instruction so that science knowledge and mathemathics skills are applied to real issues.
- Consciously plan objectives for language development (in particular English language) as a component of science instruction. Science hands-on investigations, used to introduce lessons, should be conducted by cooperative learning groups.
- Reduce the abstract nature that is inherent in basic science and mathematics through the use of concrete models.
- Emphasize the use of the whole language approach to English language instruction, diminishing native language use by LEP students. Sequence lessons around broad themes to allow for repetitive language use.
- Teach English language as an integral component of classroom instruction rather than following the more traditional "pull out" procedure.
- Teachers and administrators who are responsible for the instruction of LEP students need to work together to overcome detriments to learning, across the subjects, inherent in the present school structure.

Support for Reform of Traditional Instructional Approaches

Support for the proposed reform of instruction for diverse students emanates from successes in learning, especially by LEP students. Below are selected resources that report such success.

In *Language through science and science through language: An integrated approach*, Chellapan, (1983) asserted that:

> Because language and subject content are closely related, a valid approach would be to teach English *through* science rather than English *for* science. In this context language should be

treated more as *communicative* than as *instrumental* or functional. The proposed practice leads to blurring the distinction between science and language instruction.

Jones, in *Teaming Up* (1985), claimed that:

> Task groups (consisting of three to five students per group) for hands-on inquiry-oriented experiences, can provide meaningful instruction, develop interpersonal skills, and reduce costs.

Sutman, et al, in *Learning English Through Science* (1986) stated that:

> For children who are LEP due to hearing impairment, hands-on integrated photography-language type experiences structured to meet the specific educational objectives of increasing spoken vocabulary and improving self-esteem, produced phenomenal growth in spoken English. The experimental group learned, during a 12 week, four hours per week student participatory set of experiences, to speak *30 times* the number of words learned by students in the control group. The control group experienced English language using traditional story books. The experimental group, in addition to improved spoken language, became 'heroes' of the school, virtually eliminating its overall lack of self confidence.

Questions regarding the ability of LEP students to learn science are often raised. This issue is thoroughly addressed by Kessler and Quinn, in *Consequences of bilingualism in a science inquiry program* (1981). Their summary indicated that:

> A number of studies lead to the conclusion that bilingualism does not deter students' abilities to formulate scientific hypotheses and solutions to scientific problems. In fact this ability is enhanced by bilingualism.

Results of using the IALS approach have been reported by Bruce, Sutman, May, McConaghy, and Nolt (1996):

> The study, involving nearly 400 English language proficient and limited English language proficient fourth graders in 16 classrooms in instruction driven by hands-on science leading to activities directed at enhancing basic skills, conducted through cooperative instructional groups indicates that compared to the control group, in which science was taught through reading a science text, LEP students improved in science and language skills significantly better than their non-LEP student counterparts. And the learning of mathematics skills was ahead of the students in the control group, but not significantly so.

These results were attributed in part to the use of cooperative groups that enabled learning to occur in spite of the varied learning styles among students with diverse cultural and language backgrounds.

While not mentioned in these reports, success in learning by LEP students also depends upon support from school administration, community leaders, and student homes. The nature of the need is considered in the following section.

Unsupportive and Supportive School Settings

Although often well-intentioned, too often schools offer instruction to LEP students that results in minimal learning. The vignettes below, from *Among School Childr* : (Kidder, 1991), describe an unsupportive setting in a "typical" school:

- [The teacher] glanced at the clock, up on the wall above the closets....She had a few minutes before science. She absolutely had to help poor Pedro. "Slow learner" was the kindly term used for many of these children. It implied what she knew to be true, that they could learn, but she also knew that in this time-bound world, a slow learner might not learn at all if she did not hurry up.

- A high pitched beep from the intercom announced math, which lasted an hour. Some children left her room for math replaced by some children from the room next door. This swapping of teachers was the procedure used to group children by ability; another way of saying the students were 'levelized.'

- Some students ended in haste. The intercom would announce, "Bus one," and Chris would still be assigning homework. She wrote the assignments on the narrow chalkboard between the closets—and always explained three times what she wanted done.

The unsupportive school conditions have been characterized as:

> 'Dual captivity,' the children have to be there, and the teacher has to take the children sent to her. Put twenty or more children of roughly the same age (and of varying cultures and languages) in a little room, confine them to desks, make them wait in lines, make them behave. It is as if a secret committee, now lost in history, had made a study of children and, having figured out what the greatest number were least disposed to do, declared that all of them should do it.

The above vignettes indicate a kind of blind, uninformed, and dedicated "professionalism" that somehow leads to some learning for some students by chance.

In contrast, the following situations illustrate restructuring of school environments to support science instruction that fosters success among students with diverse language backgrounds.

- During the next to last week in August prior to the opening of the school year, all of the teachers met with the school principal, as well as with several specialist consultants who would assist in developing organizational and instructional plans for the year. The meetings covered a period of 3 or 4 days, allowing the following week for teachers and specialists to work actively together to adequately prepare for the year's activities. The specialists remained to support the teachers during the first two weeks of the instructional school year and they returned from time to time as requested throughout the year.

- With the assistance of the science specialist, the head of the school cafeteria, and the principal, the decision was made to include a unit on nutrition early in the year as part of the sixth grade science experience. Sixth graders, in groups beginning in October, assisted the cafeteria staff (parents) in preparing and distributing the free breakfasts and lunches with the school principal facilitating the process of involving students and parents. Groups of sixth graders developed the menus for the meals using both English and one or more other native languages. Teachers utilized these menus as a basis for written language lessons. The results of these lessons were posted in the halls around the school building.

The sixth graders went in pairs to other lower grade classrooms to explain what they had learned about nutrition and to describe how the menus met appropriate nutritional requirements. They performed several science demonstrations related to nutrition in each classroom.

- A plan was developed to hold a "voluntary" science fair in the late spring. Students, working in groups, could either create exhibits or projects for the fair or they could work with teachers and a science specialist to develop materials that would be used in future science instruction at different grade levels. The project or materials were related to the content designated by the syllabus for each instructional level. Groups of children from various classes prepared to present in English to other classes the projects or materials that they had developed. Assessing what students had learned through these experiences became an integral component of instruction. Portfolios, kept of each student's work served diagnostically to inform each teacher where students needed special support.

- A decision was made to develop or locate at least one hands-on science activity to be used in the science instruction each week, and to develop or find already available *related* math and language activities for instruction. Each activity was completed in English and strengthened by sparing use of native languages. The materials, reports, drawings, etc., developed by the students are displayed in the hallways or in the school's foyer. The students voted for a series of awards to be presented to each class. Every classroom receives an award.

- Out of school work related to each integrated (science, language and math) lesson was written each day on the chalkboard by a student, prior to or during the lesson; and teachers assisted students in copying the assignment both in their native language and in English (in English and a foreign language for non-LEP students). The students assisted in the translation process. This was not done hurriedly at as an afterthought. Time was allotted toward the end of the school day for students, working in groups, to assist each other in initiating the assignment. The groups included students with varying degrees of limited English (language) proficiency; and with teacher support the students were encouraged to assist each other in beginning the assignment. The school principal found ample time to visit classrooms and to be an active participant.

- The principal's office relied upon the intercom system only for emergencies and back-up. Instead of disruptive announcements, a procedure was developed that involved students in teams of two (as part of their language development) to visit other classes after lunch, and to present announcements, learning to do this both in English and other languages. Prior to and during the announcements, teachers were cued to assist the young announcers to carefully present the messages. Other students were assisted by their teachers in understanding the intent of the messages that are delivered.

- A science textbook was utilized as one of several sources of factual information. Teachers developed or purchased limited numbers of drill and practice exercises. Portfolios containing original students' work in science, math and languages were kept for each student indicating their degree of creativity and understanding. Each student who leaves the school or a given class for a new learning environment carries his/her portfolio to the new setting, with an analysis written by the student's former teacher.

The descriptions above indicate situations where both students and teachers are important individuals and contributors to the change process. Experiences modeled after these descriptions of school environments result in learning, by LEP students, far beyond the level resulting from more traditional approaches.

Other Supports to Instruction

The Condition of Bilingual Education in the United States (U.S. Department of Education, 1991) indicates the need for continued research to determine the most effective procedures for English language instruction. The Office of Bilingual Education and Minority Language Affairs provides grants to school districts for a variety of "transitional bilingual programs". We propose here that the best transitional approach starts instruction begins in English with some emphasis on use of the native language. Over a short period of time, students should become immersed almost totally in the English language. The immersion should occur within self-contained school classrooms. Those programs that use the "pull-out" strategy to instruct in English as a Second Language (ESL) segregates and splinters LEP students from the regular ongoing classroom instruction in English language within the context of science and other subjects.

This position regarding language instruction is supported by Charles Glenn, who in "Educating the Children of Immigrants" (1990) unfolds practices used in European countries and in Israel. These countries, like the United States, are responsible for the education of large numbers of immigrant school age populations. Glenn advocated the use, at the lower grade levels, of "reception classes" designed to orient new immigrants to the new culture, new language, and new subjects. He indicated that these reception classes must be supported by supplemental classes taught in the native language, gradually joined with academic instruction in the second language. These initial practices must be followed by immersing LEP students in science and other subjects taught totally in the second language (English). He concluded that these practices will best serve the needs of the immigrant students.

Studies supported by and reported over recent years by the U. S. Department of Education's Office of Education Research and Information (OERI), as well as the Reports of the National Education Goals Panel, continue to indicate that English language literacy, scientific literacy and foreign language literacy are totally inadequate among the entire United States student and adult population, so inadequate that the condition negatively impacts the country's international competitive edge. LEP students make up a significant instructional component of this illiteracy problem. For LEP students, illiteracy can be effectively alleviated by placing into practice the instructional procedures proposed throughout this monograph.

However, revised curricula and instruction, by themselves, will not meet this challenge. To paraphrase Glenn, hard work on the part of teachers and students, sensitivity by teachers to the needs of LEP students, and especially, a commitment on the part of teachers to the full participation of LEP along with EP students in learning activities especially designed for their use is required. Also, special materials and special efforts, in today's technological times, must be supplemented by support systems of the type considered in the following section.

The Role of Technology: Computers

To prepare the next generation of LEP citizens, schools are required to offer ample experiences with computer technology imbedded into most aspects of instruction, particularly in science and mathematics instruction. Aside from the use of computers to simulate science experiences that might be too dangerous to experience hands-on, or too abstract for students to grasp without the simulations, computers are excellent for collecting and analyzing data in ways that relate to the real adult working world. However, caution must be taken not to introduce computer use prior to adequate hands-on experiences with real objects. Preliminary research findings indicate that using computers too early in the instructional process to simulate the tools used in experiments and investigations leaves LEP students without truly understanding and effectively meeting the specific instructional objectives.

Useful sources of information regarding effective use of computers in instruction, especially in science instruction include:

- Volume 2, No. 3 of the *California Technology Project's Quarterly*: "Technology in the Science Curriculum K-12." This special theme issue addresses the following: "Software for the science classroom," "Telecommunications in science," "Education for a planet at risk," and "Animalia and hidden technology."

- Any issue of the journal, *Technological Horizons in Education*, contains valuable information about effective use of computers in instruction.

- Vol. 51, No. 7 of *Educational Leadership*, a journal of the Association for Supervision and Curriculum Development, is devoted to "Realizing the Promise of Technology in School Instruction".

Finally, the goals to be achieved through effective science instruction that incorporate computer technology are delineated in the publication, *Comprehensive Education Plan for the State of Florida: Improving Mathematics, Science and Computer Education* (Florida State Department of Education, 1986).

The Role of Effective Assessment of Student Learning

Substantial efforts related to revising approaches to assessing student learning are nationally underway. One of the reasons for this "alternative assessment movement," is to assure that bias against LEP students and other minorities is eliminated. Just as important is the understanding that the nature of assessment directly impacts both the content of the curriculum and the approach to instruction.

Traditionally, multiple choice standardized tests and poorly constructed teacher-made tests have resulted in excessive emphasis on teaching through lecture and learning through memorization of science facts. This reduces opportunity for LEP students to experience the hands-on investigative science process and acquire higher learning skills as considered earlier in this monograph. As described in Chapter 1, LEP and other minority students perform especially poorly on items designed to assess the development of the higher-order proficiencies.

Three chapters of *Science Assessment in the Service of Reform* (Kulm & Malcolm1, 991): "Performance Assessment: Blurring the Edges of Assessment, Curriculum and Instruction," "Assessing Accelerated Science for African American and Hispanic Students in Elementary and Junior High School," and "Equity and Excellence Through Authentic Science Assessment" address approaches to revising student assessment practices for LEP and other unrepresented and underserved youth. This publication also addresses the need to revise assessment of student learning in science so students are better served. Revisions in assessment practices are needed to reduce the use of testing as a "gate keeper," an approach that only reduces the number of minorities who are prepared to contribute to the advancement of the scientific enterprise in the United States.

Testing in American Schools: Asking the Right Questions? (Office of Technology Assessment, 1992) addresses the major issues related to reforming assessment in education in all subjects and for all students, including LEP students.

Conclusion

The Office of Bilingual Education and Minority Language Affairs of the U. S. Department of Education supports long term and short term training programs to assist teachers in reforming instruction for LEP students to better meet the national education goals and the national and state standards for science instruction. The National Science Foundation supports professional enhancement projects for teachers who teach science and mathematics. Some of these efforts are specifically directed toward the preparation and enhancement of those who teach science to LEP students. It is a challenge to both the science education and bilingual education profession to join forces to increase their efforts in supporting the forms in instruction of LEP students described in this monograph. These students specifically, and the nation more generally, can ask for no more of a significant commitment.

As Haycock and Duany (1991) stated, in *Developing the potential of Latino students* (one article in a series of "Special Reports on Minority Education" appearing in the January 1991 issue of *Principal*), "*We must stop wasting the school years of the nation's fastest growing minority.*" We can only add that the need for sustained reform in teaching science to LEP students is critical. Everyone involved in science and mathematics education must work diligently to produce the reform required to improve science teaching and learning for LEP students, as well as for their teachers. Students' ambitions must not be crippled by lack of will and commitment on the part of the professionals responsible for the education of all students.

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Romance, N., & Vitale, M. (August 1992). A curriculum strategy that expands time for in-depth elementary science instruction by using science-based reading strategies: Effects of a year-long study in grade four. *Journal of Research in Science Teaching*, 24(6), 545-554.

Science and mathematics briefing book, Volume III. (1992). Chapel Hill, NC: Horizon Research, Inc. (available through the National Science Teachers Association, Arlington, VA).

Special parent section. (1991, Fall). *OERI Bulletin*. Washington, DC: U.S. Department of Education.

Sutman, F., Allen, V., & Shoemaker, F. (1986). *Learning English through science*. Arlington, VA: National Science Teachers Association.

Sutman, F., et al. (1977). Self-esteem and vocabulary, through photography for visual dependent children. *Science and Children*. Arlington, VA: National Science Teachers Association.

Technology in the science curriculum K-12. (1992, Spring). *California Technology Project Quarterly*.

U.S. Department of Education, National Center of Education Statistics, OERI. (1992). *The condition of education*. Washington, DC: Author.

U.S. Department of Education. (1993). *Application for grants under the office of bilingual education minority language affairs*. Washington, DC: Author.

U.S. Department of Education, Office of the Secretary. (1991). *The condition of bilingual education in the nation: A report to the Congress and the President*. Washington, DC: Author. (ED 335 945).

Von Glaserfeld, E. (1988). *Cognition, construction of knowledge and teaching*. Arlington, VA: National Science Foundation. (ED 294 754).

Yager, R. (1991, Sept.). The constructivist learning model. *The Science Teacher*. Arlington, VA, National Science Teachers Association.

Appendix A

Sampling of Publications that Support Reformed Science Teaching

Azios, M., et al. (1975). *Teaching English as a second language: A handbook for science*. (Curriculum bulletin No. 75C8M5). Houston: Houston Independent School District. (ED 176 530).

(a course guide especially useful for the secondary level)

Baker, J. *Microcomputers in the classroom*. Fastback No. 124. Bloomington, IN: Phi Delta Kappa Educational Foundation.

(short, effective introduction to the utilization of computer technology instruction)

Berlin, D. & White, A. (1991). *A network for integrated science and mathematics teaching and learning*. Columbus, OH: The Ohio State University.

(description of resources available for developing instruction that integrates mathematics and science)

Bridge to communication: English for LEP students. (1989). San Diego, CA: Santillana Publishing Company, Inc.

(series of workbooks and homework activities in ESL; also a parallel series in science and social studies)

Building skills to say "no" to drugs and feel good about it. (1991). Charlotte, NC: The Drug Education Center.

(series of eight lessons including learning activities, for third and fourth graders)

Burdette, J., Conway, L., Ernst, W., Lanier, Z., & Sharpe, J. (1988). *The manufacture of pulp paper: science and engineering concepts*. Atlanta, GA: Tappi Press.

(combination of information about and student activities related to making paper)

Burns, J. (1981). *An introduction to assessment and design in bilingual program evaluation*. Los Angeles, CA: CRESST, University of California at Los Angeles.

(information useful to professional seeking to develop effective assessment of student learning practices; also useful to evaluators of programs for bilingual students)

Chang, S. & Quinones, J. (1978). *Bilingual-bicultural curriculum guide (science) for grade three*. New York, NY: ERIC Urban Education Center. (RIEMAR82, ED 209 018).

(topics, activities and illustrations that can be copied)

Delta Science Modules. (1992). Hudson, NH: Delta Education, Inc.

(services of 40 modules giving teaching directions, hands-on materials and evaluation procedures for the elementary level; heavily reading based)

English skills for life sciences: Problem solving in biology. (student version) (1990). Los Angeles, CA: Center for Language Education and Research, California State University.

(manual portion of a series of materials designed to reinforce essential concepts in the sciences through interactive, language-sensitive, problem-solving exercises emphasizing cooperative group instruction; workbook based)

Fox, S., & Best, N. (1981). *Primary bilingual science activity handbook: Grades K-2.* (RIEJAN82, ED 206 449)

(60 science activities in Spanish and English, 20 each for kindergarten through second grade levels in all areas of science)

From gatekeeper to gateway: Transforming testing in America. (1990). Chestnut Hill, MA: Boston College, National Commission on Testing and Public Policy.

(guidelines for restructuring assessment of student learning in order to better utilize the nation's human talent)

Goal post. (1991). New York, NY: National Football League Properties.

(series of football cards and teachers' guides that contain science, language and social science activities couched in a sports format)

Hands-on: Science, social studies and reading/thinking activities books. (1988-1994). Annapolis, MD: Alpha Publishing Company, Inc.

(guide-books that give students step-by-step directions; included are biology, chemistry and earth science research activities that can be used as supplemental instructional material)

Heltne, P., & Marquardt, L. (Eds.). (1987). *Science learning in the informal setting.* Chicago, IL: The Chicago Academy of Sciences.

(examination of learning processes in children, role of evaluation in science centers, critical scientific concepts, and school-science center partnerships; serves as a backdrop for developing informal science activities for LEP and other students)

Horizons plus. (1991). Morristown, NJ: Silver Burdette and Ginn Publishers.

(complete science curriculum, including a basal science textbook, readers and connection activities for kindergarten through sixth grade levels)

Malcolm, S., & Sosa, M. *Science books and films: best books for children, 1988 - 1991.* Washington, DC: American Association for the Advancement of Science.

(ongoing annual publications that provide critical reviews of the scientific accuracy and other features of a variety of science instructional materials; includes readers, texts, films, software of all types for all educational levels; also publishes *Best Children's Science Books*)

Milla, H. & Clyde J.A. (Eds.). (1990). *Portraits of whole language classrooms: Learning for all ages.* Portsmouth, NH: Heinemann Educational Books, Inc.

(directions for whole language learning using a variety of subjects including science; an excellent resource)

Mitchell, R. (1992). *Testing for learning: How new approaches to evaluation can improve American schools.* New York, NY: The Free Press.

(down-to-earth description of reform in assessment of student learning development and practice; written by the Associate Exec. Director of the Council on Basic Education)

National Council of Teachers of Mathematics. Commission on Standards for School Mathematics. (1989). *Curriculum and evaluation standards for school mathematics.* Reston, VA: Author.

National geographic educational technology catalog. (1992). Washington, DC: National Geographics Society.

(descriptions of Kids Network, an integrated science-social science program, various instructional programs presented by CD-ROM and various software kits and video disks of science instructional materials for kindergarten through twelfth grade levels; teachers' orientation materials on video disk are available)

NSTA science education suppliers. (1995). Arlington, VA: National Science Teachers Association.

(annual supplement to *The Science Teacher* magazine and other NSTA publications; includes a listing of suppliers of materials, equipment, texts, and supplementary materials with references to the science content and school levels most appropriate for these materials)

Northcutt, L., & Watson, D. (1986). *Sheltered English teaching handbook.* Carlsbad, CA: Northcutt, Watson & Gonzalez Publishing Company.

(description of sheltered English and the approach to it in teaching, including the various instructional strategies that enhance it)

(The) *Ombudsman: A program that works.* (1975, 80, 81, 85, 87, 91). (Revised and expanded). Charlotte, NC: The Drug Education Center, Inc.

(manual for a program of instructional and training materials for the elementary and secondary levels described as "working together to prevent alcohol and other drug abuse." Also see *I'm Special* and *Whoa! A Great Way to Say No.*)

Pierce, L. V. (1987). *Cooperative learning: Integrating language and content-area instruction.* Washington, DC: National Clearinghouse for Bilingual Education.

(based upon Finding Out/Descubrimiento; applies cooperative group instruction to LEP needs)

Presidential awards for excellence in science and mathematics teaching. (Best Lessons). (1991). Arlington, VA: National Science Teacher's Association.

(summaries of the "best lessons" presented in the award winners' language; earlier editions extending from 1986 are available)

Project Maine: Career awareness and native language assistance for secondary school students. (1988). Portland, ME: Portland Public Schools.

(students use native language and English to learn about career opportunities, to explore their own interests and goals and to select meaningful courses of study)

Science education news. Washington, DC: American Association for the Advancement of Sciences

(newsletter directed to science educators and science teachers)

Science snackbook: Teacher-created versions of Exploratorium exhibits. (1991). San Francisco, CA: The Exploratorium.

(complete instructions on how to build simple, inexpensive classroom versions of over 100 Exploratorium interactive exhibits)

Science teachers action book. (1992). Alexandria, VA: MGI Books.

(references to free and inexpensive sources of materials for science instruction)

Science weekly. Silver Springs, MD: Science Weekly, Inc.

(weekly newsletter using simple English language and pictures to describe hands-on science activities)

Smoradin, T., and Marganoff, B. (1986). *Computer and video instructional materials resource guide: Elementary science.* Trenton, NJ: New Jersey State Department of Education.

(curriculum guide for use by school districts)

Sutman, F., Bruce, M., May, P., McConaghy, R., & Nolt, S. (1990). *All about magnets: An IALS teacher's guide.* Philadelphia, PA: Temple University.

(integrated science, math, English language instructional package, tested with students for project SMILES)

University of California, Berkeley, Lawrence Hall of Science. (1991). *A parent's guide to great explorations in math and science. (GEMS).* Berkeley: Author.

(excellent hands-on science, based instruction program developed through the Lawrence Hall of Science)

Van Cleaver, J. (1991). *101 easy experiments that really work.* (physics and earth science). Somerset, NJ: John Wiley and Sons, Inc.

(source of experiments that can be woven or developed into an integrated series of science-driven lessons)

Video field guide series. (1989). Odum, GA: Anhinga Production.

(field guides to animals, presented on video tapes; helps to reduce dependence on language in learning)

(The) *WICAT integrated learning system.* (1991). Orem, UT: Wicat Systems, Inc.

(materials to assist teachers in integrating science and other subjects; hard copy and computer software materials. The science is not the strongest component of these instructional materials)

Wonder science: El mundo marovilloso de la ciencia. (1991). Washington, DC: American Chemistry Society.

(physical science activities for children and adults to do together)

References Related to Policy and Program Design

Assessment against new attainment targets in mathematics and science, SEAC Recorder, London, England: SEAC Information Section.

(newsletter reports advancements in the practice of school level assessment of student learning in math and science. It also reports on developments in test construction and use with ESL students within Great Britain)

Berney, T., & Hammack, F. (1989). *Project master*. (RIEAUG90, ED 317 077). New York, NY: ERIC Urban Education Center.

(description of the methodologies for the Bilingual Instruction in Literary Education project (MOBILE) that served native Spanish and Haitian Creole/French speakers; for high school level; supplementary instruction in ESL and math, science and social studies)

Brennen, R. (1992). *Dictionary of scientific literacy*. Somerset, NJ: John Wiley and Sons, Inc.

(lists and definitions of many terms used in science instruction. It serves as a resource for those who are beginning to teach science and as a dictionary for more advanced students among LEP students)

(The) *Coca-Cola valued youth program: A national network of schools*. Intercultural Development Research Assoc., Center for the Prevention and recovery of Dropouts; 5835 Callaghan Rd., Suite 350, San Antonia, TX 78228

(description of a cross-age, multicultural tutoring program designed to use potential dropouts as tutors of younger students, partially funded through the Office of Bilingual Education and Minority Language Affairs, U.S. Department of Education, Washington, DC)

Connect. Brattleboro, VT: Teachers' Laboratory.

(newsletter for teachers that supports integrated hands-on learning activities)

Contamos con ustedes, mathematics y ciencias, padres e hijos. (1989). Washington, DC: American Association for the Advancement of Science.

(guide for Spanish-speaking parents on how to assist their children in learning math and science, available both in Spanish and English)

The corporate council for mathematics and science education. (1991). Washington, DC: Corporate Council for Mathematics and Science Education Coordinating Council for Education.

(description of the Council's national efforts to improve science education for all students)

Crandall, J. (Ed.). (1987). *ESL through content-area instruction: mathematics, science and social studies* Washington, DC: ERIC Clearinghouse on Language and Linguistics. (BE 016132). (See especially: Kessler, C., and Quinn, M. ESL and Science Learning.)

(collection of essays describing some of the ways in which English language instruction is being integrated into the three subjects for kindergarten through secondary grade levels)

Crawford, J. (1992). *Hold your tongue: Bilingualism and the politics of English only.* Reading, MA: Addison Wesley Publishing Co.

(focus on weaknesses in the English -only movement in the U.S.)

Deal, T. & Peterson, K. (1990). *The principal's role in shaping school culture.* Washington, DC: Superintendent of Documents, Government Printing Office.

(case histories of successful attempts to improve school culture at various levels and in various environments, including urban settings)

Dealing with diversity. (1989, March). *Educational Leadership*, 46(6), 2-94.

(special issue on student diversity in school settings; includes many useful articles on whole language, science, remediation, the peer and the minority student, gifted students)

Directory of outreach programs of the chemistry community. (1991). Washington, DC: American Chemical Society.

(monograph providing information about the many services provided to students, teachers and institutions through the Division of Chemical Education. These are offered by private companies, local ACS sections, and by chemistry departments at universities)

Educating scientists and engineers, grade school to grade school. (1989). Washington, DC: Congress of the United States, Office of Technology Assessment.

(issues that must be considered in educating enough scientists for the nation's future well-being)

Education that works: An action plan for the education of minorities. (1990). Cambridge, MA: MAssachusetts Institute of Technology.

(recommendations for educational practices at all levels)

Fathman, A., Quinn, M., & Kessler, C. (1992). *Teaching science to English learners, grades 4-8.* Washington, DC: National Clearinghouse for Bilingual Education.

(summaries of principles underlying effective instruction with some examples of science demonstrations)

Flaxman, E., & Inger, M. (1991). *Parents and schooling in the 1990's.* Washington, DC: U.S. Department of Education, OERI, ERIC Educational Resources Information Center. ERIC Review, 1, (3).

(article in a hard copy monograph distributed through ERIC. This issue of the ERIC Review includes many additional sources of useful information published both in English and Spanish)

Fleischman, H., & Hopstock, P. (1993). *Descriptive study of services to limited English proficient students. Volume I.* Washington DC: US Department of Education.

Forum: Newsletter of the national clearinghouse on bilingual education. Washington, DC: National Clearinghouse on Bilingual Education.

(monthly newsletter of useful information concerning available resources for teachers of all subjects to LEP students; includes networking information, reference to hard copy instructional and research information and meeting date notices)

Goals 2000: Educate America. (1993). Washington, DC: U.S. Department of Education.

(report of national goals for education with successive newsletter that follows the progress of the federal government's emphasis on educational reform. As of 1994 has become federal law.)

Grand challenges: High performance computing and communications. (1992). Washington, DC: Federa' Coordinating Council for Science Engineering and technology c/o National Science Foundation.

(recommendations related to accelerating the availability and utilization of next generation high performance computers; see especially the section "Technology Links Research to Education", p.64)

Hands-on math and science learning. Cambridge, MA: Technology Education Research Centers.

(newsletter of TERC; the Spring 1991 edition for example, includes the following cogent article: "Getting Connected to Science", which considers the role of science-technical language)

Hafner, A., & Green, J. (1992). *Multicultural education and diversity: Providing information to teachers*. Los Alamitos, CA: Southwest Regional Education Laboratory.

(series of references on the status of LEP students in the Southwestern states. Also directories of post secondary courses and training opportunities for teachers of LEP students in these states)

Hopkin, K. (1991, November 25). Fighting for our future: Science and math education for the 21st century. *Business Week*. (Special advertising section). New York, NY: McGraw Hill Publications.

(excellent detailed analysis of the state of science instruction and learning in the U.S. as well as appeals to correct societal support problems with recommendations on how to do this)

Learning science: The international assessment of educational progress (IAEP). (1992). Princeton, NJ: Educational Testing Service.

(report on comparative results of test scores on the IAEP science test; a companion report, *Learning Math*, is also available)

Majumdar, S.K., et al (Eds.). (1992). *Science education in the United States: Issues, crises, and priorities*. Easton, PA: The Pennsylvania Academy of Science.

(presentations outlining the issues facing science teaching at the school level with recommendations for reform)

Maley, D., & Smith, K. (Eds.). (1991). *Aerospace resources for science and technology education*. Reston, VA: International Technology Education Association.

(examples of programs nad activities in schools in the area of aerospace-science technology education, grades K-16; such activities serve as motivation for improved science-technology instruction nad learning through group activities)

Matyas, M., & Malcolm, S. (Eds.). (1991). *Investing in human potential: Science and engineering at the crossroads*. Washington, DC: American Association for the Advancement of Science.

(results of a study conducted to examine the efforts made by U.S. institutions of higher education to increase the participation of women, non-Asian minorities and the physically disabled in science and engineering)

Miller, J., & Green, H. (1992). *The impact of parental and home resources on student achievement and career choice.* DeKalb, IL: Northern Illinois University.

(data excerpted from the larger volume *Longitudinal Study of American Youth*, research supported by the National Science Foundation; data related to cause and effect is presented as background on educational accomplishments)

Mishler, C. (1982). *The integration of experimental science with language arts instruction in the elementary curriculum.* New York, NY: ERIC Urban Education Center. (RIEJAN83, ED220275)

(description of an experiment with results that support content integration in instruction)

Mulhauser, F. (1990). *Reviewing bilingual education research for Congress.* Washington, DC: National Clearinghouse on Bilingual Education. (BE107803)

(report indicating the need to retain native language in the instruction in ESL and in other school subjects)

(The) *National Center for Improving Science Education.* (1991). the national center for improving science education: summaries of reports. (reports include) Getting started in science: A Blueprint for Elementary School Science Education; Getting Started in Science: A Blueprint for School Science in the Middle Years (1990); The High Stakes of High School Science (1991). Andover, MA: Author.

(reports that develop a rationale and offer guidelines for school science for all children)

National Research Council. (1996). *National science education standards.* Washington, DC: Author.

NSTA reports. Washington, DC: National Science Teachers Association.

(newsletter that includes sources of free and inexpensive instructional materials for science)

OERI bulletin. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement.

(newsletter designed to keep educational leaders up-to-date on educational reform. For example, the Winter 1991-'92 issue includes the following articles: "A Look at Education Reform Efforts", "Linking Pre-school and School", :libraries' Foreign Language Collections Get Boost", "Determining What Students Should Know About...Science", "Access ERIC", and "OERI Phone List")

Planning for the very young: Excellence and equity in preschool activities at science museums. (1990). Boston, MA: Association of Science-Technology Centers, The Children's Museum of Boston.

(recommendations for how museums can be effectively used to instruct in science at early ages)

Preparing for America's information age: Technology in education. (1990). Eugene, OR: International Society for Technology in Education.

(recommendations for assuring that all underserved students receive technology instruction)

Project nuevo horizontes. (1990). Brooklyn, NY: New York City Board of Education (available through the National Clearinghouse on Bilingual Education in Washington, DC).

(report on a funded project designed to provide LEP students with academic and other support services for ensuring graduation and mainstreaming. Included are projects in instruction in science, ESL)

Project future newsletter. (1992). Washington, DC: American Association for the Advancement of Science.

(newsletter that provides information about the inservice program in science for teachers of LEP students in Chicago; project materials include "Notes for Parents" and "Parent Enlightment"; newsletter includes information about science instruction as well as bibliographies of reading and activity science books)

Quality Education for Minorities Network (descriptive flier), 1818 K Street N.W., Suite 350, Washington, DC.

(description of an organization that monitors, evaluates, supports, and disseminates information, including by conducting conferences, about successful educational changes for minority advancement)

Ramirez, J., Yuen, S., & Romey, D. (1991). *Longitudinal study of structured English immersion strategy early-exit and late-exit transitional bilingual education programs for language-minority children.* San Mateo, CA: Aguirre International.

(report of the pros and cons of each approach with support from subject integration and hands-on experiences in instruction)

Rodriguez, I., & Bethel, L. (1983). An inquiry approach to science and language teaching. *Science teacher,* 20(4), 291-96.

(research with positive thrust on the effectiveness of the inquiry approach to science and language teaching among Mexican-American third graders)

Rosebery, A.S., Warren, B., & Conant, F.A. (1990). *Cheche Konnen: Appropriating scientific discourse: Findings from language minority classrooms.* Cambridge, MA: BBN Labs. (ED 326 058)

(working research and development paper describing one activity of the CheChe Konnen project that brir science and English language to classrooms of LEP students; report on a study of the effects of science on learning)

Roth, M. (1990). *Collaboration and constructivism in the science classroom.* New York, NY: ERIC Urban Education Center. (RIESEP90, ED 381 631)

(paper discussing basic beliefs and central metaphors of teaching, case histories and teaching events; heuristic diagrams are provided)

Science and children. Arlington, VA: National Science Teachers Association.

(journal directed specifically to elementary school teachers who seek ideas, approaches and materials for science instruction. Th journal can be obtained as part of NSTA membership)

Science and mathematics education programs that work. (1993). Washington, DC: U.S. Department of Education.

(description of National Diffusion Network validated programs; also a companion volume in mathematics)

Science Framework for the 1994 National Assessment of Educational Progress. (1993). Washington, DC: National Assessment Governing Board, Educational Testing Service.

(monograph, in its final form, of the framework for the present national assessment in science learning)

The science teacher. Arlington, VA: National Science Teachers Association.

(monthly journal that is an excellent source of ideas for classroom instruction in science. The journal also indicates sources of materials and texts. The journal is obtained as part of NSTA membership)

Stolfoff, D. (1989). *Limited English proficient students and mathematics and science achievement: Strategies for success practiced within the California Academic Partnership Program projects*. New York, NY: ERIC Urban Education Center. (RIEFEB90, ED 310 923)

(description of tutoring and counseling strategies, parental involvement and team teaching-curriculum development in mathematics and science instruction for LEP students as part of the CAPP project)

Technical assistance for special populations programs. (newsletter of the National Center for Research in Vocational Education). Berkley, CA: University of California.

(newsletter describing teacher-training materials through the TASPP database. The December 1989 edition, for example, indicates a number of selected resources on developing vocational programs for individuals with limited English (language) proficiency)

Tinker, R., & Kapisovosky, P. (Eds.). (1991). *Consortium for educational telecomputing: Conference proceedings*. Cambridge, MA: Technology Education Research Centers.

(report of a conference that recommends procedures to be followed to allow for use of large-scale implementation of computer utilization in instruction. Especially for Lep students)

U.S. Department of Education. (1990). *Report of the U.S. department of education task force on mathematics and science education*. Washington, DC: Author.

(report of the many sources for funding science and mathematics instruction available through the USED)

U.S. Depart.nent of Education. (1994). *A resource manual for the federal education department*. Washington, DC.

(valuable resource of potential funding for support in many areas of educational need including: bilingual education, Chapter I programs for neglected and delinquent youth, drug free schools and communities, education for homeless children and youth, Eisenhower mathematics and science education grants, English literacy program for adults, graduate assistance in areas of national need grants to institution to encourage minority participation in graduate education, inexpensive book distribution, language resource centers, library career training, mid-career teacher training, minority science improvement, National Diffusion Network (curriculum materials), school drop-out demonstration assistance, Secretary's fund for innovations in education (technology, health and alcohol abuse), talent search (for high school completion), Upward Bound and women's educational equity. This publication may be substantially revised in 1996 due to potential reductions in the Federal budget allocated to education.)

Appendix B

AN INTEGRATED ACTIVITY LEARNING SEQUENCE (IALS) IN SCIENCE FOR UPPER GRADES (7-12)

Introduction

This IALS is designed to integrate science and mathematics and English language instruction for use in the upper grades with LEP students. The format of the IALS is such that it can be used as a guide for teachers. This IALS differs from the one included in Section II in that it is divided into discrete lessons rather following a columnar format. The content of this IALS addresses the behavior of matter and it will require at least 6 to 8 lesson sessions. The suggested, as indicated below, is for five groups, each with five students.

- 25 pencils
- 25 work sheets
- 5 - 5 gallon plastic fish tanks
- 5 cylindrical hollow dishes that will fit inside of fish tanks
- enough clay to weight down each dish
- water
- masking tape
- 5 metric rules
- 10 100 cm^3 plastic graduated cylinders
- a quart or liter of denatured alcohol
- paper towels
- bottle of inexpensive perfume
- ball of string
- scissors
- English/metric measuring tapes
- thumb tacks
- chalk
- 1 to 5 inexpensive metric balances

TEACHERS' GUIDE TO THE IALS: HOW DOES MATTER BEHAVE?

Lesson One: What Do You Already Know About Matter?

This is a pretest that can be used to determine where students are in their readiness for the IALS. The answers are in parentheses. If need be, give student groups opportunity to measure and then to calculate each answer.

A. Fill in the missing numbers and unit:

1. 0.5 cm = (50) mm

2. 5 cm^2 = (2500) mm2

3. 352 cm^2 (area)
x 21 cm (length)
(7392 cm^3)

4. one meter (1m) is the same length as about (39) in

B. Write down the words below in alphabetical order. Use a complete sentence to define each word.

matter	water
centimeter	air
displace	space
particles	moving

1. (air)
2. (centimeter)
3. (displace)
4. (matter)
5. (moving)
6. (particles)
7. (space)
8. (water)

(Definitions will vary)

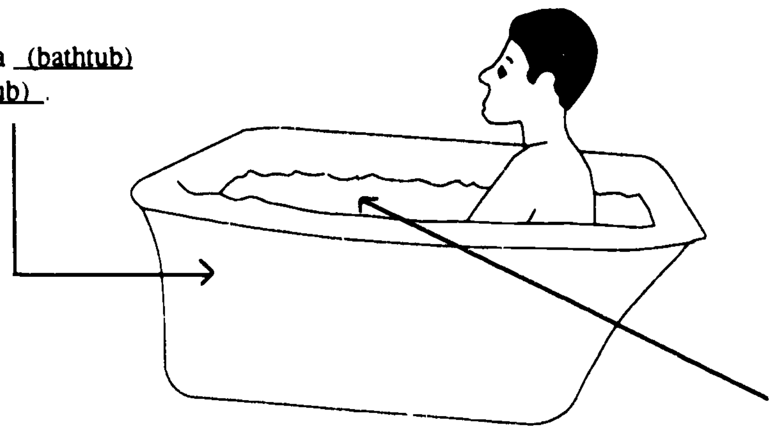
If the class has difficulty completing the above language activity help them to do so.

Following this exercise, give each instructional group opportunity to read and discuss the following material, and then do the above language activity over.

C. You always place water into a bathtub when you take a bath. What is the most amount of water you could put into the tub? When would you place too much water in the tub? Explain. Your group will talk about these two questions. Each group member will write down answers decided upon by the group. One member of the group will tell the rest of the class what answers the group agreed upon and why.

This is ___(you)___ in the bathtub or tub.

This is a _(bathtub)
or a _(tub)_.



This is called the (water level).

Talk about each word below. Write a definition for each word or group of words.

bathtub	water	
you	rises	
water level		(definitions will vary)

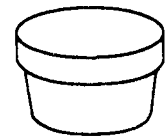
Answer this question: What happens to the water level when you sit in the tub?
The (water level rises or goes up) when I sit in the tub.
If there is lack of understanding among some of the students, ask those students who take baths to report back to their group what happens to the water level when they take their next bath.

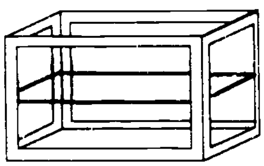
Lesson Two: A Sunken Boat

A. Each group will carry out the following activity and report their results to the entire class. The teacher and teacher's aide or assistant (if available) should move about the class helping each group conduct the investigation; but not tell the answers. Be certain that English language is used and then understood.

The problem that we will investigate is: What happens to the level of water in which a boat is floating, when the boat sinks? To do this investigation, you will need the materials shown below. Have students write down the names of the objects in each diagram using English words.

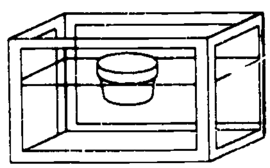
This is a drawing of a (dish or boat).



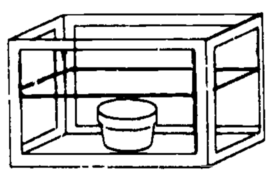


This is a (fish tank) or a tank.

It has (water) in it.



The boat is (floating) in the water in the tank.



I pushed the boat so that it (sank) to the bottom of the tank.

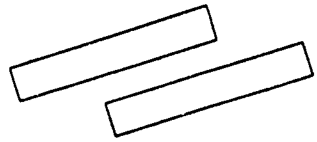
Each student in a group is given a sheet with the above diagrams drawn on it. Members of each group discuss and then agree on how to respond to each part of this activity.

Draw a line around the tank to indicate if the water level raises or lowers or remains the same when the boat sinks. Be certain that the drawing is correct. (The water level will be lower.) Before pushing the boat to make it sink ask groups to guess what will happen.

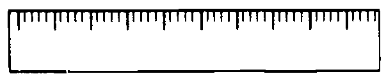
We believe that the water level (answers will vary) when the boat sinks because (will vary)

Below are drawings of the material used to carry out the above investigation.

(Clay)



(two) pieces of masking tape
(used to mark water level)



a metric (ruler)
(used to measure volume of displaced water)

C. Now, your group can find out what caused the water level to change. (drop). One member of each group will explain to the rest of the class why the water level dropped. To help your students answer why, turn the boat upside down and push it into the tank of water. Keep the boat submerged and slowly top the boat so that it slowly fills with water. Students will notice bubbles of air escaping.

Write down how your group explained the drop in the water level.
(The space in the boat was filled with air. When the boat sank this space became filled with water. This caused the water level to drop.)

Save your tank of water for the lesson three. Leave the masking tape markers on the side of the tank.

Lesson Three: Review How Much Space or Volume?

Notice the two levels of water marked in lesson two. How can you measure the volume of air that was originally in the boat? (Measure the change in height of the water in cm as the first step in finding this volume.)

The change in the height of the water (l1) _____ cm.

The total space was contained air but now contains water is called the volume of air that was displaced by the water. Water from the tank took the place of the air or displaced this volume of air. You can find this volume by measuring the three different lengths shown in the drawing: l1, l2, l3. Measure l2 and l3 in centimeters (cm).

l1 (distance between water levels)	___ cm (height) (h)
l2 (of the tank)	___ cm (length) (l)
l3 (of the tank)	___ cm (width) (w)

Multiply l2 X l3 to find the area of the tank.
l2 X l3 = area
___cm x ___cm = ___ cm^2 (area) Now multiply the area by l1.

area ( ) x l1 = ___ cm^3 (Answers will vary)

Each group should discuss among its members how to find the volume of air displaced by the water as the boat sank. Be certain that every member of each group understands how to do this. To accomplish this may require considerable discussion with some input from you as you move from group to group.

E. Describe in writing how your group found the volume of the air that was displaced by water as the boat sank. One possible way is described here. We found the volume of displaced air by measuring (each of the three lengths in cm) l1, l2, l3 of the tank. Then we multiplied those lengths. This gave us the volume in cm^3.

F. There are other ways to measure the volume of this displaced air. One way is to use a measuring cylinder. Talk about how to use a measuring cylinder to find the volume of the displaced air. Using complete sentences, write down the procedure below: (Give students help as needed.)

We can measure the volume of displaced air by using the measuring cylinder.
(Fill the boat with water. Then pour this water into the measuring cylinder. Read the volume of water (or air) directly.)
Now actually measure this volume following the procedure that you wrote above. Use the space below for any calculations you might do.

Calculations

Below write down the volume of displaced air determined by each of the two methods. Compare your results.

Volume of displaced air — First method ____ cm^3 (volume)
Second method ____ cm^3 (volume)

Do these volumes agree? Why? Why not? Allow the groups ample time to discuss the results. (Results will depend upon how accurately each group measured. Using a too thick-walled plastic boat will produce some error.)

This volume is the amount of space occupied by the air in the boat.

Write a sentence or two below to describe why the results of the two methods agree or disagree.
Answers will vary

Lesson 4: Problem Solving

A. Each person in a group will complete one of the following problems. Then explain how he/she completed the problem. Students will ask for help as needed. Use a drawing to help solve each problem.

1. Calculating A Displaced Volume. — A container, filled with 1000 cm^3 of air, is floating on the surface of a tank of water. When it sinks, the water level drops 10 cm (11). The tank is 10 cm in length (12). From this information find out how wide (13) is the tank? ________ cm. (answer)

2. Comparing Lengths — Use a ruler to find out how many centimeters make up one inch. How many centimeters make up one foot? How many centimeters make up one yard? How many millimeters make up five centimeters? Write down each answer below.

(2 1/2 or 2.5 cm/in (30 cm/ft) (90 cm/yd) (50 mm/5cm) (answers: slightly over in each case)

Each group should have a spokesman who will describe to the rest of the class how they arrived at the answer.

3. Rearrange the following 12 words to place them in alphabetical order.

		Alphabetical Order	
• tank	• measure	1. (calculate)	7. (multiply)
• dispersed	• multiply	2. (centimeter)	8. (procedure)
• volume	• divide	3. (dispersed)	9. (tank)
• centimeter	• calculate	4. (divide)	10. (volume)
• water	• procedure	5. (level)	11. (water)
• level	• yard	6. (measure)	12. (yard)

Define any 5 of the above words: (Students may need assistance in developing these definitions.)

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________

4. Write three sentences below. Each sentence is to contain two of the above words.

(1) ______________________________

(2) ______________________________

(3) ______________________________

5. Now each group should work together to complete the following activity:

Matching Math the symbols and words in column A with those in column B.

A	B	Answers
(a) displace	(1) cubic centimeter	(4)
(b) cm	(2) centimeter	(2)
(c) cm^3	(3) 4 in x 3 in = 12 in2	(1)
(d) in	(4) take the place of	(7)
(e) in^2	(5) 12 in2/ 4 in = 3 in	(6)
(f) divide	(6) area	(5)
(g) multiply	(7) about 2.5 cm	(3)

Each group reports to the class the answers that it agreed upon. Do the groups agree? Disagree? Discuss why? Why not?

Lesson Five: Mixing Matter Together

1. Supply each group with two 100 cm^3 measuring cylinders; one filled with 50 cm^3 of water; the other with 50 cm^3 of denatured alcohol. Assist each group in measuring and then mixing these two volumes into a third 100 cm^3 measuring cylinder.

Before mixing the two equal volumes of liquids, predict what the combined volume of these two liquids will be. (Prediction probably will be)

50 cm^3 (water + 50 cm^3 (alcohol) = 100 cm^3 (combined liquids)
(should be)

Now, in writing give an explanation for why the answer did not come out as you expected. Look up the definition for the word particle in a dictionary. Your teacher will help do this. Use the plural (particles) in your explanation. The definition for particle is:

____

____

____

The explanation is that: the particles of water and alcohol mix or more in between each other. Therefore, they take up less space than expected.

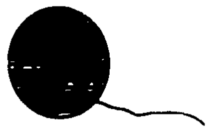
Work in your group to place the following ten (10) words in alphabetical order. Read about each word in your science text or reference book. Then orally use each word in a sentence. Now write down these sentences.

New Words		Alphabetical List	
• liquid	• particle	(alcohol)	(mix)
• procedure	• water	(describe)	(particle)
• measure	• alcohol	(explain)	(procedure)
• volume	• gently	(gently)	(volume)
• describe	• mix	(liquid)	(water)
• explain		(measure)	

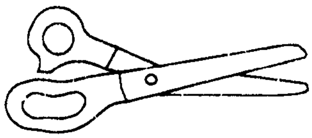
Lesson Six: Matter On The Move

This investigation is to be completed by all members of the class working together. However, each group will be responsible for one part of the investigation. Each group will report orally to the rest of the class what it has done.

You will need:

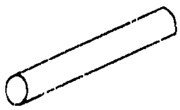


- a ball of string

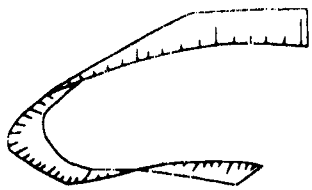


- scissors
- thumbtack

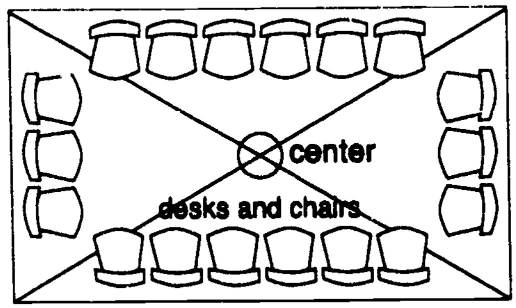
- bottle of perfume or a bottle of household strength ammonia



- piece of chalk
- metric tape

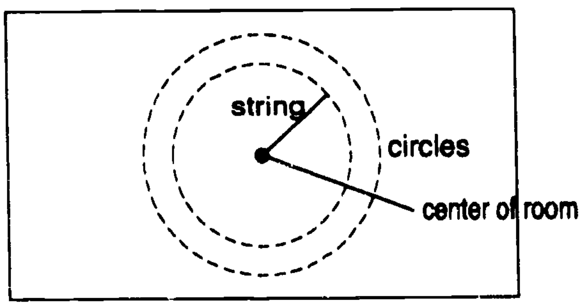


A. Groups I and II will now move all of the desks and chairs around the outside walls of the classroom. 1/3 of the desks and chairs are to be placed along each of the longest walls. 1/6 of the desks and chairs are to be placed along each of the shortest walls. Students will figure out or calculate the actual number of desks and chairs to be placed correctly.



Looking down on the floor of the classroom

Group III will figure out a way to find the exact center of the classroom floor and mark that center with an X. Lay two metric tapes or two long pieces of string from opposite corners of the room. Where they cross will be the center. Use a piece of chalk to mark this center with a big X. (Creative students may suggest other methods.)



classroom floor

Group IV will figure out a way to draw a circle with a radius of about 100 cm on the classroom floor. The center of the room should be the center of the circle. (Do this using a piece of chalk tied to one end of a 150 cm length of string.) Students should draw the circle.

Group V will figure out a way to draw a circle with its center also at the center of the room and with a radius of 200 cm. (Do this using a 200 cm length of string tied to a piece of chalk.) The teacher will help. (Use different radii depending upon the lengths (11) and (12 of the classroom).

Group VI will keep the time during this investigation. They also will write down the data that is collected. Count time in seconds by slowly saying 1-1000, 2-1000, 3-1000, 4-1000, etc.

B. Now, have the class calculate how many students are in group VI? How many students does this leave to sit around each of the two circles? One fourth (1/4) of the total number should sit around the smaller circle; and one-half (1/2) of the total number of students should sit around the larger circle. Each student should sit facing a classroom wall.

The teacher will place a bottle of inexpensive perfume at the center of the room which is at the center of the two circles. Now he/she will open the bottle of perfume. A student from Group VI (the timekeeper) will count 1-100, 2-1000 ... Each time a student in each circle first smells the perfume he or she will raise his or her right hand. Timekeepers (from Group VI) will record, on the chalk board, the number of seconds that go by before each student raises a hand. One recorder will write down the times for the inner or smaller circle. A second recorder will do the same thing for the outer or larger circle.

Record of Times

Smaller Circle A Students	Time (Seconds)	Larger Circle B Students	Time (Seconds)
1		1	
2		2	
3		3	
4		4	
5		5	
6		6	
		7	
		8	
		9	
		10	
		11	
		12	
Totals		Totals	

Calculations for determining average times.

C. Now calculate the average time that it took the perfume to reach the inner circle of students.
Find the average time that it took the perfume to reach the outer circle of students. (The teacher will assist here.)
To find these averages add the total times & divide by the number of students.
The average time that it took the perfume to reach the inner circle was _____ seconds.

The average time it took the perfume to reach the outer circle was ____ seconds.
Why are these two times different or why are they the same?

Now ask each group to write down an explanation for why there was a difference in average time. (The particles of perfume moved further to reach the students in the outer circle. If times come out the same it may be due to errors in recording individual times.)

Explain how the liquid perfume got from the bottle to the student's nose. To do this it will help to remember the definition of ... ord particle and to remember its use in explaining what happened when alcohol and water mixed. Wri... ...n the explanation.
(Perfume particles esca..ed between the air particles. They eventually reached students' noses in each of the circles.)

Now find out the average speed with which the perfume particles moved through the classroom to each circle. (To do this, divide the distances in cm from the center of the circle to the circle. The divide this distance by the average time that it took the particles to move to the students in the circle. This is the average speed of the perfume particles. Speed is how fast something moves.)

Divide

$$\frac{\text{distance (in cm.) from the center of the smaller circle to the circle}}{\text{average time (in sec) it took the particles to move this distance}} \quad \frac{= \text{cm}}{= \text{sec}}$$

COMPARE THE RESULTS

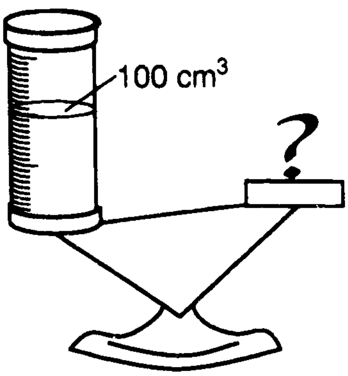
Divide

distance (in cm.) from the center of the smaller circle to any student sitting around the circle = cm (speed)
average time (in sec) it took the particles to move this distance = sec

Now write about the speed of the perfume particles. Use complete sentences.
(The average speed of the particles travelling to students in both circles should be the same. This is true even though the particles of perfume has to travel different distances.)

Lesson 7: Find the mass of one (1) cm^3 of water

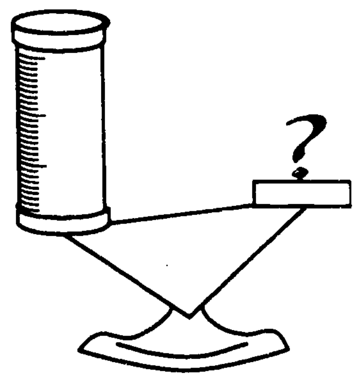
A. One student should read the following directions to his/her group. The group will discuss the directions. Each group member should repeat the directions using his or her own words.



B. Actually weigh the cylinder filled with water to the 100cm^3 mark.

You can use a balance or a scale to find out how much your group's 100 cm^3 measuring cylinder weighs when it is filled only with air. Weigh the cylinder. Now add 100 cm^3 of water to the cylinder. (Be certain that the outside of the cylinder is dry.) Now weigh the cylinder and the water. Then subtract the weight of the cylinder from its weight filled with water. This gives the weight of 100 cm^3 of water. (This weight will be about 100 g.) That is, 100 cm^3 of water has a weight, or more accurately a mass of 100 g. Now find out how much each cm^3 of water weighs in grams. Discuss how to find this out. Show the calculations here.

$(\frac{100g}{100cm^3} = \frac{g}{cm^3})$



B. Actually weigh the cylinder empty.

Lesson 8: Extending What You Know About Matter

Each group will complete one of the following activities. Members will report the results, orally, to the rest of the class. If time permits, each group may complete all of the activities.

A. Read the following. Each particles of water and each particle of alcohol are similar in that each has a positive (+) and a negative (-) end. Use this information to add to your earlier explanation for the final volume when you mixed 50cm3 of water and 50cm3 of alcohol.

(The + end of different particles are attracted to the - end of other particles. Instead of particles simply fitting between one another the particles attract each other taking up less volume than when they are separate.)

B. Tear a sheet of newspaper down the page. Then tear this same sheet across the page. Describe the differences you observe.

(When we tore the paper one way, the tear was smooth or even. When we tore the paper the other way the tear was rough or uneven.)

Explain the difference in tear by using the word particles.

(The particles that make up the paper are lined mainly in only one direction. This allows them to be pulled apart more evenly in one direction than in the other direction.)

C. Measure the length and width of your rectangular classroom. One group will find out the values for l1 and l2 in meters (m).

l1 is	___	Now calculate the total distance or
l2 is	___	perimeter around the classroom.

Now actually measure the total distance or perimeter of the classroom in meters.

Compare the perimeters obtained by the two methods. Explain differences in the results. Discuss the following questions: Figure the easiest way to determine the perimeter of a square rectangular classroom. (Find out l1. and multiply it by 4: l1 x 4 = perimeter of the square room.)

D. Another group will measure how many times each piece of string (the radius of the circle) fits around the circumference of the circle. The distance around any circle is called its circumference. These strings were used to draw the circles. Repeat for the other circle. How many times did you place each piece of string around the circumference? (The number of times for each was a little more than 3.)

The length or distance from the center of a circle to its circumference is called its radius. The length of the string used to draw each circles' circumference is its radius. Dividing the circumference by the radius, in both cases, results in a number a little larger than 6.

The circumference of the larger circle is ____ cm.
Divide the circumference by the radius = (6)
Its radius is ____ cm.

The circumference of the smaller circle is ____ cm.
Divide the circumference by the radius = (6)
Its radius is ____ cm.

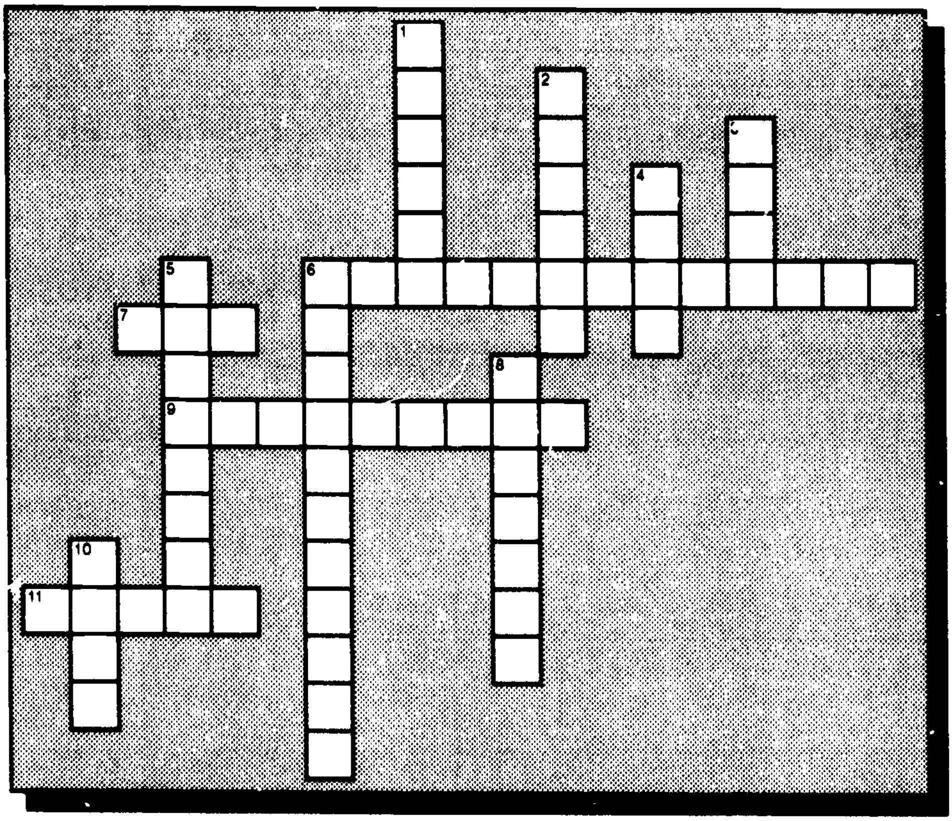
Try the same measurement for another circle. (The answer also will be a little more than 6.)
You may wish to extend the results of this activity to consider the relationship between circumference and diameter.

<u>circumference</u>
2 radii (diameter) (pi); pi = 3.14 for any circle

E. The first group will predict, using mathematics, how much time it would take the particles of perfume to reach the farthest wall of the classroom. Then explain to the class how they did this. (Calculate the predicted time by using the average speed of the particles and the distance from the center of the room to the wall.) Remember that speed was measured in cm/sec and distance in cm. The time (the answer) is in sec. Students should do their calculations on large sheets of paper, and then explain them to the rest of the class.

THE ABOUT MATTER CROSSWORD PUZZLE - A SUMMARY

A. Complete this puzzle by writing down the correct words.



ACROSS:

6. The distance around the outside of a circle is called the ____________.

7. ___________ fills up most empty spaces.

9. All matter is made up of tiny _________.

11. The ___________ level drops when the boat sinks.

DOWN:

1. _________ occupies space.

2. L1 x L2 x L3 = __________.

3. Particles of matter constantly __________.

4. L1 x L2 = __________.

5. Water can __________ air.

6. 100 ______ make up a meter.

8. A meterstick is used to _____________.

10. A property of all matter ______.

B. Choose ten new words that were used in this IALS. Write each word below. Then use each word in a sentence.

<u>Write each word here</u>	<u>Write each sentence here</u>
(1) ______________	______________________________
(2) ______________	______________________________
(3) ______________	______________________________
(4) ______________	______________________________
(5) ______________	______________________________
(6) ______________	______________________________
(7) ______________	______________________________
(8) ______________	______________________________
(9) ______________	______________________________
(10) ______________	______________________________

Summary:

In this IALS, we learned that matter occupies space and that matter can be displaced by other matter. We also learned that particles of matter move and we can calculate the average speed with which these particles move. Finally, we strengthened our use of mathematical procedures and our use of English language.