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ABSTRACT

This paper, which considers effective science teaching and learning for limited English proficient (LEP) students in U.S. schools, is based on the assumption that science and English language can be effectively learned together without excessive emphasis on students' native language, although teachers and aides who have knowledge of LEP students' first language can enhance instruction through its judicious use. Science and language instructional goals for LEP minorities; pedagogical practices that either enhance or inhibit the attainment of these goals of enhanced learning; publications that support the proposed pedagogical practices; and science/curriculum and instruction for LEP students, are all discu ssed or provided. Central to the pedagogy described n this monograph is the use of related or thematic lessons in which sciences serves as the driving force though the materials integrate both science and language (English). Each related lesson series is referred to as an IALS or integrated activity (ased) learning sequence; an IALS for the elementary grades, called "How Do Living Things Behave?" is described in full. Ways in which the IALS integrates the best pedagogical practices to greatly enhance science and basic skills learning among LEP students; the nature of science driven instruction for LEP students; and conditions to support reform in science driven instruction for these students are also described. Two appendixes are included. Appendix A provides an example of another IALS, this one designed for the upper grades. Appendix B provides 157 annotated references for science teachers, educators, policymakers, and others for improving science instruction for LEP students. (RLC)

TEACHING AND LEARNING SCIENCE WITH UNDERSTANDING TO LIMITED ENGLISH PROFICIENT STUDENTS: EXCELLENCE THROUGH REFORM

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INTRODUCTION

This monograph considers the latest understandings concerning effective teaching and learning of scie ce for limited English (language) proficient (LEP) students in t. nation's schools. It will serve as an invaluable resource for teachers, school administrators, parents, school board members, and college university level faculty who are responsible for the future well being and advancement of the LEP student population in the United States and elsewhere.

The direction for reform, encouraged and supported herein, has been shown to be effective through considerable research. The Appendices to this monograph contain an extensive annotated listing of references to instructionsl and other materials beyond those referred to throughout the narrative.

The materials included herein are based upon the assumption that science and English language can be effectively learned together without excessive emphasis placed upon the first language; although teachers and aides who have knowledge of LEP students' first language can enhance instruction through its judicious use.

We dedicate this monograph to those who have committed themselves to improving educational opportunity for the LEP student population. Their efforts are critical to assuring that this special population is prepared to contribute effectively to the needs of society, especially in the areas of science and technology. Their efforts, combined with the approaches proposed throughout this monograh, will well serve the nation's LEP student population.

The Authors

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PREFACE

Teaching and Learning Science for Understanding is a rich resource of information designed to improve science and basic skills instruction and 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 not only for limited English proficient students, but for all students especially 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. In addition, all teachers in preparation require experience in the approach embraced in this monograph. This is especially true because, as the authors state, the usual lecture approach to instruction appears to be more natural; and consequently teachers do not require as extensive an experience in the lecture approach. They do need more extensive direct experience with the so-called inquiry approach.

It is especially useful that this monograph attends to instructional materials in science developed through support

National Science Foundation support. A number of these materials, some now commercially available, have been designed to offer students ample opportunity for the kinds of hands-on investigative science instructional experiences that will improve science learning and enhance basic skills development.

It is particularly significant that the ERIC Urban Education Center which is particularly dedicated to improving education in the urban centers of the nation, has commissioned the monograph; and that a national organization, the National Science Teachers Association, dedicated to the improvement of science teaching, has joined in the publication and dissemination effort. This form of cooperative effort, to improve education, especially in urban schools, is so essential to the advancement of underserved minorities. Without such efforts, on behalf of this group, a national treasure will be lost.

I commend this monograph to all teachers as they work toward making science instruction more and more meaningful and rewarding to all of the language minorities attending schools throughout the entire nation.

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CHAPTER I

SCIENCE AND LANGUAGE INSTRUCTIONAL GOALS FOR LIMITED ENGLISH PROFICIENT MINORITIES

In 1991 the National Association for Bilingual Education honored Roberto Pettingi by recognizing him as the Bilingual Teacher of the Year (1992). Pettingi is a science teacher at the Martin Luther King Jr. High 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 or LEP. Historically these students were referred to as bilingual students. These are students from cultural backgrounds whose native languages other than English. The formal announcement of the Bilingual Teacher of the Year Award indicated that ninety percent of Pettingi's students have taken the New York State Regents Examination in biology and chemistry and have passed these rigorous high stake tests. This test passing record was amazing in that eighty five percent of his students had arrived in this country from the Dominican Republic over the past two years or less. Of these students 90 percent had successfully completed high school and had entered some form of higher education!

Roberto, himself an immigrant from Uruguay, achieved such success, as a teacher of science to LEP students, because he sees both the importance of science to society and understands that science is an excellent vehicle for teaching and learning the basic skills of mathematics and language. Aside from concern for academic learning, Pettingi has concern "for developing his students' self worth and assisting them in developing control over their destinies." He attributes his success in teaching to both his excellent education in the sciences and excellent training in teaching approaches appropriate for "bilingual" student populations. He is a motivated professional who earlier had experienced employment as a dishwasher, machine operator, garment cart pusher and NASA summer education fellow! As a teacher, holding two masters' degrees, he has utilized many of the practices described throughout this monograph. These professional practices, he states, were learned in part from his experiences as a graduate student in a program at Fairleigh Dickinson University which was designed to prepare master teachers of science and related subjects for bilingual school settings. This program emphasized the importance of organizing instruction so that LEP students will become proficient in English language as well as proficient in their knowledge of science.

Supporting others to be as successful as Roberto Pettingi in teaching the sciences to LEP students is the goal for this publication. His kind of success requires a high degree of personal effort and commitment; and to be effective that personal effort must be appropriately directed. And that direction can develop through guidelines and application of the guidelines set forth in this monograph. When appropriately directed effort and commitment exist, the results are not only rewarding to teachers, but also to their students and eventually to society generally.

Among all students enrolled in pre-college educational programs in America all minority students, including LEP students, will require the greatest amount of educational experience. This group of students, in the years ahead, will be increasingly called upon to move the nation's science and technological enterprise forward. Since the initiation of the President's "2000 Education Agenda" (1989), only minor gains have occurred in mathematics and science scores on the Scholastic Aptitude Test (SAT) among Black Americans. No gains have occurred among Hispanic Americans. This situation is one indication that there is much to be accomplished in the next few years in improving educational opportunity and experience for all minorities but especially for those minorities who are classified as LEP.

Through practices proposed in this monograph, instruction and learning in the sciences and related subjects for LEP students will improve phenomenally, and standardized test scores both in basic skills and science for the LEP population will increase. Better still, this will greatly assist overall in raising the level of scientific understanding of the entire nation.

Demography and Science Education

The message conveyed by two recent publications of the Rand Corporation: Multiplying Inequalities (1989) and Lost Talent (1990) is not news to the LEP population. Both publications present data indicating that in schools housing large numbers of minority students Hispanic/LEP students and other disadvantaged youth are clustered disproportionately into "low ability" classes. Multiplying Inequalities reports 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 discriminatory school practice of tracking has assisted in producing the long term effect of severe underrepresentation of minorities in advanced science and math classes and eventually among science and math oriented professionals generally. The practice of discriminatory tracking must not continue. It has helped to produce the following condition. Blacks and Hispanics, each constitute only about 2 percent of the scientific workforce, even though Blacks constitute 10 and Hispanics 7 percent of the total professional workforce. This disproportionate representation of minorities is damaging not only to the future well being of individuals and minorities as a group, but also to the nation's future.

Present Status of Science-Math Learning for Minorities Including LEP Students

The (1991) edition of Science and Engineering Indicators presents data indicating that gains in science on the National Asssessment of Educational Progress or NAEP test were similar for White Americans and Hispanic Americans from 1977 to 1990, but only for 9 and 13 year old students. No gain in scores occurred for either group at age 17. The National Center for Educational Statistic's publication Condition of Education - Volume II (1991) indicates that the percentages of minorities compared to percentages of whites enrolling in college as science and engineering majors only appeared to improve from 1977 to 1989 (The ratio for blacks increased from 0.65 to 0.91; while for Hispanics the ratio increased from 0.82 to 1.00). This apparent improvement resulted from a substantial decrease in the percentage of white students enrolling in these majors; consequently the improvement is not real.

The test and college level science major enrollment data indicated above is supported by the poor showing of the United States in sciences and mathematics, on recent international measures, such as the 1988 International Assessment of Educational Progress (IAEP). On the 1988 IAEP tests, on average, U.S. 13 year olds scored lowest among the major industrialized nations both in mathematics and science proficiency."

Minorities, including LEP test takers from the United States contributed to this unacceptable international comparison.

It is clear, from this kind of evidence, that there is indeed need for serious efforts to improve instruction in science as well as in mathematics, and to increase motivation to pursue science related careers, among minority students, including LEP minorities.

Need for Early Science Experiences

A summary of recently published data indicates that on the average, nearly three students out of every school classroom of 20 lives either with a drug dependent parent/s, is hypersensitive due to poor diet, or is afflicted with other learning handicaps. These figures are higher in classrooms housing larger number of minority students, especially in urban schools. Pre-K school experiences designed to prevent or to overcome these disorders that lead to reduced learning, are essential if education is to result in more effective and appropriate learning among minorities, including LEP minorities. Science offers both content and experiences that can assist young children to overcome such maladies to learning and hence to more adequately prepare then for further effective schooling.

Experience indicates that all pre-school students, including LEP students, both enjoy and learn from having live animals and plants in their environment. They learn to respond to stimuli and to improve their language through observing and handling living things. They are naturally motivated to describe, discuss and compare the characteristics and behaviors of living things especially if they have opportunity to observe living movement within controlled environments; and it is not too early to begin such observations in nursery schools. At these early ages LEP students' inhibitions to learning are readily overcome and they learn to expand their own language and to transfer such learning to English. Such concrete descriptive type experiences lay an effective background for understanding the more abstract ideas in later science instruction. Without a school environment that supplies ample opportunity for children to observe and to describe the necessary skills of abstract thinking and learning how to make informed choices never develops; and success in science is thwarted.

Learning about effective nutrition and health, through the observation of the results of varied "diets" on living organisms should be an integral component of early school science experiences. Fruits and meats, for example, look and taste differently; yet both coconut meat and fat pork rind, for example, form an oily spot on a piece of brown bag paper. And while syrup from corn, sugar, cane and sugar beet all taste sweet, only the corn syrup, when added to a solution called Benedict's solution, and heated, causes change to a variety of colors. It is not too difficult for very young children to understand that sweetness is not associated only with sugar from cane.

Chapter II includes a series of related lessons that emphasize science appropriate for young children. Because the development of language and other effective forms of communication are the key to successful human involvement in science, ample opportunity to develop these skills must be a conscious and significant component of instruction for LEP students beginning at the early childhood level. This includes learning to verbalize what has been observed and experienced in both the native and English language.

Two articles appearing in the journal Daedalus (Spring 1983 and 1990) give strong arguments for early education that emphasizes English language.

Damon's article (in the 1990 Daedalus): "Reconciling the Literacies of Generations" indicates that too many young minority students are turning away from the offerings of the American school classroom, not because they are functionally illiterate but rather, because the literacies of (their) generations have been unlinked or disconnected. In order to restore these essential literacy links or connections, Damon states, schools must acquire a surer feel for contemporary cultural conditions and craft academic programs to stimulate the intellectual and moral development of LEP students in their charge, beginning at an early age. In the 1983 article "Minority Status and Literacy in Comparative Perspective," John Ogbu reminds 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)". Earlier is better than later to place into practice educational procedures designed to reduce this "disconnectedness syndrome."

Need for Improved Academic Performance

The need for improved academic performance for LEP students is reflected in a comparison of high school completion rates. During the period from 1977-1990 the overall high school completion rate, among all 25 to 29 year olds, was nearly 86 percent. The completion rate, however, for Hispanics in this same age group was 60 percent. During this same period the number of Hispanics that completed college degrees in the sciences, compared to the number of other racial and cultural groups, dropped significantly and continuously.

Improved academic conditions include not just better facilities but also availability of materials that will improve the experiential level of LEP students. To improve this condition will require changes in approaches to instruction that have been proven to enhance language development. Research related to classroom organizational strategy referred to as cooperative learning, or better cooperative group instruction, when used in science lessons, has been shown to facilitate meeting this language objective. (Sutman et al 1993).

Time for Science and English Language Development

Many elementary school level teachers argue that they have little time for science instruction because subjects like language arts, of which ESL and foreign language are components, and math require most of the available classroom instructional time. Likewise, most high school level science teachers believe that their responsibility stops at teaching science. They have no commitment to language development. Teachers at both scho levels who take these positions slight their students; especial those who are LEP. Elementary teachers need to understand th science with its opportunities for hands-on experiences is excellent vehicle for second language development; and hi school teachers need to understand that without knowledge of t language of instruction little or no science will be learned. Lack of these understandings results from the fact that too few teachers are willing to learn outside of their "chosen-historical" field. In addition, they do not accept the idea that the school student population has changed drastically from only 20 or 30 years ago.

Students with all sorts of impediments to learning, such as language impediments, would not have attended school in large numbers in past decades. Today these students are in school and teachers must be prepared, as well as willing, to teach them and do this effectively. There must be time, and this monograph will show that time can be "made" in the curriculum, to teach science as well as effective communication to LEP students. This time is found in restructuring both the curriculum and the pedagogical approach. (See: "A Curriculum Strategy That Expands Time for In-Depth Elementary Science Instruction 1992.)

Increasing Numbers of (Qualified) Teachers of LEP Students

There are two major deterrents to elementary school level teachers offering quality science instruction. These are limited preparation in: science related subjects, pedagogical procedures and lack of experience in the practice of effective approaches to instruction. Correcting these deficiencies is, at present not being addressed adequately at either the preservice or inservice teaching levels.

A practice, at the preservice level for elementary teachers, that continues these deficiencies is the requirement in the certification standards for any "liberal arts major." In most cases, majors allowed are not liberal, instead they are narrow. Such "non-liberal" majors, instead of improving the competence of teachers to teach science or any other traditional subject, deter effective instruction in schools. Requiring a broad major that combines both the instruction of natural and social sciences would better meet the need for more effective content especially for those who teach LEP students.

An erroneous belief, by political leaders, pervades that knowledge of content alone prepares teachers adequately to teach. This is far from the truth. Extensive experience and practice with a variety of pedagogical approaches is also required. Emphasis must be given especially to instructional strategies other than lecture and discussion. Most important, for those who will teach, or are teaching, LEP students, is experience with inquiry teaching and discovery learning that emphasizes the use of hands on-manipulative materials, as well as other strategies that lead to reducing the density of language presentation and that allow students more opportunity to construct their own learning.

To assure success, in learning how to teach effectively in today's schools, pedagogical experiences must occur in school settings attended by significant numbers of minorities, in particular LEP minorities. Instruction that integrates science with the basic skills of mathematics and English language also must be emphasized. Preservice and inservice teachers need to experience the overwhelmingly positive learning results of this approach to instruction.

For the secondary school level, science teachers should continue to specialize, but not as narrowly as at present. Instead of a major in biology or physics, these teachers will benefit better from a broad natural science major. Their teaching will produce significantly better results when they experience the results of instruction based upon the old adage: "take children from where they are." If English language and/or math is/are deficiencies use science to strengthen these communications skills. Cover less science and uncover more knowledge!

Serious efforts toward the strengthening of science instruction overall are presently underway. These efforts are being supported by private foundations and industries, as well as by governmental agencies including the National Science Foundation, particularly the Human Resource Division of the Education and Human Resources Directorate, the U. S. Department of Education's Dwight D. Eisenhower Program, and the U. S. Department of Education's Office of Bilingual Education and Minority Language Affairs. The Departments of Defense and Energy also are supporting activity directed at meeting this critical need. As much as four billion dollars per year is being directed toward improved science instruction. Still, too little sustained-systemic effort continues to be directed toward knowledgeable-improved instruction in science for LEP students as well as for other minorities concentrated in the nation's urban schools.

Literature Support

It is not possible, nor perhaps necessary, to include all of the literature that supports the recommendations for improving the instruction and learning of LEP students in the limitations of the length of this monograph. Those who seek examples of this literature are referred to Appendix B for an annotated bibliography of such literature. You will note from Appendix A that it is both impossible and undesirable to separate the general literature on educational reform from the literature that addresses science specifically for LEP students. The Appendix, therefore, includes examples of reference from a wide range of sources. Additional support literature is available through the ERIC system; especially through the ERIC Clearinghouse on Urban Education, the primary publishers of this monograph, by calling (212)-678-3433. Through this number contact can be made also with the other ERIC specialized Clearinghouses such as the National Clearinghouse on Bilingual Education, and the Science/Mathematics and Environmental Education Clearinghouse.

Looking Back and Ahead

This chapter has presented significant instructional goals in science and language for LEP-minority students. It set the stage for the remainder of the monograph by identifying pedagogical practices that will enhance meeting these goals; that is enhance learning. Present school practices harmful to the academic advancement of LEP student populations were identified, and reference was made to a sampling of publications that support the proposed pedagogical practices. These are annotated in Appendix B.

The next chapter details the approach to instruction that integrates the best of pedagogical practices indicated by research to greatly enhance both science and basic skills learning among LEP students.

CHAPTER II

GRADES N-6 SCIENCE/LANGUAGE INSTRUCTION FOR LEP STUDENTS: THE IALS

The recommendations for instructional practice presented in this chapter are based upon several premises that if followed will serve as effective instruction, of LEP students, in science. They also will clarify for professional educators the differences between instruction for LEP and EP students. These premises are the underpinning for the examples of science curriculum materials included herein. The first premise is that the science content to be taught to LEP students is the same to be taught to students from all cultures and ethnic backgrounds. Science is the description that man has developed for his environment, and his explanations for how and why this environment operates. These understandings and descriptions are universal. Science content is not directed at any single culture or race.

The second premise is that: this universal science content must be complemented by cultural examples that are relevent to LEP students. Today's school level science curriculum, is usually void of cultural examples. Little or no reference is made to the contributions that individuals and groups from varied cultures have made to the understandings and advancements of science. Instead, the science curriculum is crowded with the vocabulary of science and the details of the abstract theories or explanations of science.

Hispanics and other language-cultural minorities have made and continue to make significant contributions to scientific knowledge and these must be emphasized as part of the science curriculum. All students, particularly LEP students, benefit from becoming familiar with such contributions. Immigrants from other parts of the world have made many of the most significant contributions to scientific advancement in this country; and it is the freedom and flexibility of this nation that has caused this to occur. Learning of the present contributions, especially of minorities, to science helps to give hope that they can add to such contributions. In addition, inclusion of this social aspect of science assists in reducing the density of the more difficult - more abstract components of science content and it reduces the density of technical vocabulary.

Models of Excellence (1991), published and distributed by the National Science Foundation and Hispanics in Science and Engineering, from the American Association for the Advancement of Science (1992), are two resources that describe recent successes by minorities in science. Included, for example, is the background of Alexander Cruz who grew up in the Puerto Rican section of Brooklyn, New York, where as a school age student he studied plants and animals that he collected from vacant lots. He now is a Professor of Biology and a researcher at the

University of Colorado. His research, partially supported by the National Science Foundation, allows him to bring minority students to work in his university's laboratories during summers to help them to become motivated to continue further study in the sciences.

A second example of a minority's contribution to science is the story of Dr. Maria Eleana Zavalia, daughter of migrant farming parents in California. As a child she watched her grandmother grow herbs and use them to try to heal people. She became interested in studying more about plants, and eventually she received the doctorate degree in botany from the University of California at Berkeley. Maria, now, is a Professor of Biology at California State University at Northridge. Dr. Zavalia also actively participates in the Society for the Advancement of Chicanos and Native Americans in Science and Engineering. Twice each year she organizes meetings for minority school age students to supply them with information about opportunities for study and work in the sciences.

Dr. Luis Alvarez is an example of a minority scientist, who during the earlier part of the twentieth century, received the Nobel Prize in physics for his significant contributions to the development of the nuclear-proton accellerator and the bubble chamber for detecting nuclear particles. He also was a contributor to the development of radar.

Another example is Dr. Ismael Velez of San German Puerto Rico, who was a key member of the scientific team that developed a method for producing mutations in pineapple plants that both eliminated the sharp spines on leaves and produced an increase of 700 percent in pineapple fruit production. Velez became the first president of the Puerto Rico Science Teachers' Association. Contributions made by teams, or minority members of teams, should be given special emphasis because today the most significant scientific discoveries are the result of team efforts.

The prime example of minority culture contributions to the advancement of science in the United States today is the 40,000 students from the Peoples Republic of China involved in graduate study and research in science. These students sought and won asylum here following the Tianamin Square military suppression of the democracy movement in China in 1989!

In addition to the value to minority students learning about contributions by members of their cultures to the advancement of scientific knowledge, majority students, as well, benefit from this information. It serves to foster respect, admiration and acceptance of these minority cultures. That individuals of many cultures have contributed and continue to contribute to the advancement of science in the United States benefits all students but especially those who have been underserved, including those with LEP backgrounds.

Cultural relevance is enhanced, also, through the inclusion in teaching, of analogies that take into account past cultural experiences and language that describes these experiences. As an example, textbooks in chemistry have used the following analogy to describe the concept of activation energy. Golf balls are bouncing in the rear of a station wagon being driven down a bumpy road. Every so often a golf ball bounces over the back of the rear seat and lands on the seat of the wagon. For recent Hispanic immigrants, it would be, for example, far more meaningful to refer to a burro driven carreton' carrying pinones. Without such analogies, from appropriate cultures, the abstract ideas of science are not meaningful.

A third premise is that: especially for LEP students, science instruction is most effective when the content is organized around common themes. These themes can be broad science concepts such as the particulate nature of matter, magnetic energy, energy transformations, chemical change, food chains, etc. They 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 theme or concept approach to the organization of content offers several pedagogical advantages to instruction and learning of science by LEP students. It organizes scientific knowledge in a comprehensible context which may be relevant to the present and future lives of the students. It extends the time over which a single topic is studied allowing for more time for comprehension and allowing for repitition in the use of English vocabulary. This offers maximum natural opportunity for students to practice the language and to learn the meaning of the vocabulary as well as the correct use of syntax and grammar.

The organization of science content around individual societal issues or around applications of science makes science particularly interesting to LEP students because it adds relevance to the science. This interest increases the probability that students will continue to want to learn science and language on their own once formal school level instruction ceases. Developing this self-learning pattern leads naturally to further study of science. Building science around societal issues also leads naturally to the whole approach to second language instruction, encompassing science, social sciences and other disciplines: a truly integrated curriculum. This approach increases the opportunity for LEP students to find meaning in the new language and reduces the propensity to "pack" or overcrowd the curriculum with the more complex content and vocabulary. ALso students and teachers, through this approach, are allowed more time to understand and to reflect on what is to be learned. Overall, this less "packed" approach leads to more in-depth understanding of science content as well as increased language skill development. When coupled with the use of the instructional strategies of hands-on experiences and carefully structured cooperative group instruction, reduced dependence upon a single textbook occurs, opening up more opportunities for students to refer to a variety of references in the discovery process of learning. This combination of strategies leads to significantly increased opportunities to utilize basic skills, including mathematics skill development.

The degree to which science and other subjects are integrated in instruction is a direct measure of how effective the curriculum is in helping to improve learning. The correctness of this premise is supported, for example, by the following references: "Start With Science, (Instructor, March 1, 1991), M. Linn's "Establishing a Research Base for Science Education: Challenges, Trends and Recommendations," (1987), Science and Technology Education for the Elementary Years: Frameworks for Curriculum and Instruction, (1989), and 2061 Today, (Summer 1991) and 2061 Update (1992).

Instructional Approach: the IALS

Science teaching continues to be heavily dependent on single textbooks supplemented by "cookbook" type laboratory experiments. The "textbook" strategy in general does not foster an in depth understanding of science, nor does it enhance the development of scientific processes. Instruction that is dependent on a single textbook reduces emphasis on thematic organization and the use of the whole language approach to instruction. Newer curriculum materials that are carefully designed to facilitate inquiry oriented instruction, especially for LEP students, are becoming available. These materials minimize dependence on being able to read English fluently, because they include limited new vocabulary and they include a guidelines for teachers that direct them and their students to varied sources of information for use in the discovery learning process. This approach facilitates the integration of science and language most effectively. 'Descubrimiento or Finding Out" published by Santillana Publishing Co.; CHeChe Konnen, under development by the Technologies Education Research Corp; and instructional materials from the American Association for the Advancement of Sciences Proyecto Futuro are examples of materials that are available and have been researched to indicate their effectiveness with LEP students. Science/Math Integrated With Language for Elementary Schools is a curriculum that is under development. These curriculum materials are referenced in Appendix B.

This monograph includes two examples of related or thematic lessons in which science serves as the driving force for instruction; although the materials integrate science mathematics and language (English). Each related lesson series is referred to as an IALS or integrated activity (based) learning sequence.

The IALS included in this Chapter is designed for the early elementary grades. It's title is "How Do Living Things Behave?" Before presenting this IALS, one additional, but relative premise needs to be considered.

The fourth premise is: <u>that English language development must be an integral objective of all science instruction</u>. This premise is presented last because of its special significant role in the education of LEP students; although, like the earlier presented premises, it has implications for the education of all students.

Science teachers as well as teachers of English as a second language must make special effort to cooperate in designing science instruction so that English language skill development is consciously enhanced. This can occur by affording opportunities for students to carry out investigations in groups made up of students with varying levels of English language proficiency and by designing follow through activities that motivate students to use English language.

Examples of such language activities include: keeping a dictionary of new science terms, completion of crossword puzzles that include words and definitions related to the science theme and/or individual lessons being studied, writing summaries of the results of each science investigation and the procedures used in carr ing out these investigations, writing to a friend about what we learned from a science investigation, reporting to the class or to the cooperative instructional groups the results of a recently completed science activity (the group as a whole developing a summary of the results of the science investigation just completed and reporting these results to the rest of the class using a panel format) organizing a presentation of a science investigation as a school assembly program, individual groups planning and carrying out a science fair project with individual group members reporting some component of the project to school personnel and to parents, and developing an English language newsletter about science activities carried out by the class to be addressed to parents (both first languages, and English can be included in such a newsletter); and of course through informal discussions among members of each cooperative instructional group. Short plays built around a science theme can be written by groups of students and then acted out using large poster size English language prompt cards, and individual students can draw pictures depicting the science they have learned and then write about these pictures.

There are many science trade books for children written at appropriate levels of English competency that should be a major component of the school or classroom library. Teachers should ask students to read the books that address the specific science topic under discussion or study. Reading can occur in groups or individually with LEP students reporting on what they have read, or better what questions arose from reading about specific science topics. These books should include simply written biographies about famous scientists, especially about minority scientists. Initially teachers may have to read these books with their students.

The strategies that are used to incorporate English language into science instruction should be carried into the procedures that teachers utilize to assess the science and language learning of each student and/or group of students; this because the mode of assessment will determine the expected outcomes of instruction. If students, for example, are asked to draw a picture describing what has ben learned in science and then asked to write about the picture, teachers should make this process an expectation of assessment. If students do not respond favorably to such an assessment strategy, teachers should determine the cause for this unfavorable student response and revise future instruction accordingly in ways designed to improve learning. It is important that English remain the primary language of both instruction and assessment, with the teacher, who is fluent in the native language(s) assisting orally where and when appropriate.

For teachers to effectively carry out this integrated science - English language approach to instruction requires continued creative up-grading of the teachers' knowledge of science and knowledge of materials for English language instruction.

Even at the lower elementary school level teachers will want to incorporate mathematics skill development activities into the integrated curriculum. As demonstrated in the IALS included in this chapter and later on in the monograph, these mathematic skills development activities should be directly related to the science hands on investigations and the related language activities.

A Science Driven IALS for the Lower Elementary Grades

The IALS "How do living things behave?", included in this chapter, is one to be included in the forthcoming Project SMILES instructional program. SMILES is the acronym for science, mathematics integrated (with) languages for elementary schools (1992). The IALS purposefully includes some activities that are familiar to many lower grade teachers of LEP students. However, it also includes some unique and significant components such as a demonstration of the impact of drugs on living cells. The IALS can be adapted easily to upper elementary school instruction for students who have not had the experiences at earlier grade levels.

The National Research Council of the National Academy of Science has organized a group called the Coordinating Council for Education whose mission is to develop national standards for science instruction and assessment (1992). These science standards will parallel those developed and distributed by the

National Council of Teachers of Mathematics (1989). Since the standards may not be available until 1995, teachers of LEP students must refer to local or state standards or school district curriculum guides to determine the most appropriate placement for this IALS in the overall K-6 curriculum.

As important as following available curricula is reliance of each teachers' professional judgment based upon the experiential and knowledge background of his/her students, and of the language readiness of the LEP students under his/her charge.

Notice that the IALS begins with an activity that utilizes a living animal that is familiar to many young children: guppies. Also notice that the initial science content is very concrete and that the math expectations are very basic.

The IALS, as presented here, is deliberately directed to the teachers as a guide. This allows each teacher maximum flexibility to develop worksheets and materials for use by students. The nature of these student materials will depend upon each teacher's professional judgment and creativity. This also allows teachers to select and include activities that normally would be considered to meet a high expectation level of learning.

This first IALS is organized into columns with the following headings: <u>Preparation and Materials</u>, <u>Students' and Teachers' Activities</u>, <u>Assessment of Learning</u>, <u>Content and Process Learning</u>

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 during instruction. The scope of information becomes especially significant when the instruction encompasses several disciplines or is integrated.

Teachers are reminded to bring together all of the materials of instruction prior to initiating the IALS. It is especially important for teachers to practice unfamiliar hands on procedures prior to introducing them to their LEP students.

The English names for each object or material to be used in an investigation should be reviewed with the students prior to beginning the activity in which the object or material is first used. A label, placed on each item, with its name is a useful procedure to follow. "Posted Notes" stickers and a magic marker can be used for this purpose. Teachers will want to involve their students in making these labels and in orally referring to the names on the stickers while carrying out each action. For example, say: "I am filling the fish tank with water from the faucet" while you actually fill the tank with water. Ask students to repeat this kind of verbal description of action. Be certain that your statements are short and simple. Always use complete sentences. For emphasis, the action words that will be used as the IALS proceeds are underlined. The first two columns include the many actions required by both teachers and students and the materials required to carry out these actions.

The Assessment of Student Learning Column includes simple activities that when imbedded in the instruction indicates to the teacher, either formally or informally, the extent to which each instructional objective is being met. If students respond or react favorably or positively to these activities, learning is occurring. If students do not respond well the cause is either lack of science understanding, lack of English language understanding, or lack of both. Whatever the cause or causes, students should be offered ample opportunity to repeat the activity; to re-explore the language and content. Don't fall into the practice of telling students what the answer should be or what they should learn! For telling will deter learning both of science and language. It is, however, appropriate to help students to summarize what has been learned at appropriate steps along the way. The column labeled: "Sample Questions Students May Ask" is included to assist teachers in helping LEP students phrase their questions in English, and to assist teachers in preparing for instruction. Teachers should assist students in performing other activities or investigations in order to answer their questions. Students should be offered references (pictures or written statements) that will answer their questions. The teacher may seek these references from the library or from textbooks, or he/she should develop a file of reference materials. Answers obtained by other students and written down in prior years can be excellent reference sources.

In some instances teachers of LEP students may believe that they are "sacrificing" content "coverage." This is a natural reaction for those who begin to teach differently. In fact this approach to instruction will lead to higher levels of coverage and deeper levels of understanding of the subject. The paradox in teaching is that through this process of "sacrificing" content, learning actually increases. Covering less, results in uncovering more. Uncovering a scientific concept means deeper student understanding.

The column labeled Content and Process Learning Objectives includes statements of processes and skills associated with science, as well as with other disciplines that should to begin to be developed even at early ages. The development of these processes and skills becomes an integral component of the experiential base of each student; experiences necessary for further effective learning.

In planning for teaching this IALS, as well as for others, lavishly use the cooperative group approach to instruction. This approach fosters maximum student language development through inter-student oral (and possibly written) communication. For best results, cooperative instructional groups should be an integral component of instruction starting at the beginning of the school year, because shifting the pattern of classroom organization is difficult once the school year is underway.

In classrooms in which LEP students have varying degrees of English language proficiency, or in which the LEP students come from varying language backgrounds, the teacher should consciously organize each group to include as much variation in language background, English and otherwise, as is possible. 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, etc. These assigned roles should be rotated among the students from lesson to lesson to offer opportunity for varied contributions and experiences. Each student should write down the nature of their assignment and wear a tag as a reminder of the assignment. "Translator" roles should be assigned to students who have proficiency in the primary language and/or in English.

If the cooperative instructional groups are homogenous in terms of first language competence, the teacher and aide must play increased roles as interpreter(s).

As indicated earlier, upon completion of each lesson, within an IALS, students should summarize, orally or in writing, what they have learned; and they must be involved in cleaning up and reorganizing the science and other materials that they have used. For later grade levels teachers may want to involve the class in orally constructing tests to be used to find out or assess what each has learned. Students can write down their test questions and then answer these questions. In some instances it will be more appropriate for each cooperative group to complete the test cooperatively. If approached in this non-threatening way, students will want to take these completed tests home to show a parent or parents. Or they may want to display them on the classroom bulletin board.

Remember, the teacher should limit the number of questions he/she asks in a given test. Effort should be spent assisting students to phrase their own questions in English. Also remember that an IALS is not intended to be prescriptive. Science and language results will vary each time the IALS is used as the basis for instruction.

Reading through the following IALS, or better preparing to teach it, will clearly indicate that it is structured to take into serious account premises detailed in this chapter.

The IALS can be completed in from 8 to 10 hours of instructional time. Even more important is that teachers allow ample time to repeat, if necessary, until the English language and math skills are appropriately developed, and science knowledge understanding occurs. You should plan to divide the IALS into manageable lessons. The drawn horizontal lines in the guide can assist teachers in this process.

For those teaching LEP students at upper grade levels a second IALS has been included as Appendix A. Notice that this second example includes substantive science and math content as well as activities designed to develop science laboratory skills.

TEACHERS GUIDE TO AN
INTEGRATED ACTIVITY LEARNING SEQUENCE (IALS) EMPHASIZING SCIENCE FOR PRE SCHOOL 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
• Obtain 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)	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	

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 • 2 plastic toothbrush tubes • matches • 5 of 6 filaments of green live elodea plants (from pet shop) • 2 plastic dishes • paper towels • water (standing one or two days)	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). • Place an air pump in each tank and plug it into an electric outlet. • 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? <u>Show</u> work on board using <u>many</u> examples (0 guppies • 2 guppies = 2 guppies more. 5 guppies - 2 guppies = 3 guppies more, etc.) For more advanced students use	<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? • 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.) • 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.	• Simple addition and subtraction • Introducing art (don't expect proficiency) • Describing actions orally using English language. Complete sentences • Keeping track of vocabulary in a dictionary • Care of living things • Food is made from once living things	• 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.) • What are the bubbles coming from the pump? (This is a pump for air.) • 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 bubbles 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. Labelling the art with English names of objects.	

STUDENTS' & TEACHERS' ACTIVITIES AND ASSESSMENT

- Teacher: <u>read</u> from the dictionary the simple definition for a few of the action words like: <u>move</u>, <u>place</u> <u>wim</u>.

- Be certain to show students how to <u>feed</u> fish, once each day (not too often), how to <u>place</u> stones in bottom of tank, and how to <u>connect</u> the air pump to <u>supply</u> 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, <u>divide</u> the class into two groups. <u>Ask</u> each group to <u>measure</u> 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 <u>compare</u> 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 <u>place</u> only one guppy one of the fish tanks, and <u>add</u> <u>drop by drop</u> (use the eye dropper) the one percent alcohol solution to the water, stirring the water with a straw. <u>Observe</u> a change in behavior of the fish. (<u>The fish will stop swimming by the time 20 drops of the alcohol are added</u>. (Gently <u>stir</u> the water and alcohol after each drop is added using the straw.) Once the guppy is "sleeping" immediately <u>take</u> it out of the tank and <u>place</u> it back into the <u>recovery</u> 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.

- <u>Observe</u>: The fish will "wake up." (If left too long in the alcohol contaminated water the fish will die.)

*

- <u>Place</u> the five or six filaments of the elodea plant into a fish tank containing clean water and 1/2 the guppies; <u>disconnect</u> the air pump in this tank and <u>place</u> the tank in a sunny location.

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

CONTENT AND PROCESS LEARNING OBJECTIVES

- Can students <u>measure</u> other L_1, L_2, L_3 in the classroom and <u>answer</u> how much more or less? Can they <u>describe</u> what they are doing and why using complete English sentences.

- For advanced students, can they <u>measure</u> lengths and <u>calculate</u> areas and volumes in both English and Metric systems? Can they <u>express</u> 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.)

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

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.)

CHAPTER III

THE NATURE OF SCIENCE DRIVEN INSTRUCTION FOR LEP STUDENTS

Teaching Methodologies in the Sciences

Science instruction, especially as practiced by school teachers, can be thought of as following two basic approaches: lecture/discussion or inquiry/discovery. Instruction involves both teaching and learning; lecture and inquiry are considered forms of, while discussion and discovery a; forms of learning. The term lecture, in lecture/discussion, indicates a teaching approach or strategy through which teachers convey, transmit or tell information they wish students to learn. This "telling" often is accompanied by discussion; a learning strategy that commonly involves teachers asking students questions with the expectation that the students will supply answers. The term "discussion", as commonly used is a misnomer, because in practice, minimal academic discussion among teachers and students actually takes place. Research by Mary Budd Rowe indicates that during most classroom discussion the teacher asks a question and then waits for a very short period of time to receive an answer. If no answer is forthcoming the teacher invariably calls upon another student. And many times the teacher answers the question him/herself. In classrooms where teachers continually ask questions there is little opportunity for students to pose questions or to discuss or debate issues. In LEP classes, in particular, students very rarely ask questions in English because teachers do not give opportunity or assist students in doing so.

A very famous immigrant scientist Isidore Rabi tells that when he was a child, he came home from school each day to a mother who did not ask him the traditional question: 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, reflected in this daily practice. Clearly she developed in her son, the true meaning of inquiry in school: students asking questions!

In inquiry oriented classrooms, discovery learning is also emphasized. A discovery learning environment is one in which students are given opportunity to discover or to find the answers to their questions. It is most effective when most questions are not answered by teachers; but rather they become answered through teachers supplying the resources for students to discover answers on their own. These resources include: providing materials for science laboratory investigations, making library resources available, inviting community based specialists into their classrooms, offering field trips, making reference books available, supplying newspapers and other media such as videotapes, films and computer programs.

Through quality discovery experiences students learn to learn on their own. This is a major instructional goal that needs to be met especially for LEP students.

The IALS presented in the last chapter and in the Appendix presents examples of effective inquiry/discovery directed science lessons, because they begin with a challenging hands on science activity that yields unexpected or unusual results; results that lead students to ask - why or how? Why did that happen? or How did it happen?

It is useful to think of the two instructional/learning strategies, just described, as existing on opposite ends of a continuum. Because as one strategy is emphasized in instruction the other becomes diminished. The Figure below indicates this relationship between the two strategies, as well as the primary characteristics of each. Note, as an example, that lecture/discussion places the teacher in the center of instruction while inquiry/discovery places the student in the center of the instructional process, with the teacher playing a managerial role.

The lecture/discussion approach, with LEP students, requires more immediate understanding of unfamiliar language. While inquiry/discovery strategy depends less immediately on the unfamiliar language to produce successful learning. Lecture/discussion also lends itself to individualizedcompetitive and self-centered learning with little opportunity for cooperation among students; while inquiry/discovery opens up opportunities for student-group cooperation in the instructional process.

SOME CHARACTERISTICS OF TWO APPROACHES TO SCIENCE INSTRUCTION

Inquiry/Discovery	Lecture/Discussion
o less dependent on unfamiliar language	o more dependent on unfamiliar lannguage
o uncovers the subject & the relationships among components	o covers the subject in an encyclopedic way
o develops improved attitudes about science/scientists/ science instruction	o destroys positive attitudes about science/ scientists/science instruction
o increases the learning of second language skills when supported by group based classroom organization.	o reduces the learning of second language skills. Does not lend itself to group based class room organization.
o leads to greater development of both process and manipulative skills	o leads to lesser development of process and manipulative skills
o leads to less learning of - predesigned content but instead to offering students greater opportunity to construct their own knowledge	o leads to short term learning of predesigned content, with little opportunity to construct knowledge
o allows for more experiences in the real work-world	o does not foster true experiences in the real work-world
o results in reducing school drop out rates	o results in increased school drop out rate
o results in constructive discussions among students & between students & teachers	o results in quieter class-environments that too often satisfies school administrators
o requires a more traditional form of teacher preparation	o requires a less traditional form of teacher preparation

Inquiry/discovery is an especially useful instructional approach in science for LEP students, because through this approach students learn to better understand the nature of their own questions, and they assist one another in understanding the answers to the questions through teacher managed discovery activities. Of the two instructional approaches the flexibility of inquiry/-discovery is more compatible with the constructivist theory of learning. More significant is that this approach to instruction when it utilizes cooperative groups, reduces the need to cater to individual learning styles (Bruce, Sutman, et al, 1993).

Teacher Proof Curriculum

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

During the late 1950's through the 1970's many science and mathematics instructional materials, developed through funding by the National Science Foundation and private foundations and agencies, claimed to be inquiry/discovery based. These materials were designed to involve students in extensive laboratory type hands on investigative experiences. Years of experience observing teachers using these materials indicate that, in fact, such laboratory type investigations, placed in the hands of most teachers, were used, and continue to be utilized in a lecture/discussion format. These were not teacher proof!

A second fault with these materials was that they, too often, were written at very high English language readability levels. These two weaknesses made the materials ineffective for the instruction of LEP students in both science and English language. LEP students forced to experience such instructional materials did not fare well in increased science comprehension; hence they become disinterested in enrolling in next level science and mathematic courses and therefore they were not able to pursue science careers.

The National Science Foundation now is supporting the development of materials that are overcoming these two weaknesses. It also supports teacher training and enhancement programs throughout the country designed to prepare teachers to instruct more effectively giving emphasis to inquiry/discovery.

One approach that works well in developing skill in inquiry/discovery is for teachers to work together or to mentor with master teachers who are skilled in this strategy. Even then teachers must work in an environment that is supportive of this approach; an environment that offers the resources and the personnel needed for effective instruction emphasizing inquiry/discovery. This support role must be supplied by school administrators, peers and parents.

The guidelines for programs funded by the U. S. Department of Education's Office of Bilingual Education and Minority Language Affairs offer financial support for training programs for teachers of LEP students in a number of areas including science and mathematics instruction (1990, 1991, 1992).

Examples of Available Science Instructional Materials

Almost all of the instructional materials in the sciences for LEP students distributed to schools by commercial publishers are encyclopedic in nature, thus calling upon students and teachers to read extensive amounts of written materials in English. Some of these materials have been translated into Spanish or into other languages. These materials, generally, are inappropriate for producing the most effective science instruction of LEP students. A few examples of these very traditional science materials are included in the Appendix; since they can serve as reference materials for students following completion of, or as part of, IALS modules. These also may serve as sources of content information for teachers.

To reiterate, caution should be taken in using such materials as the only or the major source of instructional experiences. An example of reason for this caution is exemplified by a high school level biology textbook published in 1991. This book contains an average of 41 new vocabulary words per chapter. This book of 38 chapters contains nearly 1600 technical terms! Even for majority English proficient students this condition is pedagogically unacceptable. Those who wish to understand further this excessive packing of terminology in standard textbooks are referred to the article: "The Basal Conspiracy" appearing in Education Week (1991.) Below are examples of science instructional materials that will better serve science language and mathematics instruction of LEP students.

Recent Science Programs: Elementary School Level

o 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 content 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 several introductory sections: "Hispanic Culture, Past and Future," "Integrating Hands on Activities and Cultural Connections," and a resource "Locating Hispanic Science and Engineering Role Models." This resource was developed through a project within the city of Chicago School District.

o 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. The development of this instructional program was supported by the National Science Foundation. It contains many hands on science activities; and it encompasses information in the areas of health and social sciences presented in simplified English language. Users will want to be cautious of some content errors and of the highly prescriptive approach. However, its level of language presentation does makes it useful in the instruction of LEP students.

o <u>Full Option Science Study</u>, or 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 is designed to be used as a supplement to any basal science program for the upper elementary and middle school grades. The hands-on science investigations of the FOSS program could serve effectively as the basis for science instruction if placed in the hands of teachers who already are knowledgeable in science. The FOSS program, published by Encyclopedia Britannica Films, was not specifically designed for LEP students. However, if utilized effectively it could serve advanced LEP students.

o <u>Kids Network</u> (1990) is a supplemental science program, whose development also was supported by the National Science Foundation, designed for use at the middle and upper elementary grade levels. The program developed by the Technology Education

Research Corporation or 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 requirements of Kids Network make it very appropriate for the English language development of LEP students. Of particular interest is that students learn how to use the word processor in communicating information to one another. On the negative side, the program is costly to initiate.

o <u>Finding Out</u> or <u>Descubrimiento</u> (FO/D), (1988) is a supplemental instructional program designed specifically for use by LEP students. It 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 both in English and Spanish language. <u>FO/D</u> was developed by DeAvila and Associates and is published the Santillana Publishing Company of San Diego, California. FO/D is especially effective in introducing science content to LEP students as well as in developing basic measurement and math skills. If the Spanish translator is utilized judiciously, FO/D can serve effectively to develop English language among LEP students.

o "Science and Technology for Children" is a full elementary level science program, under development by the National Sciences Resources Center of the Smithsonian Institution and the National

Academy of Sciences in Washington, DC. Several modules are presently available. The instructional program places great emphasis on hands on investigations. Kits of equipment and materials, as well as written directions, are being made available as they are completed. Though not specifically directed to LEP students, this program could effectively serve academically able LEP students.

o Project SMILES (Science/Math Integrated with Language for Elementary Schools, already referred to, is a science driven instructional program designed specifically for LEP students at the elementary school level. The program, under development, consists of a series of thematic units or Integral Activity Learning Sequences (IALS). As indicated in Chapter II each IALS is introduced through a science activity producing unusual results. This activity is followed by other science investigations and appropriate related language and math activities that are designed to develop both math and English language skills. The activities are designed to be taught using cooperative (instructional) groups. This program is being developed through the Science and Mathematics Teaching Center at Temple University in Philadelphia, PA, in part through Pennsylvania State Department of Education support. The format of the IALS, at present, is a teacher's guide with directions for teachers of LEP students to develop their own student worksheets, etc. Publication of this program has not occurred as yet.

Recent Science Programs: Secondary School Level

o Chemistry and the Community or ChemCom (1988, 1992) is a chemistry instructional program whose development was funded by the National Science Foundation and the American Petroleum Institute. While designed for use at the 10th or 11th grade level, the English language readability level of ChemCom is grade nine. The science content of ChemCom is not heavily packed with science language because of the inclusion of social science implications of science as well as with ample science and social science hands on investigations. Although not specifically designed for LEP students, research indicates that ChemCom effectively serves the instructional needs of LEP student populations. The program, which contains narrative and investigative activities under a single cover, is published by Kendall/Hunt Publishers of Dubuque, Iowa.

o Supplementary workbook type materials, whose development is based upon the Cognitive Academic Language Learning Approach, or CALLA model, have been published under the title of Content Points A: Science, Mathematics and Social Studies Activities. This material, published by Addison Wesley Publishing Company, contains mostly paper and pencil directed activities. The few hands on science activities included are prescriptive, consequently, these materials are of limited use for science concept and language development. There is little carry through from one lesson to the next. This reduces opportunity for students to develop the scientific terminology and other related language structures.

Clearly, there is need for additional effective science instructional materials to be developed for use in the instruction of LEP students, especially for the secondary level. Thos、 who would develop such materials will want to seriously consider the premises proposed earlier in this monograph as a basis for such development..

Teaching Science and Language Competence

The above examples of instructional materials indicate an ongoing problem related to effective science instruction and the development of English language skills. Developing both competencies requires very special attention to how instruction unfolds; that is how communication occurs between teacher and student.

J. Lemke, in his book Talking Science: Language Learning and Values (1990), indicates examples of the poor quality of oral communication that goes on in science classrooms. Below is a typical example of such communication from a high school chemistry classroom.

"Teacher: This is a representation of the one Sorbital.
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."

Notice from this example, which is typical of much of the science instruction occurring today at the secondary school level, that thoughts are left incomplete, that emphasis on grammar and appropriate language structure is ignored, and very little is expected from students in terms of understanding content beyond that which is to be memorized. Also, note that the only question asked by the student (Jennifer) is merely questioning her own response; and the question is incompletely stated.

Lemke indicates that this is an example of classroom dialogue referred to as "question - answer - evaluation pattern" or "triadic dialogue." It has been referred to earlier in the monograph as "discussion." He indicates that any rules underlying typically used instructional dialogue "stacks totally against learning either science or language." The triadic dialogue, he asserts is a pattern that students quickly adopt. And this pattern leads neither to learning content or language. All triadic dialogue accomplishes is maintaining some form and degree of teacher classroom control. If this example indicates poor quality science-language instruction for majority students, imagine the poor level of instruction it exemplifies for LEP students!.

Triadic dialogue of the type presented in the example does not assist students in putting together workable "science sentences: and "science paragraphs." It indicates 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. This form of instruction "appears to take for granted that students will just catch on through this 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 backgrounds where the activity,s 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 communication in science classrooms. These components are summarized below:

- Give students more practice talking science, correctly.
- 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 fallable-human social activity, rather than as a superhuman infallable activity.

- Emphasize that science is just another 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 III: "Science Driven Instruction," is embodied in what is today referred to as the constructivist learning theory. The usefulness of this theory is suppported through research indicating that most students enter school with misconceptions about both natural phenomena and the explanations for these. Also known is that science instruction in schools, as presently practiced, (for the most part), does not easily eliminate these misconceptions, even among able students. In addition, even those students who perform well on standardized tests, too often are unable to apply memorized facts and algorithms in correctly interpreting experiences. These inabilities cause educators to seek other than a "rote model" for instructional practice. That model, constructivism, as indicated earlier, is based upon the premise that the degree or extent of successful learning outcomes is dependent upon offering 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 upon the rate at which this communication occurs.

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

In a National Science Foundation publication, Van Gloserfeld (1988) indicates 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.

The individualized prescribed type of curricula, developed during the 1970's, failed because students were expected to learn quantities of information with minimum application of this information. In addition, teachers constrained by the traditional school structure and by the need to prepare students for standardized tests, expected all students to end up at the same level of learning, in spite of the fact that science curricula were designed to be individually prescribed. The need to perform well on standardized tests drove instruction away from the goal of individual prescription.

When instruction in science is built upon the "constructivist theory" "levelling" is deemphasized. Instead each student is challenged to reach high expectations at his/her own level of competence.

Following is a list of instructional practices that grow directly out of the acceptance of constructivism. This list is a significant revision, by the authors, of a list presented by Yeager in "The Constructivist Learning Model" (1991). Constructivism mandates that instruction of LEP students must be designed to:

- seek and use questions, experiences, and ideas proposed by LEP students to guide the preparation of and the presentation of science directed lessons and instructional units.
- promote collaboration in learning among LEP students.
- use more open ended questions developed both by teachers and students, and set the stage for LEP students to fully elaborate on their responses to these questions.
- allow ample opportunity for LEP students to test their own ideas.

- offer LEP students opportunities to challenge each other's explanations and approaches. This should occur individually and within cooperative groups. The group approach must allow for interaction of students with other students, as well as students with teachers and with aides.

- assure the availability of adequate time for reflection, analysis, general problem solving, and understanding through the use of both the first language and English.

- give ample opportunity for students to investigate using hands on materials, both individually and in structured groups. (Investigations should be utilized more to introduce topics or concepts rather than to verify these.)

- utilize lectures, demonstrations, note taking, films, etc. more for summarizing than for the formal introduction of lessons and units.

- assure greater opportunity for more self student evaluation and opportunity for choices when they are involved in assessment procedures.

- assure that teachers and textbooks become a less significant source of information. (A variety of sources of information must be made available for student discovery.)

- offer ample opportunities for LEP students to apply learned knowledge and skills in the new situations.

A careful review of the above educational practices indicates similarity with those proposed in Chapter II for inquiry/discovery directed instruction. Those who are particularly versed in language instruction will see similarity between constructivism and the "whole or natural language approach" as described in <u>Portraits of Whole Language Classrooms</u> (1990). Whole language deemphasizes pure memorization of language and gives emphasis to language skill development and comprehension through use of the language in real world settings, such as during the learning of science integrated with other subjects.

The IALS presented in Chapter II and in the Appendix is a second example of instructional materials that in effect is constructivist driven and that emphasizes the whole language approach to English language development.

Looking Forward and Back

This chapter has unfolded a model for better understanding the relationshship between the lecture/discussion and inquiry/-discovery strategies in teaching science to LEP students; as well as the tie of inquiry/discovery to the constructivist instructional theory, and the whole approach to English language instruction. The value of emphasizing inquiry/discovery in instruction, for LEP students, has been indicated; and the essential need for teachers to gain practice with this approach has been indicated. Especially when teachers revert to lecture/discussion, it is essential that they carefully plan their presentations so as to assure that correct and complete English language structures are called upon and expected by their students. Emphasis has been given to the fact that English language literacy must be a prime goal of science instruction if that instruction is to produce learning and attitude change related to further instruction in science among LEP students.

Those teachers, and others, who are serious about changing instructional practice through the model proposed here are referred to a publication by Fradd: Meeting the Needs of Culturally and Linguistically Different Students (1987). Chapter four of this reference considers conditions to support necessary instructional reform.

CHAPTER IV

CONDITIONS TO SUPPORT REFORM IN SCIENCE DRIVEN INSTRUCTION FOR LEP STUDENTS

Summation

For those who follow the practice of reading only the final chapter of a publication such as this, the authors introduce it with the major recommendations presented throughout the earlier chapters. This is followed by consideration of the nature of various supports needed to better assure that effective learning of science, language and mathematics will occur among LEP student populations.

The recommendations for effective reform are:

(1) integrate language and math skill development with science in instruction.

(2) introduce math skills related to science or strengthen these skills through their applications.

(3) call upon math content and science content, as well as hands on group activity, to introduce and to strengthen second language vocabulary and structure.

(4) tied to science, the abstract nature that is inherent in basic math skills is reduced.

(5) offer opportunity for students to assist each other, through group instruction, in the process of learning (facilitated or managed by the teacher and/or the teacher's assistant).

(6) overcome the disruption to learning inherent in the use of "pull out" type ESL instruction, and emphasize the use of the whole approach to English language instruction. This is opposed to <u>excessive</u> use of native languages in instruction. Sequencing lessons around themes allows for repititive language use both in English and in the native tongue.

(7) teachers and administrators must work to overcome the weaknesses associated with school structure and practice that are detrimental to effective instruction of LEP

students. This need is particularly critical in urban school settings.

Support for Reform of Instructional Approach

Support for the approach to instruction, proposed herein for LEP students, comes from the professional experiences of the authors, from testimony by teachers who have experienced the success of this approach to teaching LEP students, and from the literature. Below is support specifically from research based literature in support for the approach that has been described.

In the "Bilingual Mathematics and Science Achievement Evaluation Report" (RIEMAR91), Berney et al indicates that:

> Project BSMA, an instructional program designed to provide intensive mathematics and science instruction, beyond concepts presented at the mastery level in the native language produced significantly positive results in terms of learning in all three academic areas.

In "Language Through Science and Science Through Language: An Integrated Approach" (RIEMAR86), Chellapan (1983) indicates that:

> While the need to strengthen the transfer of language skills across disciplines, as well as to integrate language instruction with other components of the curriculum is recognized, it also is clear that the language of science has a set of symbols that are different from those that are learned for daily life . . . . 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. This leads to blurring the distinction between science and language instruction.

R. M. Jones in "Teaming Up" (1985) indicates that:

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

In 1977 Sutman et al 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 <u>30 times</u> 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; reducing lack of self confidence.

The reverse issue of how ability to learn science is impacted by bilingualism has raised the question: are students with limited English language proficiency, who gain or develop bilingual competence, able to learn science as effectively as other students? This issue is thoroughly addressed by Kessler C. and Quinn M.E. in the publication: "Consequences of Bilingualism in a Science Inquiry Program" (1981). They state that:

> research leads to the conclusion that bilingualism does not deter students' abilities to formulate scientific hypotheses and solutions to scientific problems. Instead this ability is enhanced by bilingualism.

Sutman, et al (1993) reports on the results of a study involving the use of the IALS approach:

> The study, involving nearly 400 English language proficient and limited English (language) proficient fourth graders in

> 16 classrooms in hands on science driven basic skills activities, was conducted mainly through cooperative instructional groups. The results of this study indicate that compared to the control group, in which science was taught through reading a science text, LEP students improved in science knowledge on a par with their non-LEP student counterparts. And the learning of basic skills (math and written English) was significantly ahead of the students in the control group.

The conclusion was drawn that the use of IALS materials in the group instructional format compensated for the varied learning styles among the students. That is, learning styles had no impact on the learning that took place.

The results of the kind of research reported here support testimonial statements made by knowledgeable educators concerning the improvement of instruction for LEP students. However this instruction will only be totally effective if it is bolstered by a variety of supports from school, community and home. This need for support and the nature of that support is considered in the following, and final, two sections of this chapter. The first section describes unsupportive school settings. The second looks for effective change.

<u>School Settings Unsupportive and Supportive of Quality Science</u>

Too often school settings are unsupportive of the kind of instructional approach described herein. Though well intentioned, these schools supply instruction to LEP students that produces minimal learning. The vignette below indicates a "typical" school setting. The vignettes are taken from a popular book: Among School Children (1991).

> She (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 ....
>
> The teacher told herself, some kids don't know they want to learn until you put it in their heads that they do. She mulled over the other teacher's comment: I'll teach the ones who want to learn. She would answer that her own son might not get taught if his teachers followed that strategy. And still, it was alluring. You can't fail if you don't try.
>
> At eight (o'clock), 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.

These vignettes indicate a kind of blind - uninformed and dedicated "professionalism" that somehow led to learning for some students. The learning that takes place in arcane environments such as that described occurs almost by chance. Schools must be restructured to reduce this typical approach to instruction.

In contrast the descriptions that follow indicate the kind of restructuring of schools that is needed to facilitate successful science instruction for LEP students for the twenty-first century.

Case I.

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 and 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 language(s). 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 appro-priate nutritional requirements. They performed several science demonstrations related to nutrition in each classroom.

Case II.

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 the materials were related to the content designated by the syllabus for each instructional level. Groups of children from different classes were invited to present either the projects or materials that they developed to other classes; and the teachers assisted them in preparing for these presentations. Assessing what students had learned through these experiences became an integral component of instruction. Portfolio or folders were kept of each student's work. These served diagnostically, informing each teacher where students needed special support.

Case III.

A decision is made to develop or to locate at least one hands on science activity to be used in the science instruction for each week, and to develop or to find already available related math and language activities for instruction. Each activity is completed using English, 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 vote for a series of awards to be presented to each class. Every classroom receives an award.

Case IV.

Homework related to each integrated (science, language and math) lesson was written each day on the chalkboard by a student, prior to the lesson; and teachers assisted students in coping the assignment both in their native language and in English, (in English and a foreign language for non-LEP students). The students assist in the translation process. This is not done in a hurry at the end of the day as an afterthought. Instead assigning out of school work became an integral component of the instruction. 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 in a group - instructional activities.

Case V.

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, to present announcements, learning to do this both in English and in other languages. Prior to, and during the announcements, teachers are cued to assist the young announcers to carefully present the messages. Other students are assisted by their teachers in understanding the intent of the messages that are delivered.

Case VI.

A science textbook is utilized only as one of several sources of factual information. Teachers develop or purchase only limited numbers of drill and practice exercises. Portfolios containing work in science, math and languages are kept by each student indicating at any moment in time 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.

A sociologist of teaching has described the school conditions described in Among School Children as indicated in the last section, 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.

In contrast the descriptions above developed by the authors, indicate situations where students and teachers are considered as important human beings; individuals who have the potential to learn cooperatively. Experiences with school environments modeled after these descriptions indicate that learning in such environments occurs far beyond the level found in more traditional schools. However, school environments like these described above alone are not enough. In addition, special emphasis on language development must occur across the entire school both for LEP and EP students.

The monograph: The Status of Bilingual Education in the United States (1991), prepared for the Office of Bilingual Education and Minority Language Affairs OBEMLA, indicates the need for continued research to determine the most effective procedures for English language instruction; although OBEMLA awards grants to school districts solely for programs of the transitional type that range from those in which content area instruction occurs primarily in the native language to those in which students are immersed almost totally in the English language within self-contained school classrooms. Some programs call upon "pull out" type English as a Second Language or ESL instruction; a strategy which takes LEP children out of the classroom, individually or in small groups, for concentrated short term ESL experiences. The pull out procedure, in effect, segregates and splinters LEP children by excluding them, in spurts and starts, from the regular ongoing classroom instruction in other areas of study.

Charles Glenn, in: "Educating the Children of Immigrants" (1990) unfolds practices used in other democratic countries especially in Europe and Israel. These countries, like the United States, have experienced large immigrant school populations. Glenn concludes that, at the lower grade levels, a combination of reception classes designed to orient new immigrants to the new culture and language, and continued home language supplemental classes, joined with academic instruction in the second language, for a short initial period, (prior to immersion in science and other subjects) will best serve immigrant students' needs.

At the secondary level all students including LEP students, should enroll in subjects such as cultural history to be taught in the native language of the majority of LEP students. This will strengthen their native language competence and at the same time serve as a powerful vehicle for developing foreign language competence.

It is obvious that both limited English (language) proficiency as well as lack of bilingualism among EP students are problems that pervade too high a percentage of the school age student population in the United States. Science literacy for all students is also a prime goal. Therefore, science must play a significant role in language development both as part of initial ESL experiences, ongoing science experiences, and in developing native language proficiency. Only this integrated format can effectively address the variety of educational goals and objectives important to be met by the LEP and EP student populations.

With all that has been said about curriculum structure, no approach no organizational pattern will be effective, in Glenn's words, "without hard work, sensitivity, and a commitment to the (conscious) full participation of LEP and EP students in learning activities designed by professionals to meet the significant goals of instruction . . . . . "

The Role of Technology: Computers

It is not possible to consider in detail every means of support for enhancing science instruction for LEP students. However, this monograph must not end without at least mention of the role of computers in this process; as well as a massive movement that is underway to reform approaches to assessment of student learning in science.

Today's and tomorrow's schools, to be effective, must incorporate computer technology into most aspects of instruction. This is particularly true for instruction in science and mathematics. Aside from their use to simulate the ideas of science that may be too dangerous to be experienced hands-on, computers are very effective in simulating ideas that otherwise are very abstract and therefore difficult to comprehend. In addition, science is an excellent context in which to teach computer skills in preparation for the real world of work. Research just beginning, however, indicates that the introduction of computers prior to extensive hands-on science and other real experiences may deter the value of the computer in understanding science. Preliminary judgment indicates that too early use of computer simulations <u>cannot substitute</u> for real experiences. Simulations, used appropriately, should be able to complement the real experiences of the science classroom.

Several very useful sources designed to assist schools in effective use of computers in science instruction include: Volume 2 No. 3 of the <u>California Technology Project's Quarterly</u>: "Technology in the Science Curriculum K-12." This "theme issue" of the <u>Quarterly</u> addresses: "Software for the Science Classroom," "Telecommunications in Science," "Education for a Planet at Risk" and "Animalia and Hidden Technology." Standards for Schools for use of computers are presented in the article "Vision: Technologically Enriched Schools of Tomorrow."

The goals that schools can achieve through effective science instruction through computers are clearly delineated in the publication: Comprehensive Education Plan for the State of Florida: Improving Mathematics, Science and Computer Education in Florida (1986).

Reform In Assessing Student Learning in Science

A substantial effort to revise approaches to assessing student learning is underway nationally. There are a number of valid reasons for this "alternative assessment movement," including bias against the assessment of learning by LEP students and other minorities. Related to these two concerns is an even more important consideration; that the nature of assessing student learning has direct impact on both the content of the curriculum and on the strategies emphasized in teaching.

Traditionally multiple choice standardized tests and poorly constructed teacher made tests have resulted in excessive emphasis on rote memorization of science facts and reduction in experiences students have with hands on science investigations and other experiences designed to develop levels of proficiency beyond the memorization of science facts. The Nation's Report Card (1990), for example, indicates the results of the National

Assessment of Educational Progress examinations. These results indicate appalling scores on science items that measure students' understanding of simple science principles, ability to apply basic scientific information, ability to analyze scientific procedures and data, and ability to integrate specialized scientific information. LEP and other minority students perform especially poorly on items designed to assess these levels of scientific proficiency. It therefore follows that there is need for serious review of and development of revised approaches to assessment of student learning.

Three chapters of: Science Assessment in the Service of Reform (1991): "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. The "assessment monograph" addresses the need to revise science assessment to better serve these students. Revisions in assessment practices are needed to reduce the use of testing as a "gate keeper"; an approach that continues to increase the number of minorities who contribute to the advancement of the scientific enterprise in the United States.

Testing in American Schools: Asking the Right Questions (1992), prepared for the U. S. Congress, by the Office of Technology

Assessment addresses the major issues related to reforming assessment in education in all subjects and for all students including LEP students.

Accellerated movement to improve assessment of student learning is relatively recent. Therefore little more can be said here about its impact on educational practice, particularly as it relates to the instruction of LEP students. The National Science Foundation continues to be a leader in supporting efforts designed to improve practices related to science instruction.

Conclusion

The Office of Bilingual Education and Minority Language Affairs (OBEMLA) of the U. S. Department of Education supports long term and short term training programs specifically for teachers of LEP students. The National Science Foundation supports many teacher enhancement projects for teachers of science and mathematics; some are specifically directed toward the preparation or enhancement of teachers of science to LEP students. It is a challenge to both the science education and bilingual education profession to join forces to redirect more effort toward the advancement of the proven approaches, described in this monograph, to the instruction of LEP students. These students specifically, and the nation more generally, can ask no more significant commitment.

Or as Kati Haycock and Luis Duany state, 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 to these two quotes: The need for sustained - systemic reform in teaching science to LEP students is imminent. All appropriate professionals must work diligently to produce the reform required for improved science instruction for LEP students and their teachers. Students' ambitions must not be crippled by lack of will and commitment on the part of professionals!

TEACHERS GUIDE TO AN
INTEGRATED ACTIVITY LEARNING SEQUENCE (IALS) EMPHASIZING SCIENCE FOR PRE SCHOOL 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

- Obtain 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

STUDENTS' & TEACHERS' ACTIVITIES

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

ASSESSMENT OF LEARNING

- 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

CONTENT AND PROCESS LEARNING OBJECTIVES

(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

QUESTIONS STUDENTS MAY ASK

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 • 2 plastic toothbrush tubes • matches • 5 of 6 filaments of green live elodea plants (from pet shop) • 2 plastic dishes • paper towels • water (standing one or two days)	out of the tank using a measuring cup, *pouring* cups of water back into a quart container, to see that 4 cups make one quart. • Children determine the temperature of the water when it is placed in the tank; (do this to the nearest degree). (then after two days) Count 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 less than 70°F and 70°F is 10°F more than 60°F. If the thermometer also reads °C count differences in temperature in °C. (°F = Fahrenheit, °C = Celsius). • Place an air pump in each tank and plug it into an electric outlet. • Use strainer to take guppies, one at a time, from a container, placing them into one of the tanks. Students count 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.	place 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? (Don't expect proficiency in learning from the dictionary activity. This will take much more experience. But don't give up. Continue this activity over the entire year.) • Are students able to develop action expressions in English using basic verbs, nouns? • 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.) • 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.	• Simple addition and subtraction • Introducing art (don't expect proficiency) • Describing actions orally using English language. Complete sentences • Keeping track of vocabulary in a dictionary • Care of living things • Food is made from once living things	• Do the measurements made by the different groups agree? (Yes, unless someone has made an error.) • Why do we use two diff rent kinds of degrees? (°F was developed in England, °C in France.) • What are the bubbles coming from the pump? (This is a pump for air.) • 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 <u>draw</u> 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 <u>draw</u> the original guppy develop a lesson during which the students <u>observe</u> and <u>describe</u> the guppy. Notice head, tail, fins, eyes, etc. Speak about each and ask class to repeat the sentence. "We can <u>see</u> the guppie's fins <u>move</u>," as an example. Students should <u>label</u> their drawing, using "post it" notes. If old enough, students <u>write</u> the labels.	• <u>Exhale</u> through a bent soda straw into a tube filled with water partly *immersed* in water. <u>Collect</u> the exhaled gas. Can the students determine if this gas <u>supports</u> 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: <u>fish tank</u>, <u>water</u>. For younger children use pictures.	• Can students show that fish (animals) get the oxygen they need from dissolved air containing oxygen? (<u>Place</u> a glass of cold tap water on the warm window sill. Students <u>watch</u>, over a period of a day, to see bubbles form as the water warms. This demonstration can be accelerated by <u>using</u> a hot plate kept on low heat. Can these bubbles be collected in an inverted plastic tube? The bubbles are air that remain <u>dissolved</u> 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 <u>assist</u> in <u>writing</u> down words under appropriate letters. While doing this, <u>help</u> them to make up an <u>action</u> 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. Labelling the art with English names of objects.	

PREPARATION AND MATERIALS	STUDENTS' & TEACHERS' ACTIVITIES	ASSESSMENT OF LEARNING	CONTENT AND PROCESS LEARNING OBJECTIVES	QUESTIONS STUDENTS MAY ASK
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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 moth 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.)

STUDENTS' & TEACHERS' ACTIVITIES

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

- <u>For Advanced Students</u>:

  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.

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

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

  Apparently, regular air <u>supports</u> 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 <u>make</u> drawings of the investigation and keep a written history. They also may want to <u>write</u> down each question that they are seeking to <u>answer</u>.

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

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 <u>in sunlight</u> 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.)

APPENDIX A

AN INTEGRATED ACTIVITY LEARNING SEQUENCE

IN SCIENCE

FOR THE UPPER GRADES

APPENDIX A

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

Introduction

The IALS included here like the one included in Chapter II is deisnged to integrate science and mathematics and English language instruction. This IALS is presented as a "Guide for Teachers." It is designed to span six to eight lessons of instruction. However, it differs in that it is divided into discrete lessons rather than following a columnar format. The content of this IALS comes from the physical sciences. Note that the quantity of materials needed allows for five groups with five students in each group.

- 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 tape
- 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 the readiness of students for this IALS. The answers are in parentheses. If need be, give students opportunity in groups to measure and to calculate the answers.

A. Fill in the missing numbers and units:

1. 0.5 cm = (50) mm

2. 5 cm^2 = (2500) mm^2

3. 352 cm^2 (area) x 21 cm (length) = (7392 cm^3); 60 cm − 24 cm = (46 cm)

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

B. Write down these even words in alphabetical order and define each using a complete sentence.

matter	water
centimeter	air
displace	space
particles	moving

1. (air) 2. (centimeter) 3. (displace)

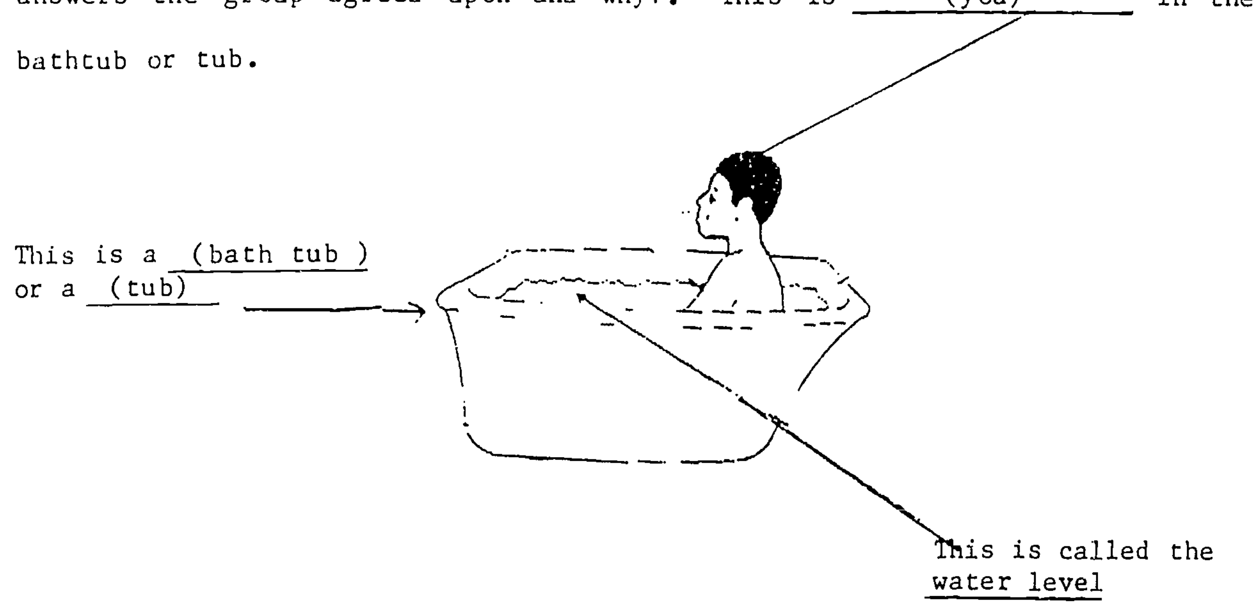
4. (matter) 5. (moving) 6. (particles)

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, have each student instructional group discuss the following questions, and then complete the rest of this page.

C. You always place water into a bathtub when you take a bath.

How much water do you 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.



Fill each space with the correct word. Choose from the words below:

bathtub	water
you	rises
water level	

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 what happens when they take their next bath.

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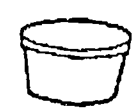
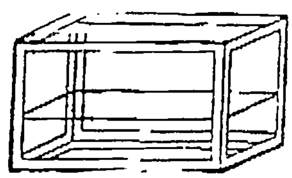
Lesson Two: A Sunken Boat

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 without giving away the answers. Be certain that the English language to be used is understood.

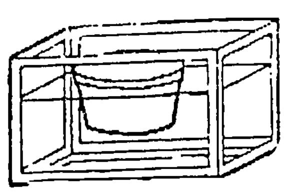
What happens to the level of the water if a boat floating in the tank sinks? To do this investigation, you will need the materials shown below. Label the diagrams using English words.

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.

The boat (sank) to the bottom of the tank.

Each student in a group should be given a sheet with the above diagrams drawn on it. Members of each group are asked to agree on how to respond to each part of this activity.

Draw a line under the picture that shows the boat after it sinks. Draw a line on the tank to indicate if the water level raises or lowers or remains the same when the boat sinks. Is the drawing correct? Perhaps the group believes the water level does not change or remains the same. If so, show this on the drawing.

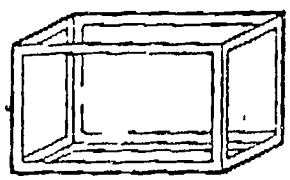
- Tell why your group believes that the water level rises.
- Tell why your group believes that the water level drops.
- Tell why your group believes that the water level stays the same.

Your group should decide on an answer and write it down below. Then you should agree upon a reason for this decision.

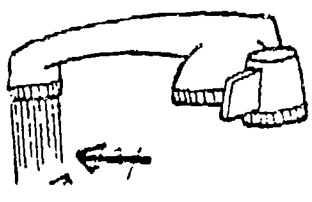
We believe that the water level (answers will vary) when the boat sinks because (will vary)

B. Now that each group has formed an hypothesis each will investigate to find out what really happens. Does the water level rise, drop, or remain the same when a floating boat sinks? (The water level drops or lowers.)

To find out you will need to use the items drawn below. (Students will write down the name for each item.)

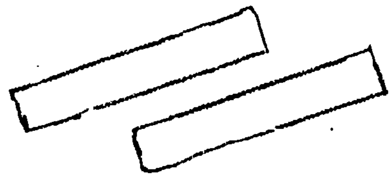


(fish tank)



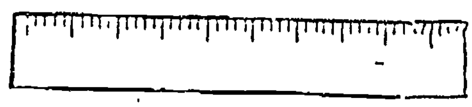
(water from faucet)

(bowl or boat)



(two) pieces of masking tape

(clay)



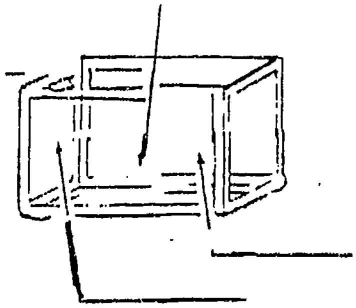
a metric (ruler)

Ask one person from each group to make up a sentence using the name of each item. Now each group, with your assistance, will complete the following activity: before they do the teacher adds just enough clay to the bottom of each boat or plastic dish to slightly submerse the plastic dish (boat).

C. Half fill the tank with water. Float the boat in the water. Mark the water level with a small piece of masking tape. Now push the boat under the surface of the water. Mark the new level with the second piece of tape.

Use the drawings below to show what actually happens to the water level. Fill the blanks next to each drawing to show what happens:

Show the original water level.



Draw the sunken boat.
Draw the new water level.
Correctly write down the words to show what has happened.

Complete each sentence below:

The boat is <u>(floating)</u> in the water.

When the boat <u>(sinks)</u> the water level <u>(drops)</u>.

D. Now, your group can find out what caused the water level to change. (Teacher: the level will drop.) One member of each group will explain to the rest of the class why the water level dropped. To help you do this, turn the boat upside down in the tank of water. Keep the boat submerged and slowly let the boat fill with water. Did you 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.)

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

Lesson Three: <u>Review How Much Space or Volume?</u>

Notice the two water level marks. How can you measure the volume of water that fits between two marks? (Measure the change in height of the water as the first step in finding this volume.)

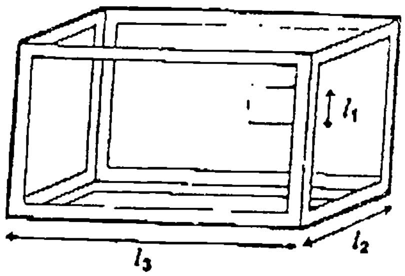
The change in the <u>height</u> of the water (L_1) ________ cm.

The total space that contained air but now contains water is called the displaced volume. Water from the tank took the place of or displaced this volume of air. You can find this volume by measuring the three different lengths shown in the drawing: L_1, L_2, L_3. Measure L_2 and L_3 in centimeters (cm).

L_1 (distance between water levels) ________ cm (height) (h)

L_2 (of the tank) ________ cm (length) (l)

L_3 (of the tank) ________ cm (width) (w)



Now multiply L_2 x L_3 to find the area of the tank.

L_2 x L_3 = area

_____ cm x _____ cm = ________ cm^2 Now multiply the area by L_1.

area ( ) x L_1 ________ cm^3

_____ cm^2 x _____ cm = ________ cm^3 (Answers will vary)

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

E. Write down how your group found the volume of the air that was displaced as the boak sank. One possible way is described here. We found the volume of displaced air by measuring (the three lengths L_1, L_2, L_3 of the tank. Then we multiplied those lengths to get 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 you can use a measuring cylinder to find the volume of the displaced air. Write down the procedure below: (Give students help as needed.)

We can measure the volume of displaced air by using the measuring cylinder.

First: ____

____

Now measure this volume by following the procedure that you wrote above. Use the space below for any calculations you might do.

Calculations

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. Also, 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. Do the two methods of finding out this volume agree?

Write a sentence or two to describe why they agree or disagree. This answer 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 is filled with 1000 cm^3 of air. is floating on the surface of a tank of ater. When it sinks, the water level drops 10 cm (L_2). The tank is 10 cm in length (L_3). How wide (L_2) 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.

____ cm/in ____ cm/ft ____ cm/yd ____ mm/5cm ____ (answers)

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. (procedur
• 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:

Definitions:

1. ____________________

2. (example) (The centimeter is a small unit of metric length

3. ____________________

4. ____________________

5. ____________________

4. Writing Sentences   Write three sentences. 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   Match 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 in^2	(1)
(d)	in	(4)	take the place of	(7)
(e)	in^2	(5)	$\frac{12\ in^2}{4\ in} = 3$ 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? Disuss why? Why not?

Lesson Five: Mixing Matter Together

1. Supply each group with two 100 cm^3 measuring cylinders, and with water and denatured alcohol. Assist each group in measuring and mixing 50 cm^3 of each liquid.

o Use a 100 cm^3 measuring cylinder to measure 50 cm^3 of water.

o Measure 50 cm^3 of alcohol into a second 100 cm^3 cylinder.

Predict what the combined volume of these two liquids will be when they are added together?

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

- Carefully pour the 50 cm^3 of alcohol into the 50 cm^3 of water. Place the cap on the cylinder and gently mix the two liquids. Now read the combined volume. (The volume turns out to be (97 cm^3.) Is this the volume you expected? If you answered no, write down why. If yes, write down your reasoning. ______________________________

- Now, orally, explain in writing, 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 particles of (water and alcohol mix together 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 reference book. Then use each word in a sentence.

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)	

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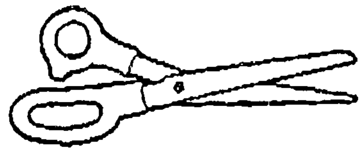
Lesson Six: Matter On The Move

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 will report to the rest of the class what they have done.

You will need:

- a ball of string

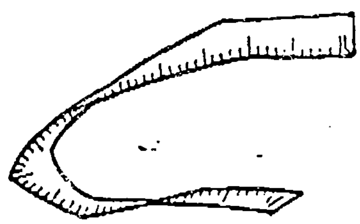
- scissors
- thumbtack



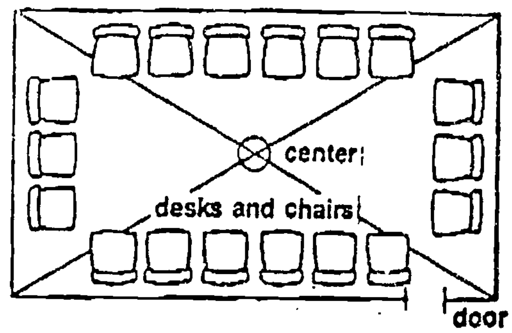
- bottle of perfume or a bottle of household strength ammonia

- piece of chalk

- metric tape

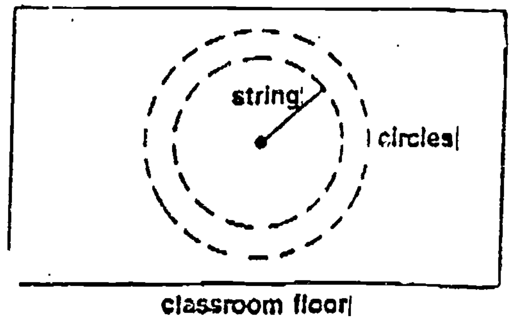


A. Groups I and II now will move all of the desks and chairs around the outside walls of the classroom. 1/3 of the desks and chairs are to be placed along each of the longest walls. 1/6 of the desks and chairs are to be placed along each of the shortest walls. Students will figure out or calculate the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



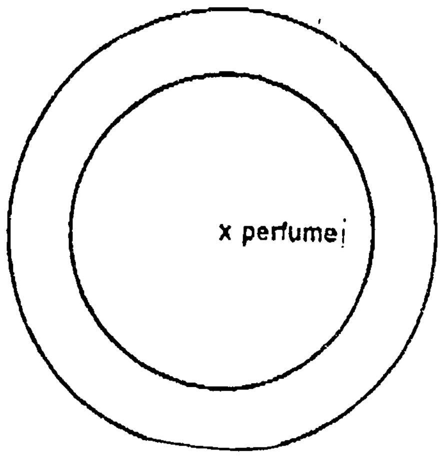
Looking down on the floor of your classroom

Group III will figure out a way to find the exact center of the classroom floor and mark that center with an X. Use two metric tapes or a long piece of string to find the center of the floor. Mark this center with a big X.



Looking down on the floor of your classroom

Group IV will figure out a way to draw a circle with a radius of 150cm on the classroom floor with its center at the center of the room. (Do this using a piece of chalk tied to one end of a 150cm length of string.) They 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 250cm. (Do this using a 250cm length of string tied to a piece of chalk.) The teacher will help. (Vary the radii depending upon the lengths (l_1) and (l_2 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, 3-1,000, 4-1,000, etc.

B. 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 this number should sit around the smaller circle; and one-half (1/2) of this number of students should sit around the 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 and at the center of the two circles and then open the bottle. A student from Group VI (the timekeeper) will count 1-1000, 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 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		Larger Circle B	
Students	Time (Seconds)	Students	Time (Seconds)
1		1	
2		2	
3		3	
4		4	
5		5	
6		6	
		7	
		8	
		9	
		10	
		11	

C. Find 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 do this you add up the total times & divide by the number of students.)

The average time that it took the perfume to reach the inner circle was ________ seconds.

Totals	12 Totals

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

Average Times ______________ ______________

The difference in average time is (because the particles of perfume had further to travel to rea:h the outer circle. If times come out the same i· 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 you to remember the definition of the word particle and to remember its use in explaining what happened when alcohol and water mixed. Write down the explanation.

(Perfume particles moved between the air particles. They eventually reached students noses in each of the circles)).

Now find out how fast the perfume particles moved through the classroom? To find out, divide the distances from the center of the circles to the circle themselves by dividing the distance the perfume particles moved by the averge time that it took the particles to move to the students in each circle. This is the average speed of the perfume particles. Speed is how fast something moves.

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Divide

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

COMPARE THE RESULTS

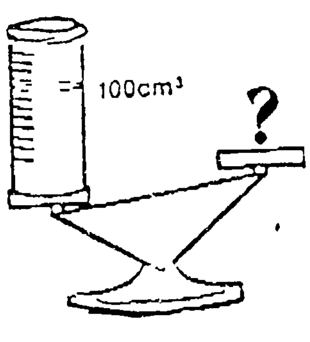
Divide

$$\frac{\text{distance (in cm.) from the center of the larger circle to any student sitting around the circle}}{\text{average time (in sec.) it took the particles to move this distance.}} = \frac{\text{cm.}}{\text{sec.}} \text{ (speed)}$$

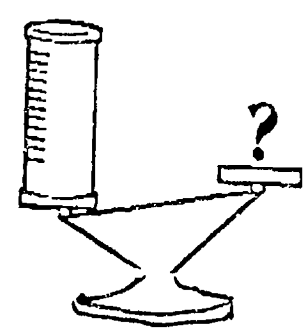
Now write about the speed of the perfume particles. Use complete sentences. (The average speed of the particles travelling to students in both circles is about the same. This is true even though the particles had to travel different distances.)

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.



You can use a balance or a scale to find out how much your groups 100 cm^3 measuring cylinder weighs. Weigh the cylinder. Then add 100 cm^3 of water to the cylinder. (Be certain that the outside of the cylinder is dry.) Weigh the cylinder and the water. When you subtract the weight of the cylinder from its weight of the cylinder from its



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

weight filled with water you will find the weight of $100\ cm^3$ of water. (This weight will be 100g.) This tells you that $100cm^3$ of water has a mass or weight of 100g.

Now find out how much each cm^3 of water weighs in grams. Discuss how to find this out. Show the calculations here.

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

B. Actually weigh the cylinder empty.

Lesson 8: Extending What You Know About Matter

Each group will complete one of the following activities. They will report the results, orally, to the rest of the class. Or you may want to ask each group to complete all of the activities.

A. Particles of water and alcohol are similar in that each particle has a positive (+) and a negative (-) end. Use this information to add to your earlier explanation for the final volume when you mixed $50cm^3$ of water and $50cm^3$ 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 separated.)

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. Use the word particles in your explanation.

(The particles that make up the paper are lined up 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 finds out the values for L_1 and L_2 in meters (m).

L_1 is ______

L_2 is ______

Now calculate the total distance around your classroom. This distance is called the perimeter.

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

Compare the perimeters obtained by the two groups, explaining differences in results. Discuss the following questions: Figure the easiest way to determine the perimeter of any rectangle like your classroom? Suppose that the rectangle is a square? (Find out L, and multiply it by 4: $L_1 \times 4$ = perimeter of square).

D. Another Group will measure the distance around each of the circles used in the earlier lesson. The distance around any circle is called its <u>circumference</u>. Measure the two circumferencea using the same piece of string used to draw the original circles. How many times did you place this piece of string around the circumference? The number of times was a little more than ________ for each circle.

The length or distance from the center of a circle to its circumference is called its radius or 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 <u>circle</u> is ______ cm. Divide the circumference by the radius = (6)

Its <u>radius</u> is ______________.

The circumference of the smaller <u>circle</u> is ______ cm. Divide the circumference by the radius = (6)

Its <u>radius</u> is ______________.

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

$$\frac{\text{circumference}}{2\ \text{radii}} = \hat{\pi}\ (\text{pi});\ \text{pi} = 3.14 \text{ for any circle}$$

E. The firth group will predict, using mathematics, how much time it would take the particles of perfume to reach each of two walls of the classroom. Then explain to the class how they did this. (Calculate the predicted time by using the speed of the particles and the distance from the center of the room to each wall. Remember that speed was measured in $\frac{cm}{sec}$ 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.

D. Another Group will measure the distance around each of the circles used in the earlier lesson. The distance around any circle is called its circumference. Measure the two circumferencea using the same piece of str ng used to draw the original circles. How many times did you place this piece of string around the circumference? The number of times was a little more than ________ for each circle.

The length or distance from the cente: of a circle to its circumference is called its radius or 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.
Its radius is ______________.
Divide the circumference by the radius = (6)

The circumference of the smaller circle is ______ c.
Its radius is ______________.
Divide the circumference by the radius = (6)

Try the same measurement for another circle. (The answer also will be a little more than 6.)

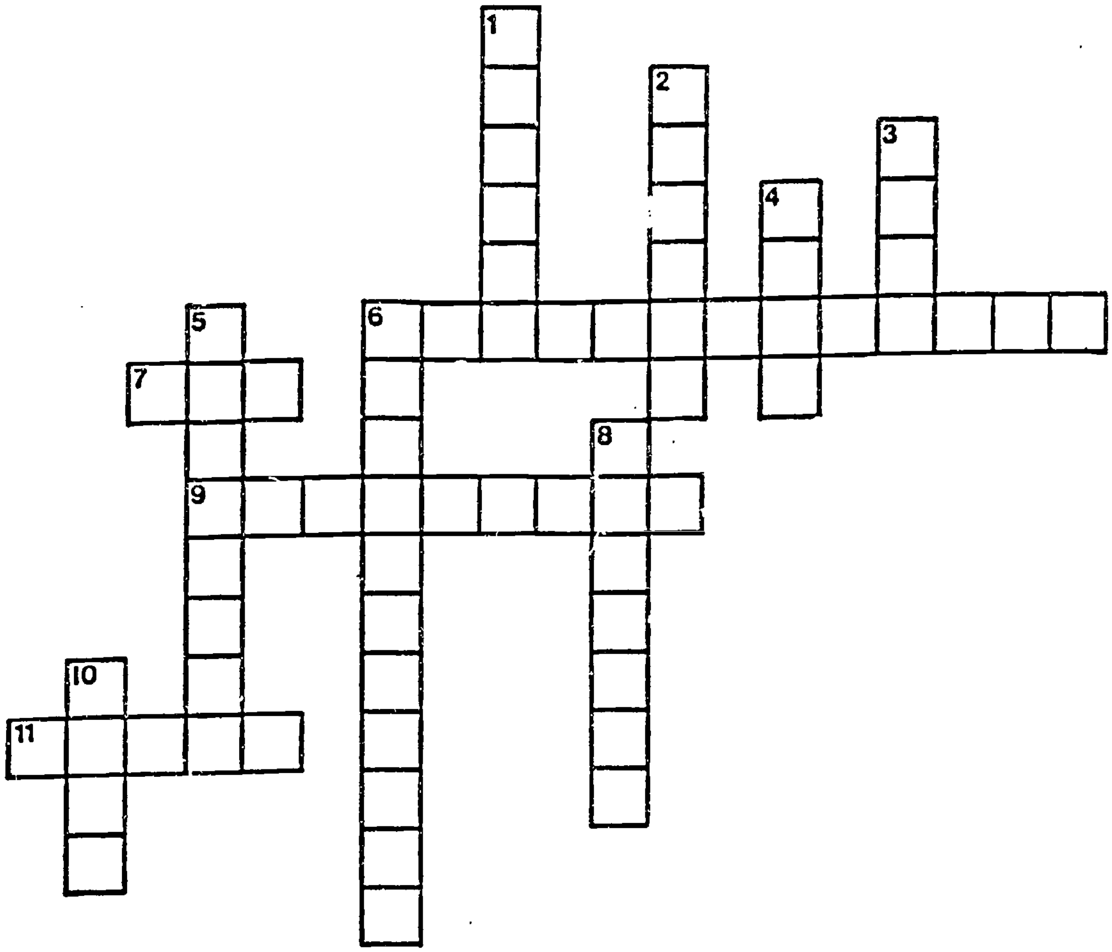
You may wish to extend the results of this activity to consider

$$\frac{C}{2r} = \frac{2}{11} \quad \frac{2}{11} = 3.14 \text{ for any circle}$$

E. The firth group will predict, using mathematics, how much time it would take the particles of perfume to reach each of two walls of the classroom. Then explain to the class how they did this. (Calculate the predicted time by using the speed of the particles and the distance from the center of the room to each wall. Remember that speed was measured in $\frac{cm}{sec}$ 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. $L_1 \times L_2 \times L_3 =$ ____________.

3. Particles of matter constantly ________________.

4. $l_1 \times l_2 =$ _____________.

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 write a sentence using each word.

Write each word here	Write each sentence he.
(1) ________________	________________________________
	________________________________
(2) ________________	________________________________
	________________________________
(3) ________________	________________________________
	________________________________
(4) ________________	________________________________
	________________________________
(5) ________________	________________________________
	________________________________
(6) ________________	________________________________
	________________________________
(7) ________________	________________________________
	________________________________
(8) ________________	________________________________
	________________________________
(9) ________________	________________________________
	________________________________
(10) ________________	________________________________
	________________________________

APPENDIX B

REFERENCES FOR SCIENCE TEACHERS, EDUCATORS, POLICY MAKERS AND OTHERS FOR IMPROVING SCIENCE INSTRUCTION FOR LEP STUDENTS

References included in this section are divided into three categories: First is a listing of the references included in the narrative of the monograph. Second is a sampling of instructional resources to enhance science learning. And third are, references that serve as background for the policies and programs designed to improve instruction for LEP students. The last two set of references are annotated.

Additional valuable information related to science instruction for LEP students, can be obtained from two bibliographies distributed by the National Clearinghouse on Bilingual Education. This clearinghouse is located in Washington, DC. These bibliographies are: "The NCBE MINI BIB: Math and Science Instruction" and "NCBE Selected Products: Program Information Guides, Occasional Papers and Other Publications."

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B-2: SAMPLING OF INSTRUCTIONAL RESOURCES TO ENHANCE SCIENCE LEARNING

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

(this is one of several excellent science hands-on based instructional programs developed through the Lawrence Hall of Science)

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(a compilation of materials for informal instruction developed and being developed through NSF funding)

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(a course guide especially useful for the secondary level)

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(a short effective introduction to the utilization of computer technology in instruction.)

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

(describes resources available for developing instruction which integrates these disciplines)

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

(a 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.

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

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 and student activities related to making paper)

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(includes topics, activities and illustrations that can be copied)

"Cemo ayudar a sus trijos a usar la biblioteca," Perkinson, K. Officinia de Investigacion y Progreso Educativo. Washington, DC: U. S. Department of Education

(a guide to assist teachers and parents of LEP students in teaching students how to effectively use the library)

Delta Science Modules, Delta Education, Inc. Hudson, NH.

(directions, hands-on materials and evaluation procedures are included in 40 modules 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, Los Angeles, CA.

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

Fox, S., & Best, N. (1981). *Primary bilingual science activity handbook: Grades K-2.* Journal announcement RIEJAN82, ED206449.

(60 science activities in Spanish and English, 20 each for grades K, 1 and 2 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)

Hands on: science, social studies and reading/thinking activities books. Annapolis, MD: Alpha Printing Company, Inc.

(these are guide-books designed to 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. (Ed). (1987). *Science learning in the informal setting.* (1987). Chicago, IL: The Chicago Academy of Sciences.

(examines learning processes in children, the 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.

(a complete science curriculum, including a basal science textbook, readers and "connection" activities for grades K-6)

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

(gives 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.

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

(describes 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 grades K-12; teachers' orientation materials on video disk are available).

NSTA Science education suppliers. (1992). Washington, DC: National Science Teachers Association.

(an annual supplement to *The Science Teacher* magazine and other NSTA publications; includes a listing of suppliers of materials, equipment, texts, supplementary materials, etc., and reference to the science content and the school level where these materials are most effectively used)

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

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

Pierce, L. (1987). *Cooperative learning: integrating language and content area instruction, Washington, D.C., National Clearinghouse for bilingual education.*

(based upon FO/D; applies cooperative group instruction to LEP needs)

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

(summarizes the "best lessons" presented in the award winners language; earlier editions back to 1986 are available)

Project Excell: Excellence in Chinese-English Language and Learning.

(this is a comprehensive program of career/vocational courses, with staff development materials and guide material for parent involvement; grades 9-12; Seward Park High School, 350 Grand St., New York, NY 10002)

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

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

Science books and films. Washington, DC: American Association for the Advancement of Science.

(an ongoing newsletter that provides 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)

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

(a newsletter directed to science educators and science teachers)

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

(provides 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.

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

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

(a 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.

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

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

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

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

The ombudsman: A program that works. The Drug Education Center, Charlotte, NC.

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

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

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

Van Cleaver, J. (1989). *Chemistry for every kid.*

Somerset, NJ. John Wiley & Sons, Inc.

(a series of activities or investigations that can be woven into an interested series of science-driven lessons).

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

(a source of experimewnts 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)

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

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

B-3: BACKGROUND REFERENCES FOR POLICY AND PROGRAM DESIGN TO IMPROVE INSTRUCTION IN SCIENCE FOR LEP STUDENTS

America 2000 (beginning in 1991). Washington, D.C., U.S. Department of Education

(a newsletter that reports the progress of the federal government's emphasis on educational reform)

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 in second language within Great Britain)

Berney T. & Hammack F. (1989). Project master, journal announcement: RIEAUG90, ED317077, New York, NY: ERIC Urban Education Center.

(description of an instructional program that provided bilingual enhanced science instruction to 575 Spanish speaking students)

Berney, T. & Platkin, D. (1989). Journal announcement: RIEAUG90, ED317083. New York, NY: ERIC Urban Education Center.

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

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

(reference lists and defines 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)

Chester, D. Education Department. (1991). *A resource manual for the federal education department.* Washington, DC: National Center for Education Information.

(a 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)

Connect. Brattleboro, VT: Teachers' Laboratory.

(a 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)

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

(collection of essays describing some of the ways in which English language instruction is being integrated into the three subjects, grades K-16)

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

(points out 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)

Delta Science Modules. (1992). Hudson, NH.

(catalog of science instructional modules and replacement parts; useful for all school levels)

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

(monograph provides 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.

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

Educational leadership 46(6). (1989). "Dealing with Diversity." Alexandria, VA: Association for Supervision and Curriculum Development.

(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)

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

(includes definite recommendations for educational practices at all levels)

Fathman, A., Quinn, M., Kessler, C. (1992). *Teaching science to English learners, grades 4-8.*

(summarizes principles underlying effective instruction, does not include the IALS or sequential strategy, gives a few incomplete examples of science demonstrations, not hands on student oriented activities)

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

(article appears 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)

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)

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

(contains 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 (Hands On!). 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)

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

(an 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)

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

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

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

(reports on the 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)

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

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

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

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

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

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

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

(describes an experiment whose results support content integration in instruction)

Mulhauser, F. Reviewing bilingual education research for congress. (1990). BE107803. Washington, D.C: National cclearinghouse on Bilingual Education.

(report indicates the need not to eliminate native language from instruction in ESL and in other school subjects)

NSTA reports, Washington, D.C.: National Science Teachers Association.

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

OERI Bulletin. Washington, D.C.: U. S. Department of Education, Office of Educational Research and Improvement.

(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 A Boost," (1-800-424-1611)," "Determining What Students Should Know About .... Science." "Access ERIC," and "OERI Phone List.")

Our lagging kids: TV alone doesn't explain the predicament, editorial (February 16, 1992). Philadelphia, PA: The Philadelphia Inquirer.

(analyzes the results of the 1991 survey conducted by Educational Testing Service associated with the International Assessment Educational Progress; indicates that low standing in test performance in science and math in the U.S.A; cause is not only the results of excessive time spent watching TV)

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.

(reference suggests 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.

(includes 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).

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

(information for those seeking details about the inservice program in science for teachers of LEP students in Chicago; project materials include "Notes for Parents" and "Parent Enlightenment"; 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.

(monitors, evaluates, supports, and disseminates information about successful educational changes for minority advancement; conducts conferences and supplies information relevant to its mission)

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. (1991). San Mateo, CA: Aguirre International.

(report presents pros and cons of each approach and supports subject integration and hands-on experiences in instruction)

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

(report indicates many sources of funding for science and mathematics instruction available through the U. S. DoEd)

Rodriguez, I. & Bethel, L. (1983). An inquiry approach to science and language teaching, Journal of research in science teacher, 20(4) pp 291-96. New York, NY: John Wiley Publishers.

(reports positively on the effectiveness of the inquiry approach to science and language teaching among Mexican American third graders)

Roseberry, A., Warren, B., & Conant, B. (1992). Appropriate scientific discourse: Findings from language minority classrooms. Cambridge, MA: TERC

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

Roth, M. (1990). Collaboration and constructivism in the science classroom. Journal announcement: RIESEP90, ED381631, New York, NY: ERIC Urban Education Center.

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

Science and children. Washington, DC: National Science Teachers Association.

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

Science education programs that work; a collection of proven exemplary educational programs and practices in the National diffusion network. (1991). Washington, DC: U. S. Department of Education.

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

Science Framework for the 1994 National Assessment of Educational Progress. (pre publication draft). (1991). Washington, DC: National Assessment Governing Board, Educational Testing Service.

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

Stolfoff, D. (1989). Limited English proficient students and mathematics and science achievement: Strategies for success practiced within the California academic partnership program projects, journal announcement: RIEFEB90, ED310923. New York, NY: ERIC Urban Education Center.

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

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.

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

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

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

The national center for improving science education: summaries of reports. (1991). Andover, MA: (includes) 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).

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

The science teacher. Washington, DC: 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)

Tinker, R., & Kapisovosky, P. (ed.) (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)

About the Authors

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 establilshed 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 the 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. 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.

Francis X. Sutman has taught sciences and mathematics in the public schools and continues this teaching through the National Science Foundation's school outreach effort. He has been a research chemist for Exxon Science and Engineering Laboratory and served as a professor of science and science education at a number of institutions of higher education in Puerto Rico and in the continental U.S.A. At NSF he serves as Program Director for the Assessment of Student Learning Program in science and mathematics. He also is Senior Scholar in Science Education at Temple University. Sutman was Dean of the College of Education at Fairleigh Dickinson University, served as President of the National Association for Research in Science Teaching and 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 has authored many articles in science education as well as five books. He is co-author of <u>Learning English Through Science</u>, published by the National Science Teachers Association and <u>Educating Personnal for Bilingual Settings</u> published by the American Association of Colleges for Teacher Education.