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ABSTRACT

Insights gained from experience and research on language minority students' academic success are reviewed as background for presentation of a curriculum that is bilingual and content-based and uses cooperative learning techniques. First, findings on three elements of success (interest and motivation, intelligence and development, and psychosocial access) are examined. The discussion then turns to providing students with access to learning opportunities, the process of concept development, the relationship between student and teacher, and development of cooperative work skills. Finally, the Finding Out/Descubrimiento Approach (developed by Edward A. De Avila, Sharon E. Duncan, and Cecilia J. Navarrete) is described and its curriculum is outlined. The approach provides an integrated language skills program for oral and written communication mastery in English and Spanish within a cooperative learning environment. It is used in grades 2 through 5, and is designed to meet the needs of students from diverse cultural, academic, and linguistic backgrounds by capitalizing on their natural interest in how the world works. The program consists of two phases: (1) introduction to social aspects of cooperative work, and (2) supervised content-learning activities. Organization of the classroom environment and appropriate learning materials are discussed, science and math activities drawn from the curriculum are listed, and several sample activities are outlined in detail. (MSE)

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Preface

Teacher Resource Guides have been submitted to NCBE by practitioners involved in teacher education, research, and the education of language minority students. These Guides are intended to be practical resource guides on current or innovative teaching practices in bilingual education and in the education of limited-English-proficient students. Every effort has been made to cull the most practical aspects of each curriculum guide and to incorporate these into a concise classroom resource with sample lesson plans or activities.

This year's NCBE Teacher Resource Guide Series revolves around literacy instruction and the integration of language and content-area instruction, areas of particularly high interest to practitioners in the field. Specifically, the four 1987 Guides address: (1) developing materials and activities for promoting English language and literacy skills among young children from non-literate backgrounds; (2) integrating native language, ESL, and content-area instruction in science and math at the elementary level; (3) developing literacy materials and integrating language and content instruction for secondary students with limited formal schooling experience; and (4) approaches to integrating language and content instruction for language minority students.

Lorraine Valdez Pierce
Teacher Resource Guides
Series Editor

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Persons wishing to obtain FO/D materials should contact Santillana Publishing Co. for ordering information at (800) 526-0107.

Introduction

What conditions are necessary for the academic success of language minority students? How do the ingredients essential for quality education interact with one another to expiain student performance? How can the elements of academic, linguistic and social diversity be used to our advantage in the classroom? Recent explanations of the failure of language minority children to achieve in public schools have not done very much to answer these questions or to improve our ability to provide quality education. While it is true that there is still a good deal we do not know, this Teacher Resource Guide will describe an approach which is based on what we *do* know about the sociological, psychological, and educational processes that contribute to the success of some students and the failure of others.

Fifteen years of research and experience suggest that there are three useful elements that underlie individual success: (1) interest and motivation, (2) intelligence and development, and (3) psychosocial access. A discussion of the interaction of these elements may lead us to answers to the questions posed in the introductory paragraph. Continuing investigation of these factors has provided a basis for the design of a cooperative learning and dual-language content-based curriculum called *Finding Out/Descubrimiento (FO/D)* (De Avila, Duncan & Navarrete, 1987).

The purpose of the following discussion is not to explain all academic performance or school-related behavior but rather, to set the stage for a description of the *Finding Out/Descubrimiento* approach by providing a theoretical framework that draws from psychology, sociology, and linguistics. Interest, intelligence, experience, and access are necessary attributes for academic success. Each of these components viewed in isolation is sufficient to explain or predict differences in performance. Academic excellence, however, results from a combination of these attributes. Although these factors can be distinguished from one another for purposes of discussion, they cannot be separated when it comes to the design and delivery of educational programs.

Interest and Motivation

Research on children's interests is fairly clear: Children like to do things that help them gain a sense of mastery over their environment. Almost 30 years ago, Robert White (1959) called this intrinsic need "effectance." Human beings spend the major portion of their youth attempting to learn how to be effective. The role of education, whether it be in the home or the school, is to assist in this process. Research leading to development of the curriculum described here attended to the following questions: What kinds of things do children between the ages of 3 and 12 like to do? Similarly, what kinds of things found in the popular culture carry an educational value across different developmental and interest levels? Our search for an approach to facilitate the development of effective children in both home and school leads to a more general question: What are the kinds of things that are of value to parents *and* of interest to children that are least influenced by linguistic, cultural, and geographic differences? Answers to these questions have established the direction and content of the FO/D approach.

Moreover, these considerations have led us to conclude that some of the *most universally held interests* are to be found in the areas of *science and mathematics.* Probably all children have wondered about where the sun goes on a rainy day, why water boils, or why things always fall down. Not only do science and math offer educationally meaningful content, they offer a perfect context in which to foster the development of higher-order thinking skills.

Intelligence and Development

In our approach, we define intelligence as *what a child can do with what she or he knows.* Explained in this way, there are two important aspects in determining a child's level of intellectual development. The first is *what a child knows* and brings to the educational setting; the second is *what the child can do with this knowledge.* In a limited sense, intelligent behavior results from the interaction of a child's *repertoire* and *capacity.* Note that in the following discussion, repertoire skills can include social as well as purely intellectual skills, insofar as social skills promote academic performance. By repertoire, we refer to all those things a child brings to the educational setting, the various strategies characteristics of his or her development. This includes his or her language and culture and an understanding of the social demands of the classroom and/or test situation, as well as a host of other skills associated with family background. · A child's repertoire is the machinery that runs his or her intellectual mill. A child with a very rich and elaborate repertoire is in a better position to behave intelligently because she or he has a greater number of intellectual and social strategies with which to approach a task.

Capacity is the ability to integrate or to separate things in order to produce novel responses. For example, when a child enters a testing situation (particularly one involving an I.Q. test), it is assumed that she or he has been exposed to the content of the test. If, however, the child comes from a home where English is not spoken, there is a good chance that he or she has not learned sufficient English to deal with much of the test's content. As a consequence, it is virtually impossible to tell whether the child has missed a test question because she or he does not know or understand the concept, or whether the child does not possess sufficient skill either to understand the instructions or complete the task. The same thing can occur during classroom recitation when, if the teacher addresses the child and the child does not respond, we do not know whether the child did not understand the English words used by the teacher or did not have the intellectual ability to answer. In both cases there is the danger of confusing intellectual ability with linguistic deficiencies.

In the same way that a child's background can negatively influence performance by leaving an incorrect impression of lower intelligence, it can also influence in a positive direction by leaving an equally incorrect impression of higher intelligence. Consider the child from a highly educated and verbal background where oral behavior is socially rewarded by the family. In this case exposure to a large vocabulary aids performance in reading, and the child's verbal skills may be incorrectly interpreted as high intelligence.

Academically successful children have acquired a great many strategies for dealing with subject matter in school. They are not necessarily any more intelligent; they are simply in a better position to behave intelligently. That is, they have more strategies. Our position is that one of the major purposes of education is to facilitate the development of generalizable strategies that will serve the student regardless of background characteristics. The distinction between background and direct experience has been discussed in a variety of articles. For a more complete discussion see De Avila, Havassy, and Pascual-Leone (1976).

Appreciating children's diverse backgrounds and their equally different repertoires leads to the recognition of the fact that children cannot be compared fairly. If intelligence is what children can do with what they have been exposed to, then how is comparison of children possible? In a series of experiments conducted over the past fifteen years in Canada, Mexico, and the United States, we have found that when the effects of prior experience (i.e., repertoire) are controlled through the use of pretraining procedures, many of the differences in intellectual ability between ethnolinguistic groups seem to disappear. In other words, *ethnolinguistic group differences in intellectual ability reported in the literature are largely a function of repertoire differences and not intelligence per se.* For example, in a large-scale study involving nine different ethnolinguistic groups, De Avila and Duncan (1980) found oral English language proficiency a far stronger predictor of academic success than intelligence or intellectual development.

The overriding purpose of a cooperative learning approach to content is to aid cognitive functioning and improve academic performance. Our purpose is to enhance the development or acquisition of intellectual strategies (i.e., to increase the repertoire) that can be applied in a variety of educational and other settings. We can make the assumption that although unsuccessful students may be lacking in academic strategies, the problem is one of repertoire and not of capacity. Students have the necessary capacity; they have just not had sufficient experience.

We can approach the task of helping children to acquire repertoire skills by taking their natural interest in how the world works and *focusing on mathematical and scientific processes*. We can focus on the general question of how we go about doing this by examining what is learned. We begin our discussion of the learning process by distinguishing between two types of learning, although some of the distinctions we make are somewhat arbitrary in the more abstract (academic) sense.

The best way to understand a cooperative learning approach to content is to consider the difference between the facts, labels, and names found in science and the concepts and intellectual processes underlying them. We distinguish between the word and its meaning or between the label for an object and its function. Labels vary; functions do not. Except in the rarest of circumstances, the properties of water and geometry, for example, remain invariant to time and place. Water is affected by gravity in North America as it is in Katmandu; a right angle is the same throughout the world. One learns the names of objects in a way different from the way in which one understands the objects at a conceptual level. Learning concepts and processes involves active participation by the learner, whereas learning the names of objects tends to be a rather passive activity.

The use of concrete objects in this approach serves two functions: (1) it facilitates cross-model multiple presentation which is consonant with learning set methodology, and (2) it requires motor involvement (muscle tension), which is necessary for learning. Although we have discussed interest and motivation separately from intelligence and experience, they are inextricably bound, in and of themselves, however, they provide an incomplete picture. More complete understanding of a cooperative learning, hands-on approach requires discussion of a third factor in students' support system: Access to the materials and experiences that ameliorate or impede intellectual and academic development.

Access to Learning

Educational access is associated with the concept of educational equity. It is embedded in the very definition of educational equity as described in the Civil Rights Act of 1964, which guarantees "equal access to educational opportunity." The Civil Rights Act--and most legislation that addresses these issues--assumes that access and opportunity are synonymous as long as students are instructed at the same location (ideally, in integrated classrooms). More recent discussion by De Avila and De Los Santos (1979), however, suggests that the issue of language minority education requires a rethinking of the concept of educational equity. Consideration must be given not only to *where* students receive instruction but also to *how* the instruction is delivered and received.

Access can be discussed in linguistic, psychological, and sociological terms. At the most basic level, it can be considered in terms of socioeconomic status (SES). Some children, as a result of the mere fact that their families are of higher SES, are exposed to educational and quasi-educational experiences that have a beneficial impact on intellectual performance.

To fully understand the concept of access as it applies to the psychological aspects of educational performance, it is worthwhile to recall differences between the two types of learning discussed earlier. In recent research on learning, old distinctions between list learning (memorization) and concept formation have become blurred--some writers even argue that all learning can be considered the same. At the classroom level, however, it is important to remember that there is a difference between memorizing a list of names and forming concepts about previously unknown relationships. We believe that compensatory programs tend to emphasize the former at the expense of the latter and that such emphasis constitutes a "denial of access." This point is well illustrated in recent work predicated on the concept of direct instruction, which argues in favor of highly structured, large group instruction whose educational content is of a low cognitive level.

As a result of this line of thinking (bolstered by legislative fiat), there has been a tendency at the classroom level to develop compensatory programs aimed at improving basic skills that, from our point of view, can deny access to the kinds of experiences and processes necessary to develop thinking skills of a higher order. Underlying our view are the assumptions that deficiencies must first be remediated and that children need to know their facts before taking on more abstract material. These assumptions are particularly evident in the case of language minority students, where proficiency in English is used as a prerequisite for participation in classes involving more complex material. The inevitable result is continued failure because programs emphasizing rote skills tend neither to be at levels commensurate with students' development nor interesting in a personal sense.

Another type of access has to do with the student's ability to communicate in the classroom. Students unable to participate in oral discussion or interchange are denied access, regardless of the presumption of full "opportunity." In other words, the opportunity to be in a math class does not provide access if students cannot participate because they cannot understand the language of instruction. A number of researchers have found that proficiency in English is a strong predictor of academic success among language minority students. It does not follow, however, that English must be mastered *before* participation can take place.

We have found that one of the strongest predictors of conceptual learning (as distinct from memory work) is the amount of time students spend talking and working together. In a teacher-centered, heterogeneous classroom, there is little chance for dialogue among students or with the teacher, who simply does not have the time to interact with regularity. Furthermore, if the teacher does not speak a child's language, there is little chance that the student will be called on for recitation except to answer basic factual questions. If oral English proficiency is viewed as a dimension of social status, which is more than likely in a linguistically heterogeneous class dominated by native English speakers, the student with limited or no English is relegated to a lower social status in the classroom. The net result is a lowered frequency of verbal interaction, a further distancing between the limited English speaker and the rest of the students, and a presumption of lower overall ability.

Providing Opportunities

We begin our description of how issues of access are resolved in a cooperative, hands-on approach by asking several questions. For example, what are the necessary organizational conditions for providing effective instruction in academically, linguistically, and socially heterogeneous groups? What are the necessary roles and responsibilities for effective classroom organization? What kinds of classroom organizations are conducive to learning set or concept formation? How does memory work fit in? What is the teacher's role in a cooperative learning environment? Answers to these questions require the formulation of a complex model based on the cooperation of all involved, with rights, responsibilities, and roles well defined and tasks orchestrated in a manner consistent with them.

One of the clearest conclusions that can be drawn, considering the differences among students, is a need for complex models of instruction. Because traditional teacher-centered instruction runs the risk of promoting unequal access, we need to formulate a model that enables the teacher to accommodate differences and move students in the same direction. There is simply no way an individual teacher can address all the diversity brought to the classroom by students who differ along the dimensions described earlier without a high level of organization.

Student reviews involve systematic ratings of critical behaviors such as the amount of time students spend on and off task, the time spent talking and working together, and so on. The use of an observation form enables the teacher and aide to have focused meetings and to provide each other with feedback regarding student progress and general classroom operation. Teachers and aides alike have remarked that these meetings become increasingly important as the school year goes on and that they help establish congenial and essential relationships between them.

We have argued that educational excellence, or the lack of it, results from the interplay of social, psychological, and educational factors. Given that these factors are the provisos for academic excellence and that the above framework is ultimately useful, the question becomes one of designing and instituting appropriate programs. The cooperative learning approach described in this teacher's guide represents one such attempt.

The Learning Process: Concept Development

Concept formation, or the learning of abstract notions such as the concept of standardization of measurement, requires repetition. However, in learning a concept there is an important difference that can be best understood through the description of a concept formation task. Concept formation has been studied in the laboratory since the nineteenth century under various names, including "insight," "inference," and "problem-solving." The common element among them is that they all demonstrate the principles of how thinking skills are developed.

In a cooperative learning approach to content we use Harlow's (1949) concept of the "learning set" to explain the process of forming or acquiring a thinking skill. In a typical learning set experiment, a child is presented with a set of objects (e.g., three red, wooden shapes; two rectangular, and one triangular shape) and asked to identify the one that is different. A reward is given if the correct identification is made. If the child fails, the shapes are removed and presented again in a different configuration. The process is repeated until the experimenter feels that the concept has been learned. A second problem is then introduced that differs form the first only in that another set of objects is used (e.g., two round blocks and one square block).

Researchers have found that concepts formed in this manner are highly stable across time and situations. Once the concept is learned, the student attempts to apply it--in this case, shape differences--to solve other problems that, from the student's point of view, appear to be similar. The concept becomes a strategy for dealing with new situations.

One important difference here is that the process of repetition in each presentation differs slightly from the former along some irrelevant dimension. In memorization tasks the child simply keeps repeating the same thing over and over. In forming a concept, thinking skill, or learning set, each repetition involves a slight variation. In repeating the concept, students find that the situations, objects, and names vary. The child learns to form a concept that enables her or him to distinguish the relevant from the irrelevant features of the situation or stimulus.

The Relationship Between Teacher and Student

The Teacher as Facilitator

The instructional role of the teacher in a cooperative learning approach is cardinal; without the teacher there is no program. However, the teacher's role in the cooperative learning classroom is slightly different from that in a conventional classroom. In brief, the role of the teacher is to contribute to the development of learning sets and, with the aide's assistance, to focus students' perceptual apparatus on the essential features of a task. This is effectively accomplished by asking constructive questions and providing quick feedback. The best teacher never tells the answer but instead asks another question, thus unobtrusively guiding the learning process. A more complete description of the interaction flow is provided in the following discussion.

The cooperative learning teacher is also a manager, chiefly responsible for the smooth running of the classroom. The teacher is the final arbiter. The teacher is the child's access to knowledge. Without the teacher there is little, if any, learning that is meaningful in a modern society.

Guiding the Learning Process

With the exception of the initial orientation and the final wrap-up of each learning activity, the teacher is not the focal point in the classroom. Moving from one learning center to another, the teacher is a supportive catalyst of the learning process rather than a source of expected answers. The teacher generates student interaction; asks questions; talks about problem-solving strategies, role performance, and cooperative behaviors; and generalizes concepts or principles.

To maximize the development of problem-solving skills and increase interdependence among students, Lotan (1985) argues that the teacher must let students find out and learn by themselves. Students should not be given ready-made answers or asked to repeat and memorize things they do not really understand. Interactions will depend on the teacher's knowledge of the learning process and decision making in a particular situation. This teacher guide suggests two general guidelines for teacher/ student interaction to help support the development of problem-solving skills: *assisting* and *giving feedback.*

Assisting Students

In the first guideline, the teacher assists learning by sharing information, helping students analyze phenomena or problems, and extending and generalizing concepts or relationships. In sharing information, the teacher describes in detail his or her observation of students' actions with the learning materials. For example, the teacher might observe a group working on graphs and comment, "I see Susana got the same results by organizing her data in columns instead of rows."

The teacher also prompts students to describe and share their information with others by asking open-ended questions such as: "What other ways are there to...?"; "How can you prove that...?"; "How did you make...?"; "What did you find out?"

The teacher also helps students to examine a problem in terms of its parts and interrelationships--without giving the answer. For instance, the teacher may observe a group of students having problems making a flashlight and may assist them by saying, "Not everyone's flashlight is working. Have you tested each part? By sharing with one another the parts that do work, you might be able to figure out how to get the complete flashlight working."

When experiments do not follow the predicted path, there is good opportunity for students to attempt to discover why, to think more, to plan better, and to learn more. In a truly scientific sense, every experiment "works" even though it may not take the anticipated course. It is equally important that students be given opportunities to react to a situation. This allows them to think aloud and to hear how others plan, organize, predict, and interpret information.

In extending, the teacher helps students apply experiences to general concepts, principles, or rules. Generalizations come as a result of many experiences, observations, and experiments. The complexity of the generalizations will, in part, depend on the maturity of the students. Some examples for stimulating generalizations are: "What other objects could you use for...?"; "What other ways are there of...?"; "It is generally believed that..."; "What can you say about what you found out?"; "Some people say..."; "Evidence seems to indicate..."; "Remember how we found some of the answers when we worked on problems about...?"; "How can we use what we learned in...?"

It is important to challenge students when they make sweeping generalizations based on one experiment, such as "Magnets will pick up all metals." After experimenting with different metals, the teacher might ask, "What metals does the magnet seem to pick up?" This question will help to stimulate more discussion and further experimentation.

Effective Feedback

Another guideline for teachers to follow is to give effective feedback. Providing students with specific, evaluative information on their performance is an essential component of the learning process. The teacher confirms or verifies the students' accomplishments, needs, or social behavior. Feedback may focus on the student's performance on a task, worksheet, skill, or general progress.

The concept of effective feedback is derived from sociopsychological and organizational theories that propose that effective feedback increases the level of satisfaction, as well as the amount of effort one is willing to put into work. However, in order for feedback to be effective it must be frequent, well-timed, specific, authentic, and sincere.

Developing Cooperative Work Skills

Many educators see interaction between children as one of the chief motivators of intellectual development. When experiencing the different perspectives of their peers, children can examine their own environment more objectively. Cooperative learning activities require group work, and therefore proper steps must be taken to achieve learning and assimilation of new concepts in a group setting. Students must have the opportunity to acquire the vocabulary and resources to achieve a requisite level of intellectual discourse. Furthermore, the experience must be structured so that students will listen, explain, and provide feedback for one another. Practice in cooperation is essential.

Cooperative group work may involve a radical change for students who have unconsciously internalized regular classroom behavior in which they normally are told to do their own work, keep their eyes to the front, and stay quiet. In a cooperative learning classroom, students are responsible for their own behavior but also, to a large extent, for the group's behavior. Students learn to ask for help and to ask for each other's opinions, to listen to others, to explain, and to demonstrate how to do something.

To assist in the implementation of cooperative learning, teachers can design activities in which children work cooperatively in a group setting and increase their awareness of the effects of positive and negative behavior on group problem solving. For examples of such activities, refer to De Avila, Duncan, and Navarrete (1987).

Assigning Roles and Responsibilities

Fundamental to cooperative learning group work is the recognition of each student's role and responsibility in the group. The basic objective is to avoid the creation of status differences between groups and to foster a recognition of interdependence. Typically, group assignments can be made weekly during the introduction to a theme; individual role assignments can be made daily or weekly.

The first step in assigning roles is to form groups. Place students in work groups on a weekly basis. A work group ideally consists of four to six students of varying academic and linguistic levels. Work groups should not consist of either high or lower achievers exclusively. In bilingual settings, groups should not be exclusively comprised of limited-English or English-proficient students.

Among the many ways to assign students to work groups is on the basis of ;hievement and language skills. In this situation, the teacher builds groups on a representative basis. Another way to form groups is to have students draw straws. No matter what method is employed in group formation, it is important that students see t! :t it is done in a totally impartial manner and not on the basis of predetermined status. It is also important that the procedure not result in ability groups in which one group dominates over another or is seen as the high-status group. Students should be mixed by sex, reading level, and language proficiency. Issues concerning individual status are addressed in the assignment of roles within each group and are discussed in the Teacher's Resource Guide which accompanies the FO/D program.

It is essential that the children understand that their active participation is critical to the success of the group. Although some of them may be better at certain tasks, such as reading or math computation, the point remains that every student has something to contribute. Just as students must learn to help one another, they must also learn to help the teacher in coordinating all aspects of the program. As discussed earlier in this guide, a cooperative learning classroom represents a complex social environment, one that requires delegation of authority and sharing of responsibility. The main purpose of teaching students how to work cooperatively in groups is to demonstrate the value of collective enterprise in completing intricate tasks and to promote interaction between individuals acting as equals. It is critical that the students understand that their participation and contributions, however small, are important to the success of the group.

The *Finding Out/Descubrimiento (FO/D)* Approach

Finding Out/Descubrimiento is a complete, integrated language skills program that develops mastery of both oral and written communication within a cooperative learning environment. It promotes either English or Spanish proficiency from a natural, meaningful perspective for those in grades 2 to 5.

FO/D is specifically designed to meet the needs of students from diverse cultural, academic, and linguistic backgrounds. It is an educational management system for a complex yet coordinated instructional program which enables the teacher to accommodate differences and move students simultaneously in the same direction. Over 100 intrinsically interesting hands-on math and science activities in the FO/D curriculum facilitate learning across a broad set of educational objectives.

FO/D helps children acquire a broad repertoire of skills by capitalizing on their natural interest in how the world works. In the first step of this two-phase program, students are introduced to the social aspects of working together cooperatively and fulfilling specific roles in small, randomly mixed groups. Cooperative group work may involve a radical change for some students. In FO/D, they will learn to ask for help and give help when asked, to solicit other students' opinions, to listen to others, and to show each other how to do things. Eight preparatory cooperative learning exercises are provided in the FO/D Teacher's Resource Guide which demonstrate how to function successfully in the environment of small, independent groups.

The second phase involves the implementation of content learning activities within these multiple groups, or learning centers, which operate simultaneously under the direction of the teacher and the teacher's assistant. The role of the teacher in FO/D is that of a manager and a supportive catalyst of the learning process. Moving from center to center, he or she provides essential assistance and feedback while:

- generating student interaction;
- asking questions;
- delegating responsibility;
- talking about problem-solving strategies, role performance, and cooperative behaviors;
- helping students to examine a problem without giving the solution; and
- generalizing concepts and principles.

The many enriching components of the FO/D curriculum--colorful activity cards, challenging worksheets, assessment tests, posters, and teachers' resource materials--combine to ensure optimum development of each student's potential. Activities have a defined structure and specific goals, yet they contain variables which allow each student to extend the lesson to his/her highest level of proficiency and academic ability. In this way the same topic is as effective with the limited-English student as it is with the English-proficient--and even gifted--student.

Science is a subject which is particularly suitable for language acquisition for several reasons:

- It requires the manipulation of concrete, easily identifiable materials;
- It entails explicit, nonsubjective descriptions which can be demonstrated;
- The content and terminology are neutral, not "culturally loaded"; and
- Scientific experimentation lends itself to group interaction and communication.

Classroom Organization: Work Spaces

The most useful way to set up a classroom to facilitate cooperative learning is by arranging it into work spaces. Work spaces or learning centers might be thought of as areas surrounded by either visible or tangible boundaries. They are not necessarily the same as traditional self-contained learning centers but rather can take on a number of spatial configurations, including: booths, mats, corners, flat surfaces, vertical surfaces, and underneath furnishings (tables, canopies, umbrellas).

Children need clearly defined and sufficient work spaces. Cooperative learning activities require ample work space for materials and groups of four to six children to work together. Since the majority of activities involve physical movement and conversation, students might need even more space than the materials require for a particular activity. Therefore, the teacher must carefully plan work spaces.

Learning Materials

Student materials for cooperative learning activities created by De Avila, Duncan, and Navarrete (1987) consist of the following items: (1) training exercises which introduce students to the social and academic prerequisites of the program; (2) student activity cards with task instructions for students, complete with pictograms; (3) student worksheets which require students to demonstrate acquired skills and concepts; and (4) unit tests for content-referenced assessment of student progress A detailed description of tools, equipment, and raw materials necessary for math and science activities is provided in the *Finding Out/Descubrimiento* Teacher's Resource Guide (De Avila, et al., 1987).

The FO/D Teacher's Resource Guide describes the theoretical foundations of the cooperative learning, hands-on approach to science and mathematics activities and also provides practical suggestions for implementing a successful program. The Guide provides lesson plans accompanied by student activity cards. Each lesson plan includes the title of the unit in English and Spanish, the objective to be accomplished and the thinking skills practiced, materials needed to conduct the activity, key words and concepts being learned, and suggestions and questions for student/teacher interaction and discussion (in English and Spanish). An overview of the FO/D curriculum can be found in Tables 1 and 2.

Although the FO/D Teacher's Resource Guide provides all the practical and theoretical information needed for a successful FO/D program, it may be beneficial to use the guide in conjunction with an FO/D training workshop.

Sample Learning Activities

The sample learning activities which follow Tables 1 and 2 were taken from *Finding Out/Descubrimiento* (FO/D) (De Avila, Duncan & Navarrete, 1987). Skill areas covered by the FO/D curriculum for science and math activities include: communicating, observing, measuring/comparing, organizing/classifying, predicting, and interpreting.

Finding Out/Descubrimiento (FO/D)
Overview of the Curriculum

TABLE 1 - English

Unit 1 Measurement

Ancient Body Measure
Paper Clip Chain
Body Measure
Weighing Things in Grams
Graphing What You Like
Measuring a Big Animal

Unit 2 Change & Measurement

Making a Meter Stick
Measuring with Millimeters
Measuring in CM & MM
Heating a Corn Kernel
Think Dilution
How to Use Litmus Paper
Heating a Raisin
Completing a Metric Ruler

Unit 3 Shapes

A Polygon Mobile
So What's a Polygon?
Perimeter Shapes
Showing Symmetry
Finding the Perimeter
Measuring Round Things
Curving a Line

Unit 4 Crystals & Powders

Sugar Crystal Mountain
Salt Crystal Garden
Guessing the Mystery Powders
Vinegar Test
Starch Test
Antacid Tablet Experiment

Unit 5 Balance & Structures

Bridge of Strength
How Stable a Bridge?
Pegboard Balance
Balance Game
Building a Structure
Balancing with Paper Clips
A Large Balance
Connecting Straws
Seesaw Balance
Soda Straw Balance

Unit 6 Coordinates & Measurement

N-S-E-W Game
Coordinate a Visit
Latitude & Longitude
A Map with a Key
Comparing Heights
Tangrams

Unit 7 Clocks & Pendulums

Chinese Water Clock
Clepsydra
French Sand Bottle
Weight for the Pendulum
Games with Pendulums I
Patterns and Designs
A Bouncing Time
Pendulum Swing
Finding Pendulum Trails
Games with Pendulums II

Unit 8 Time & Shadows

How Long?
Second Hand
How Long Is a Minute?
Making a Sundial
Casting a Shadow
Shadows & Light
Where Do Shadows Fall?
Measuring Shadows

Unit 9 Reflection/Refraction & Optical Illusions

Drawing a Light Map
Making a Periscope
Camera Obscura
Water Drop Lens
Making a Flip-It
Disappearing Colors
Photographic Memory
Practice Bouncing Light
Building a Camera
Developing Film
Printing a Photo

Unit 10 Estimation

Millimeter Check
Measuring in Liters
Meter Bounce
Pouring Sand
Building Solids
Balancing One Gram

Unit 11 Probability & Estimation

Hex Game
Race to the Moon
Dice Examination
Fill It Up
Bean Cookies
Cubic Centimeters
Basket Throw

Unit 12 Sound

Musical String Instruments
Tube Sound
Stereo Sound
Changing Pitch
Sound of Music
Phone Call
How Sounds Are Made
String Sounds
Guitar Sounds
Hum Sounds

Unit 13 Water

Water Games
Water Droplets
Stir Crazy
Size & Amount
Mixing Basic Colors
Salt Water Colors
Layered Colors
Floating Holes

Unit 14 Water Measurement

Hand Soak
Weighing with Water
Squeezing a Sponge
Liter Fill-Up
Measuring in Liters
Milliliter Fill-Up
Boat of Clay

Unit 15 Magnetism

Magnet Power
Attract & Repel
Magnetic Dust
Strength of an Electromagnet
Floating a Pin
Magnetic Mystery

Unit 16 Electricity

How Batteries Work
Connecting a Bulb
Making a Flashlight
Generating Electricity
Completing a Circuit
The Secret Connection

Unit 17 Heat

Candle Making
Heat Conduction
Melt the Wax
Stopping the Heat
Popping Penny
Reading a Celsius Thermometer
Shrinking Rubber Band

Finding Out/Descubrimiento (FO/D)
Overview of the Curriculum

TABLE 2 - Spanish

Unidad 1 La Medida

Método antiguo de medir
Cadena de sujetapapeles
Midiendo el cuerpo
Pesando objectos
Diagramando lo que te gusta
Midiendo un animal grande

Unidad 2 El Cambio y la Medida

Haciendo un metro
Midiendo en milímetros
Midiendo en cm y mm
Calentando un grano de maíz
Diluyendo un líquido
Cómo usar el papel de tornasol
Calentando una pasa
Haciendo una regla numerada

Unidad 3 Las Formas

Móvil de polígonos
¿Qué es un polígono?
Perímetros de diferentes formas
La simetría
Cálculo del perímetro
Midiendo objetos redondos
Redondea una línea

Unidad 4 Cristales y Polvos

Montaña de azúcar cristalizada
Jardín de sal cristalizada
Polvos misteriosos
La prueba del vinagre
La prueba del almidón
Experimento del antiácido

Unidad 5 El Equilibrio y la Estructura

Un puento resistente
¿Es muy firme el puente?
Una balanza casera
Juego de equilibrio
Construyendo una estructura
Equilibrando con sujetapapeles
Balanceando objetos grandes
Construcción de popotes
Equilibrios
Equilibrio de popotes

Unidad 6 La Coordinación y la Medida

Norte-Sur-Este-Oeste
de un lugar
Latitud y longitud
Un mapa con clave
Comparando alturas
Rompecabezas chino

Unidad 7 Relojes y Péndulos

Reloj de agua chino
La clepsidra
Reloj de arena
Pesas para el péndulo
Juegos con péndulos I
Patrones y diseños
Cronometrando rebotes
Movimiento del péndulo
Encontremos huellas de péndulos
Juegos con péndulos II

Unidad 8 Tiempo y Sombras

¿Cuánto tiempo?
Segundero
¿Cuanto dura un minuto?
Hagamos un reloj de sol
¿Qué cosas dan sombras?
Sombras y luz
¿Dónde caen las sombras?
Midiendo sombras

Unidad 9 Reflexión/Refracción e Ilusión Optica

Dibujemos un mapa con luz
Hagamos un periscopio
Cámara oscura
Lente de agua
Haciendo dibujos animados
Colores que desaparecen
Memoria fotográfica
Hagamos que rebote la luz
Construye una cámara
Revelando rollos de fotografía
Imprime una fotografía

Unidad 10 Estimación

Estimando longitudes
Midiendo en litros
Rebote métrico
Vertiendo arena
Construyendo sólidos
¿Cuánto pesa un gramo?

Unidad 11 Probabilidades y Estimaciones

Juego de probabilidades
Carrera a la luna
Examen de dados
¡Llénalo!
Galletas de frijol
Centímetros cúbicos
Tiro a la canasta

Unidad 12 El Sonido

Instrumentos musicales de cuerda
Sonidos de tubos
Sonido estereofónico
Cambiando de tono
Un sonido musical
Llamada telefónica
Cómo se hacen los sonidos
Sonido de cuerda
Sonido de guitarra
Un sonido que zumba

Unidad 13 El Agua

Juego de agua
Gotitas de agua
Revolviendo a lo loco
Tamaño y cantidad
Mezclando los colores básicos
Colores en agua salada
Capas de colores
Agujeros que flotan

Unidad 14 El Agua y La Medida

La mano remojada
Pesando con agua
Exprimiendo la esponja
Llenando con litros
Midiendo en litros
Llena con mililitros
Lancha de arcilla

Unidad 15 El Magnetismo

Fuerza magnética
Atraer y repeler
Polvo magnético
La fuerza de un electroimán
Un alfiler en el aire
Misterio magnético

Unidad 16 La Electricidad

Como funciona una batería
Conectemos una bombilla
Hagamos una linterna eléctrica
Generando electricidad
Completar un circuito
La conexión secreta

Unidad 17 El Calor

Haciendo velas
Conductor de calor
Derrite la cera
Detiene el calor
El centavo que salta
Leyendo un termómetro centígrado
El elástico que se encoge

Sample Learning Activity 1: Crystals and Powders

Salt Crystal Garden (Jardín de sal cristalizada)

Objective: To observe and describe the formation of salt crystals; to hypothesize reasons for their growth.

Thinking Skills: Observing, communicating, comparing, organizing, inferring, relating.

Materials: Glass bowls, water, ammonia, blueing, salt, food coloring (optional), coal, charcoal, broken brick, measuring spoons, mixing cups, worksheets, pencils.

Vocabulary:

crystal	food coloring	brick	base	garden	tablespoon
ammonia	coal	soak	mix together	mixing bowl	
blueing	charcoal	material	solution	sprinkle, pour	

Vocabulario:

cristal	colorante de cocina	ladrillo	base	jardín	cucharada,
amoníaco	tizón de carbón	remojar, empapar	mezclar	plato hondo	cuchara para
azulete	carbón de leña	material	solución	echar	medir

Directions to Students (From FO/D Student Activity Cards):

(English Version)

(1) Choose a base; it can be coal, charcoal, or brick. Put the base into water until it is all wet.
(2) Put the base into a glass bowl.
(3) Mix together 1 tablespoon each of water, blueing, and ammonia. If you'd like, add a few drops of food coloring, too.
(4) Pour the whole mixture over the base.
(5) Sprinkle some salt on the base.
(6) Watch your garden grow! It should keep growing for 2 days. What kinds of changes do you see? Write what happens on your worksheet. If the base dries up, add 2 tablespoons of water and 2 tablespoons of ammonia.

(Spanish Version)

(1) Escoge el material que usarás de base (podría ser carbón de tiza, carbón de leña o un pedazo de ladrillo). Pon la base en el agua hasta que se empape.
(2) Pon la base ya mojada en un plato hondo de vidrio.
(3) En un platito, mezcla: 1 cucharada de agua, 1 cucharada de azulete, y 1 cucharada de amoníaco. Si quieres, agrégale unas gotas de colorante de cocina.
(4) Echa la solución sobre la base.
(5) Añádele un poco de sal.
(6) Observa cómo crece tu jardín. Debe crecer durante 2 días. ¿Qué cambios has visto? Escribe en tu hoja de trabajo lo que pasó. Si se seca la base, agrégale 2 cucharaditas de agua y 2 cucharaditas de amoníaco.

Suggested Questions for the Teacher
(To be asked during and after each group's completion of the activity.)

Finding Out

1. What do you think is happening?
2. What could be making the crystals grow?
3. How important do you think it was to soak the base first? Why?
4. Do you think a piece of wood would make a good base? How about a piece of metal?

Descubrimiento

1. ¿Qué creen que está pasando?
2. ¿Qué hace que los cristales crezcan?
3. ¿Qué importancia tuvo remojar la base primero? ¿Por qué?
4. ¿Creen que un pedazo de madera sería una buena base? ¿Y un pedazo de metal?

Sample Learning Activity 2: Reflection/Refraction and Optical Illusions

Disappearing Colors (Colores que Desaparecen)

Objective: To observe and test that white light is made up of many colors. This phenomenon appears most when using the three basic colors: red, blue, and yellow.

Thinking Skills: Observing, communicating, comparing, organizing, relating.

Materials: Cardboard (i.e., the back of a tablet), scissors, cm ruler, watercolor paints, brushes, string, compass, worksheets, pencils.

Vocabulary:

compass	radius	equal	twist
section	disc	twirl	spin

Vocabulario:

compás	radio	igual	torcer
sección	disco	girar	dar vueltas

Directions to Students (From FO/D Student Activity Cards):

(English Version)

(1) Use the compass to make a circle that is 4 cm from the center to the edge. The distance from the center to the edge of a circle is the *radius*.
(2) Mark off three equal sections as you might cut a pie.
(3) Paint the sections blue, yellow, and red. Let the paint dry.
(4) Make two small holes about 1 cm apart on opposite sides of your color wheel.
(5) Cut a piece of string 105 cm long.
(6) Thread the string through the two holes and tie the ends together. Center the color wheel on the strings.
(7) Hold the strings at the ends and twist the color wheel until it's tightly wound. Pull the strings gently so the color wheel spins. What happens to the different colors? Where do colors come from? What happens when you mix colors together?

(Spanish Version)

(1) Usa un compás para hacer un círculo que tenga cuatro centímetros desde su centro hasta su extremo. La distancia del centro de un círculo hasta su extremo se llama *radio*.
(2) Haz tres secciones iguales, comi si estuvieras cortando un pastel.
(3) Pinta las secciones de distintos colores: azul, amarillo, y rojo. Deja que los colores se sequen.
(4) Haz dos agujeros pequeños en lados opuestos del círculo, y que estén a 1 cm de distancia de cada uno.
(5) Corta un pedazo de cuerda que tenga 105 cm de largo.
(6) Pasa la cuerda por los hoyos y amarra los extremos. Mueve la rueda de colores hacia el medio de la cuerda.
(7) Sujeta la cuerda por los extremos y enrolla la rueda de colores hasta que esté bien apretada. Tira la cuerda suavemente para mover la rueda. ¿Qué le sucede a los colores? De dónde vienen los colores? ¿Qué sucede si mezclas otros colores?

Suggested Questions for the Teacher:

Finding Out

1. Do you think your eyes are playing tricks on you? What do you think your brain is doing when it sees all those colors moving so fast?
2. What kind of results do you think you would get if you used all six colors?

Descubrimiento

1. ¿Creen que sus ojos los están engañando? ¿Qué creen que hace el cerebro cuando los colores se mueven a tanta velocidad?
2. ¿Qué resultados creen que obtendrían si usaran los seis colores?

Sample Learning Activity 3: Water

Water Games (Juegos de agua)

Objective: To observe and compare the rate of water flow on different surfaces. To measure volumetric displacement.

Thinking Skills: Observing, communicating, comparing, organizing, relating.

Materials: Water, small plastic or paper cups, medicine cups, eyedroppers, liquid detergent, cooking oil, fine gravel or pebbles, sheet of glass, gram scale, balance scale, sponge, watch with second hand, aluminum foil, plastic wrap, paper towels, waxed paper (optional: tiles, plastic chips, marbles), worksheets, pencils.

Vocabulary:

amount	level	overflow
liquid	surface tension	viscosity
spill	weigh	balance

Vocabulario:

Cantidad	nivel	derramar
líquido	tensión en la superficie	viscosidad
verter, derramar	pesar	equilibrar

Directions to Students (Adapted from FO/D Student Activity Cards):

(English Version)

(1) Use an eyedropper to fill a cup with water. See who can fill it the fastest without spilling any water.
(2) Fill half a cup with water. How many rocks can you put into it before the water overflows? Record your results.
(3) Weigh your cup and a friend's cup. Make sure both have the same number of rocks in each cup. Which one weighs more? Can you balance two cups filled with rocks and water? Record how many rocks were in each cup.

(Spanish Version)

(1) Llena un vaso con agua usando un gotero. Con un amigo/a, observa quién puede llenarlo más rápidamente sin derramar nada.
(2) Intenta llenar un vaso sólo hasta la mitad. Observa cuántas piedritas puedes poner en el vaso sin que se derrame el agua. Escríbelo.
(3) Pesa tu vaso y el de tu amigo. Llena ambos vasos con el mismo número de piedritas. ¿Cuál pesa más? ¿Puedes hacer que se equilibren los dos vasos llenos de agua y piedritas? Anota el número de piedritas que tiene cada vaso.

Suggested Questions for the Teacher:

Finding Out

1. What do you think keeps the water from spilling when it is filled beyond the top of the glass?
2. Which do you think would hold more rocks before overflowing, a glass of oil or a glass of clear water?

Descubrimiento

1. ¿Por qué no se derrama el agua aunque llenen el vaso más allá del tope?
2. ¿En qué vaso podríamos echar más piedras sin que se derramara el líquido: en uno de aceite o en uno de agua pura?

Sample Learning Activity 4: Change and Measurement

Measuring in CM and MM (Midiendo en CM y MM):

Objective: To measure the length of objects in centimeters and millimeters; to describe the difference in measurement between centimeters and millimeters.

Thinking Skills: Observing, communicating, comparing, organizing, relating.

Materials: Rulers (cm and mm), pencils, worksheets, objects for students to measure (e.g., egg cartons, spoons).

Vocabulary:

c ntimeter	worksheet	complete	object	ruler
accurate	total	measure	difference	record
choose	millimeter	length	actual	

Vocabulario:

centímetro	hoja de actividades	completo	objeto	regla
exacto	total	medir	diferencia	anotar
escoger	milímetro	longitud	real	

Directions to Students (From FO/D Student Activity Cards):

(English Version)

(1) Pick an object and write its name on your worksheet. Measure it with the cm ruler and write the length on your worksheet.
(2) If the length of your object falls between 2 cm on the ruler, then you will have to record the measurement in both cm and mm. Record both measurements.
(3) Put the cm and mm answers together. Write the answer in cm using decimals. The numbers after the decimal point show the extra mm.
(4) Measure other things. Use both cm and mm rulers. What's the difference between the cm and mm rulers?

(Spanish Version)

(1) Escoge un objecto y escribe su nombre en tu hoja de trabajo. Mídelo con unas reglas de cm y anota la medida.
(2) Si la medida del objeto cae entre dos marcas de la regla de cm, entonces tendrás que hacer la medida también con una regla de mm. Anota ambas medidas.
(3) Ahora escribe otra vez la medida en cm pero con decimales. Los decimales son los mm "extra." Un centímetro es igual a 10 mm.
(4) Mide algunas otras cosas con las dos reglas. ¿Cuál es la diferencia entre la regla de cm y la de mm?

Suggested Questions for the Teacher:

Finding Out

1. What objects did you measure? Did everyone who measured the same thing get the same length?
2. How do you change centimeters to millimeters?

Descubrimiento

1. ¿Qué objetos midieron? ¿Obtuvieron la misma medida todos los que midieron el mismo objeto?
2. ¿Cómo se convierten los centímetros a milímetros?

Conclusion

The curriculum described in this Teacher Resource Guide, *Finding Out/ Descubrimiento (FO/D)*, has been extensively pilot-tested at the Bilingual Consortium Schools of San Jose and thoroughly evaluated by the Center for Educational Research at Stanford (CERAS), which found that:

- Children showed highly significant improvement in problem-solving, reading skills, and English proficiency;
- On tests of reading, language, and mathematics, as well as on problem-solving, "low achievers" gained as much in absolute achievement as "high achievers"; and
- Children who participated in this program actually gained on statewide norms on the California Test of Basic Skills.

A summary of this and other studies can be found in a review of the research on FO/D by De Avila (1987).

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About the Authors

Edward A. De Avila has been conducting educational research for over twenty years. A senior consultant for over one hundred educational institutions and agencies, Dr. De Avila has contributed significantly to our understanding of the relationship between language, thinking, and academic performance among language minority populations. Perhaps best known as a co-developer of the Language Assessment Scales with Dr. Sharon Duncan, Dr. De Avila is currently Executive Director of De Avila, Duncan and Associates, Inc., San Rafael, California, where he continues to conduct research and develop educational materials.

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Cecilia J. Navarrete taught the first FO/D classroom at the Migrant Enrichment Center in Albuquerque, New Mexico, in 1974. From 1980 to 1985, as part of the Multi-Cultural Improvement of Cognitive Abilities Project at Stanford University, she assisted in the further development, implementation, and evaluation of FO/D. Dr. Navarrete has been a Senior Educational Evaluation Specialist for Interface Consultants, Inc. in Portland, Oregon. She is presently with the Quest National Center of Columbus, Ohio.