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Science education at an elementary school: Teaching the scientific processes to English language learners

Albert Steven Lozano

SCIENCE EDUCATION AT AN ELEMENTARY SCHOOL: TEACHING THE SCIENTIFIC PROCESSES TO ENGLISH LANGUAGE LEARNERS

A Project

Presented to the

Faculty of

California State University,

San Bernardino

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

in

Education: Bilingual/Crosscultural Option

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Approved by:

[redacted]

Esteban Diaz, First Reader

December 6, 1996

Date

[redacted]

Iris Riggs, Second Reader

Abstract

The underachievement of minorities and women in science continues in many elementary classrooms as traditional methods of instruction prevail. In order for minorities and women to become future scientists, elementary science education must allow students to participate in science as scientists. The utilization of the scientific processes is an everyday activity for scientists. The goal of this project was to provide English Language Learners with the opportunity to act as scientists by using the scientific processes in the elementary school classroom.

The traditional methods of science teaching in elementary schools have not been effective for minority students, particularly those whose are English Language Learners. In this project a different method of instruction was used. A teacher-developed thematic unit was taught to third-grade Spanish speaking students and instruction focused on utilizing the scientific processes of observing, communicating, comparing, ordering, and categorizing. This project analyzed three related aspects; (1) the methods of instruction used during instruction; (2) the mediational lessons, techniques, and devices used in teaching the scientific processes, and (3) the final student products. Analysis shows that the teacher-developed unit was able to teach English Language Learners both the content of the unit and the scientific processes.

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Chapter One

Introduction

This project is an analysis of a teacher-developed unit on insects taught to third grade Spanish-speaking students. The focus of the analysis is to examine selected lessons from the unit that incorporated the processes of science. Furthermore, the lessons, techniques, and devices used to teach the processes of science will be examined. The intention of the project is to examine if the teacher-developed lessons, techniques, and devices were successful in teaching the science processes to a group of students who are English Language Learners (ELL). Student work samples that utilized the processes, the lessons that instructed the students, and teacher vignettes about the lessons will be discussed.

The structure of the project is as follows. Chapter one uses the Sociocultural Contexts Model in order to help analyze several contexts relevant to elementary school science for Hispanics (Teft-Cousin, Díaz, Flores, & Hernández, 1995). In chapter two, the literature review will focus on two factors related to the past underachievement of Hispanics and ELLs in science education. The first is a review of science education in America, starting from the introduction of science in public education and culminating with a current philosophy on the education of elementary school science. The second portion of chapter two is reviews the difference between how Hispanics/ELL's learn and the methods of instruction primarily used in teaching science to elementary students. The intent of the literature review is to demonstrate that the manner in which science has been and continues to be taught does not generally coincide with the manner in which Hispanics and ELLs learn.

Chapter three contains: (1) the research design of the project; (2) data needed for analysis; (3) a description of the subjects; (4) the methodology used; (5) data collection; and (6) the type of analysis. Chapter four will report on the analysis and results of the lessons conducted in the classroom/teacher context. The lessons, techniques, and devices utilized in teaching the students will be discussed along with the final student products. This section focuses on one of the contexts of the sociocultural contexts. Chapter five will discuss the interpretations, limitations, conclusions, and implications of the project.

Background to the Study

Social/Cultural/Community Context

As America enters the twenty-first century, American public education must be able to produce a record number of needed scientists. Recent data shows that in the future there will be an increase in the need for scientists and engineers by as much as forty percent (Government-Institute-Research Roundtable, 1987).

Although the need for an increase in the effectiveness of science education is clear, current statistics are not encouraging. For example, a 1989 international survey ranked the United States' elementary and secondary science students at or near the bottom of the seventeen countries surveyed (International Association for the Evaluation of Educational Achievement, 1989). Additionally, the percentage of students currently entering doctoral programs in mathematics and science is expected to drop by five percent (Rendoin & Triana, 1989).

If America is to meet its future science and engineering needs, steps must be taken to enhance the science education of all its students. With the growing numbers of minorities and women in higher education, it is imperative that science education use these growing cohorts in order to fill its need for future scientists.

Two social variables are beginning to alter the chances of students that are currently underrepresented in science and engineering fields. The first is a change in social attitude regarding the participation of minorities and women that is occurring for some in the field. In Science for All Americans, the authors (Rutherford & Ahlgren, 1989) state that all children need and should receive a fundamental education in science and mathematics so that all children can live more productive and better lives. The authors emphasize that "all" children here refers to all children. They state:

> ... it becomes clear that the nation can no longer ignore the science education of any students. Race, language, sex, or economic circumstances must no longer be permitted to be factors in determining who does and who does not receive a good education in science, mathematics, and technology. To neglect the science education of any (as has happened too often to girls and minority students) is to deprive them of a basic education, handicap them for life, and deprive the nation of talented workers and informed citizens--a loss the nation can ill afford (pp. 156-157).

Along with this changing sociocultural attitude are changing demographics, particularly with reference to Hispanics in California. Projections indicate that by the year 2030 forty-four percent of California's school-age population will be of Hispanic origin, up from a figure of twenty-nine percent in 1986 (Valencia, 1991). This demographic phenomenon will make Hispanics the largest ethnic group in the state, surpassing the expected figure of thirty-three percent for Anglos for the year 2030 (Valencia, 1991). Along with this is an expected nineteen percent rise in the percentage of college bound minority students (Rendoin & Triana, 1989).

These three sociocultural factors: (1) an increased need for more scientists and engineers; (2) a more favorable attitude toward the inclusion of minorities and women in science; and (3) a demographic change indicating a rise in the Hispanic population; all indicate a possible influx of Hispanics into science and engineering jobs. Educators who are of Hispanic background and/or able to effectively educate Hispanics in science and mathematics will be in great demand.

Educational Outcomes for Hispanics

Though the increasing Hispanic population provides a possibility of potential scientists, historic indicators reveal limited outcomes for Hispanics students in science. The past underrepresentation of Hispanics in higher levels of science education has only recently been documented. For example, Rakow and Walker (1985) report that data taken from the 1981-1982 Minnesota Science Assessment and Research Project (MSARP) (a modified version of the National Assessments of Education Progress (NAEP) in Science) signifies one of the first attempts to systematically gather information regarding the early academic achievement and attitudes of Hispanic students in science. The findings in this study indicated that Hispanics and blacks scored lower on achievement at the ages of nine, thirteen, and seventeen than did their white counterparts, who scored above the national average at all three age-levels. In fact, a 1975 report on the underrepresentation of minorities in the biological sciences focuses primarily on blacks and whites due to the shortage of data on other minority groups (Barbosa, 1975).

There does exist, however, more recent data that indicates a lack of educational success for Hispanic students. For instance, a 1984 National Science Foundation report indicated that Hispanic Americans comprise slightly over two percent of the total number of engineers and scientists, and this cohort is making less money and has less experience than their Anglo counterparts (Rakow & Bermudez, 1988). Furthermore, a national survey indicated that Hispanics and Blacks did poorer on SAT scores, national science examination results, and were disproportionately under-represented in the science work force as compared to Anglos (White, 1992).

It has been indicated that there exists a gap between what the science community is looking for (more potential scientists and engineers) and the achievement of potential scientists and engineers (Hispanics) in the American education system. Many different factors have been examined regarding the underachievement of Hispanics in the sciences, and it is important to analyze what is occurring within the educational process. Fiscal constraints, the knowledge base, attitudes, and perceptions of both teachers and administrators, and the skill level of teachers are important variables within the educational process. It is these entities in the district school context that will now be addressed.

District/School Context

In addressing how to enhance the academic achievement of Hispanics in science, it is important to note that both the subject matter and the students involved are important elements. That is, the subject of science in the elementary schools in general may unnerve a good many teachers. In addition, Hispanics are linguistically and culturally different from; (1) many of their teachers, and (2) the language and culture of science education. The following analysis will first look at science in general terms, and subsequently will exam the science education of Hispanics within the district/school context.

In the district/school context, there are many variables that can impact the science education of students. For example, a district may adhere to the belief that science education consists of reading a certain science textbook and answering questions from the text. On the contrary, another district may adopt a different theoretical rationale as to what constitutes good science pedagogy and emphasize hands-on or inquiry learning. These two districts may also show differences in their theoretical rationales toward science education by allocating different amounts of money to their respective science programs. However, one of the most important variables in the science education of elementary students that exists in the district/school is the attitude elementary teachers have about teaching science, and this variable will be expanded on below.

Many teachers have reported that science teaching is not something they favor. One study indicated that teachers preferred teaching reading (thirty-six percent) and mathematics (twenty-three percent) more than science (sixteen percent) (Morey, 1990; Weiss, 1987). In fact, John Goodlad reported that science was the only subject elementary teachers thought they did not adequately teach (Barrow, 1987). The goal of producing more scientists will be harder to attain if teachers feel less enthusiastic about science than another subjects, for the tendency of teachers is to instruct in subject areas they enjoy.

Another important variable in the district/school context is the amount and type of training elementary school teachers receive in science education, both at the pre-service and in-service level. Elementary teachers generally do not receive adequate science education in college. According to the National Science Teachers Association (NSTA) recommendations, pre-service instruction should include only one biological science course, one physical science course, and one earth science course in undergraduate work. Using these as a baseline, only thirty-one percent of teachers in grades K-3 and forty-two percent of teachers in grades 4-6 met there standards (Weiss, 1987). Therefore these low requirements, although meeting the recommendations of the NSTA, are not providing teachers the opportunity to learn science content in greater depth, thereby hindering their effectiveness as science teachers (Zeitler, 1984).

Although teachers' lack of desire to teach science and their content knowledge of science may inhibit science teaching effectiveness, teachers' reasons for teaching science in general may also run contradictory to the desires of the science community. Specifically, teachers have indicated that the main reason for teaching science is to teach basic science content and the importance of science in daily life, while learning inquiry skills and becoming interested in science are viewed as less important (Weiss, 1987). This attitude runs contrary to science community expectations that the emphasis in science should be on the processes of science and not the content (Zeitler, 1984). The views held by both pre-service teachers and classroom teachers indicates that what the science community wants to be taught and what actually is being taught are distinctly at odds.

Another important factor in the district/school context is the pedagogical training teachers receive. Good methods course instruction should contain a hands-on emphasis, promoting creative skills and problem-solving ability (Barrow, 1987). On the contrary, teachers are not using these methods in their classrooms. In interviews, teachers stated that a hands-on emphasis, creative skills, and problems-solving ability were not being promoted in their classrooms. This calls into question the effectiveness of teachers' pedagogical training.

Both teacher attitudes toward science education and the training they receive may inhibit the ability of all learners to excel in science. These factors are subsequently enhanced when one takes into account students who are linguistically and/or culturally different. As stated earlier, the science achievement of Hispanics is below the national average in virtually all levels of analysis. This level of achievement is not unknown nor a big surprise to many educators. In a survey of teachers who instruct in a largely Hispanic community, teachers responded to the question "What do you consider to be the three most important reasons why Hispanic Americans are underrepresented in careers in science and technology"? The responses can be grouped into the following categorizes: (1) lack of encouragement from family and community; (2) skill deficiencies; (3) financial barriers; (4) lack of role models; (5) achievement motivation; (6) career awareness; (7) lack of self-esteem; and (8) dropout rate (Rakow & Bermudez, 1993). The nature of their responses indicate the type of perceptions and attitudes held by teachers about the future of Hispanics as scientists.

These findings carry with them two implications which are important in light of the factors at the social/cultural/community level (e.g. demographics and science emphasis) which are affecting education. First, the teachers interviewed tended to put the responsibility of science education underachievement on the Hispanic students and/or community and not the educational and/or science communities. The tendency to "blame the victim" is not new to educational research, but in this example it does shift the emphasis on improving the science achievement of Hispanics from a "team" effort (i.e. scientists-educators-Hispanics) to one solely on the shoulders of the students and their families.

Secondly, it is important to note that these teachers are currently teaching Hispanic students. With the predicted changes in the Hispanic community, particularly in California, many science education teachers who currently do not teach Hispanics will have them in their classrooms and may thus have more people to "blame" for failure in science. Future science teachers may: (1) be pushed by the social cultural factors of the scientific/economic communities into teaching a subject they do not enjoy as much; (2) do not have adequate science content knowledge; (3) teach under a premise of teaching content instead of process; and (4) have students in their classrooms who are culturally and/or linguistically different. The clash of attitudes and the changing society may thus further disenfranchise Hispanic and English Language Learners in science.

Another important variable is the training received by teachers of Hispanics, and particularly teachers who have students who are English language learners (ELL). Too often the instructional focus is primarily on English language acquisition, with content such as science an afterthought. "Historically, schools have focused on linguistic variables, rather than specific disciplines, as the most important components of educating bilingual-bicultural children" (Mason & Barba, 1992, p.24) English as a second language (ESL) training has also focused primarily on communications skills, thus not exposing many language minority students to higher-order thinking skills and problem solving

(Rakow & Bermudez, 1993). The call for a multicultural education has been around since the 1960's, yet due to definitional problems and a lack of consensus as to its constructs, teacher education programs have been inconsistent in their approaches (Atwater & Riley, 1993). What is needed as the next step is to begin looking at a multicultural science education, which Atwater and Riley (1993) define as; "... a construct, a process, and an educational reform movement with the goal of providing equitable opportunities for culturally diverse student populations to learn quality science in schools, colleges, and universities" (p.664).

Classroom/Teacher Context

Level of academic achievement of Hispanics, teacher attitudes, and teacher training have all been regarded as factors which have had an impact on the achievement of Hispanics in science education (Rakow & Bermudez, 1988). However, the focus of this paper is to examine what goes on in the classroom, the actual learning and teaching of students. Research has shown that different ethnic groups favor different learning styles. However, a survey of teachers conducted in West Texas shows that many educators tend to teach different groups of students in the same manner, unwilling or unable to differentiate between Hispanic Americans and Euro-Americans (Rakow, 1989, cited in Rakow & Bermudez, 1993).

In order to understand the manner in which science instruction is provided, one must differentiate between types of instruction. One method, called lecture-discussion, is characterized by teachers who merely transmit prescribed knowledge to "learners" who passively sit and are required to memorize this knowledge. This knowledge is usually contained in science text books, and the responsibility of the learners is to memorize the information of the text books. The "discussion" portion of the instruction generally entails a teacher asking students questions related to the content transmitted, and students are judged to be "learning" if they are correctly able to recite the lecture notes (Sutman & Guzman, 1992). This instructional approach restricts the learning of all students due to the limited opportunity students have to discuss ideas, ask their own questions, solve problems and generally develop their own thinking skills. This methodology stifles the academic growth of language minority students even more due to its emphasis on understanding oral language, providing little or no room to practice oral production of a second language with the teacher or peers (Sutman, Guzman, & Swartz, 1993).

In contrast to this method is the inquiry-discovery learning approach. In this environment, students are encouraged to ask and research their own questions by utilizing their pre-existing knowledge and teacher provided resources. An inquiry-based approach to science education has led to greater understanding of science processes and manipulative skills usage, allowing students to construct their own knowledge and providing more experiences in the real world of work. As opposed to the former method, the inquiry-discovery learning approach also encourages student-student interaction which assists language minority students more because it leads to, "better understanding the nature of their own questions, and they assist one another in understanding the answers to the questions through teacher managed discover activities" (Sutman, et al., 1993, p.45). The positive benefits of the inquiry-discovery method are not restricted to the understanding of scientific processes and knowledge; research has shown that this method of instruction is particularly useful in developing classification and oral communication skills of language minority students (Rodriguez & Bethel, 1983).

While the inquiry-discovery method of instruction has been shown to benefit not only language minority students but all learners, so too do the practices that are derived from "constructivism". The following is a revised list constructed by Yeager (1991) in "The Constructivist Learning Model", a list which contains elements similar to the inquiry-discovery model (Sutman & Guzman, 1992):

- seek and use questions, experiences, and ideas proposed by Limited English Proficient (LEP) students to guide the preparation of and the presentation of science directed lessons and instructional units.
- promote collaborative 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.
- 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.)
- 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.) (Sutman & Guzman, 1992, pp. 58- 59).

The parallels of the inquiry-discovery method and constructivism both point to more student-centered curriculum in which students use hands-on materials in order to construct their own knowledge. One such methodology, cooperative learning, has shown to have additional benefits such as increased academic achievement, more prosocial behavior, and better ethnic relations amongst students (Kagan, 1986). These methods of instruction are in accordance with the expectations of the science community and are the preferred method on instructing not only language minority students but all science education students. Sutman and Guzman (1992) write:

> 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 (p. 12).

The utilization of a hands-on method of science instruction appears to address the social-cultural factors that affect the nature of science education. It can provide for greater achievement of Hispanics and language minority students in science, thus helping address the concern that the science community will not be able to meet future demands. However, current research on teaching and learning in science suggests that a purely hands-on method falls short, that the construction of scientific knowledge entails more than experiential learning.

Although many educators call for an approach to science education that emphasizes a hands-on methodology, one must remember that the social construction of science knowledge occurs on two planes, individual and social. In analyzing science education, one can see the importance of hands-on learning on the <u>individual</u> plane. The constructivist view held by many science educators propose that children must experience science and appropriate what they see and/or experience. On the individual plane, it is the role of the teacher to provide students with the appropriate scientific experiences so that students are able to alter their pre-existing scientific notions and/or understand and interpret an occurrence for themselves (Driver, Asoko, Leach, Mortimer, & Scott, 1994).

Scientific knowledge, however, also occurs on the social plane. The social constructivist perspective is one in which learning itself involves being introduced to and understanding the symbolic world, in this case the symbolic world of science. Students must not only be allowed to experience the physical aspects of science, but must be assisted in understanding the language, concepts, and processes that are a part of science. This is achieved by both activity and dialogue on a social level, as more capable peers or adults (e.g. teacher) interact with students and provide structure and guidance until the student is able to appropriate the knowledge.

The theory of social construction of knowledge stems from work done by Lev Vygotsky (1978). Vygotsky called the area between what the student can do alone and what a student can do with assistance the "the zone of proximal development (ZOPD)". Vygotsky defined the ZOPD as "the distance between the actual developmental level as determined by independent problem solving and the level of potential problem solving under adult guidance or in collaboration with more capable peers" (as cited in Tudge, 1990, p. 157).

This perspective places the teacher or more capable peer in a position of providing students with the opportunity to learn on both the social and individual planes. "If teaching is to lead students toward conventional science ideas, then the teacher's intervention is essential, both to provide appropriate experiential evidence and to make the cultural tools and conventions of the science community available to students" (Driver, et al., p. 7). Science is human's symbolic interpretation of natural phenomenon. This symbolic system, a socially constructed system, must be taught to students as well (Driver, et al.).

The social construction of science knowledge places importance on both the social and individual experiences of students. The lack of success of Hispanics and ELLs in

American schools indicates that at some point these students are not being provided with the experiences and/or the culturally appropriate tools and conventions of the science community. In order to understand why this is occurring, analysis must investigate what is actually happening in elementary science classrooms in America.

While teacher training emphasizes a more hands on approach to science instruction, studies have shown that teachers are still utilizing the lecture-discussion method. For example, an Illinois survey of teachers reports that science instruction still depends on books, and that a lack of equipment/facilities and a low priority of science education still prevails (Morey, 1992). A national survey reports that although teachers feel that laboratory-based science classes are more effective, actual classroom implementation has not increased in terms of time in hands-on instruction in the last ten years (Weiss, 1987). Furthermore, this survey reports that the move away from a textbook orientation has not begun. Only twenty-eight percent of instruction was devoted to hands-on or laboratory usage for teachers in grades K-6.

Many elementary teachers are not implementing the inquiry-discovery, and/or hands-on methodologies, nor are they providing students with the appropriate ZOPD's necessary to learn science effectively. Contributing to this lack of appropriate instruction may be the limited qualifications of those providing instruction to many Hispanic/ELLs. In many instances, bilingual aides rather than certified classroom teachers are providing instruction when the teacher is monolingual English. Furthermore, many "bilingual" classrooms lack materials to conduct hands-on experiments and are relying on out-dated textbooks. Additionally, due to the emphasis on lecture-discussion, many science classrooms with language minority students continue to rely on drill-and-skill work, thus not allowing students to construct their own knowledge nor develop higher-order thinking skills (Mason & Barba, 1992).

It is not difficult, therefore, to understand the low achievement of Hispanics and ELLs. The social and cultural emphasis on science and the changing demographics have not coincided with a change in science methodologies. The question arises as to how one should teach Hispanic and ELLs. In the Science Framework for California Public Schools Kindergarten Through Grade Twelve (California Department of Education, 1990), the message provided by the state board of education calls for "thematic teaching, coupled with active learning" (p. v). This point is elaborated further in the foreword.

> By active learning, we mean instructional activities where students take charge of learning the major ideas in science... In science classes we typically think of hands-on laboratory experiences, but there are many other forms of active learning, including active reading, listening, discourse, and using new technologies" (California Department of Education, p. vii).

This statement by the state of California to its teachers suggests that the social construction of science education must not only be accomplished on the experiential-individual level but also must occur on the symbolic-social level.

Science involves more than finding correct answers. It entails a manner of thinking, processes that form the center of science pedagogy. The authors of the framework feel that working with these processes "... forms the core of science pedagogy: observing, communicating, comparing, ordering, categorizing, relating, inferring, and applying. As scientists use these processes in their everyday work, so science teaching should center instruction, particularly hands-on instruction, on these fundamental processes" (California Department of Education, p. 144). This perspective thus requires a social construction of knowledge perspective, for it involves the processes of knowledge construction not only on the individual-experiential level but on the symbolic-social level as well. This belief is one shared by those who adhere to the social construction of science knowledge. "Learning science involves young people entering into a different way of thinking about and explaining the natural world; becoming socialized to a greater or lesser extent into the practices of the scientific community with its particular purposes, ways of seeing, and ways of supporting its knowledge claims" (Driver, et al., 1994, p. 8).

Finally, the focus on scientific processes in the teaching of science accomplishes two things, both of which fall within the social constructivist perspective. First, instruction is geared toward both doing science and socially constructing knowledge as opposed to simply finding the correct answers. Secondly, Vygotsky and his followers contend that the role of a teacher is to determine the level of a student or a group of students was functioning with respect to science and then create lessons (ZOPDs) that challenge them to greater potential. That is, the Vygotskian framework itself calls for science teachers to set up ZOPD's that are best suited for their students. "This also advocates a student-centered science program created by teachers who are free to design the types of experience that best fit their students" (California Department of Education, p. 144).

The Problem

Statement of the Problem

As indicated by the historical underachievement of Hispanics in the sciences, there is a problem in the methodologies used in teaching science education for Hispanic students in elementary schools (grades 3 - 5).

Research Questions

1) Will ELL students learn using a thematic process-oriented approach to science teaching?

2) What mediational teaching strategies provide a scaffold for students as they move to new levels of understanding and utilization of the scientific processes?

Definition of Terms

English Language Learners (ELL): A designation for students whose primary language is not English and whose Language Acquisition Skills (LAS) test performance indicated none or only some mastery of English communication skills.

Curriculum-design: Primary language instruction of elementary students in a language other than English. In this project, the language of instruction is Spanish.

Thematic process-based science education: Teaching students science material in a thematic unit with a focus on implementing the scientific processes.

Lecture-discussion based science education: A method of instruction whereby students read and/or listen to instruction with little or no student-student nor student-teacher interaction.

Hands-on science education: "Hands-on science is defined as any science lab activity that allows the student to handle, manipulate, or observe a scientific process" (Lumpe & Oliver, 1991, p. 345).

Hispanic Americans - People whose ancestors are from a Spanish-speaking country.

When applicable, a more specific term will be utilized (e.g. Mexican Americans).

Zone of proximal development: The distance between the actual developmental level as determined by independent problem solving and the level of potential problem solving under adult guidance or in collaboration with more capable peers (cited in Tudge, 1990, p. 157).

Cognitive styles: "... the characteristic self-consistent modes of functioning found pervasively throughout an individual's cognitive, that is, perceptual and intellectual, activities" (Witkin, 1967, p. 234).

Field independence: the ability to perceive items as discrete from the organized field of which they are a part" (Witkin, 1967, p. 236).

Field dependence: "In a field-dependent mode of perception, the organization of the field as a whole dominates perception of its parts; an item within a field is experienced as fused with organized ground" (Witkin, 1967, p. 236).

Observing: using one's senses in acquiring information about the environment.

Communicating: the ability of using language and symbols to convey information from one person to another.

Comparing: the ability to examine what is similar and/or different between two objects or events.

Ordering: placing objects or events in a linear format based on a common variable.

Categorizing: placing objects or events in groups according to a common or several common features.

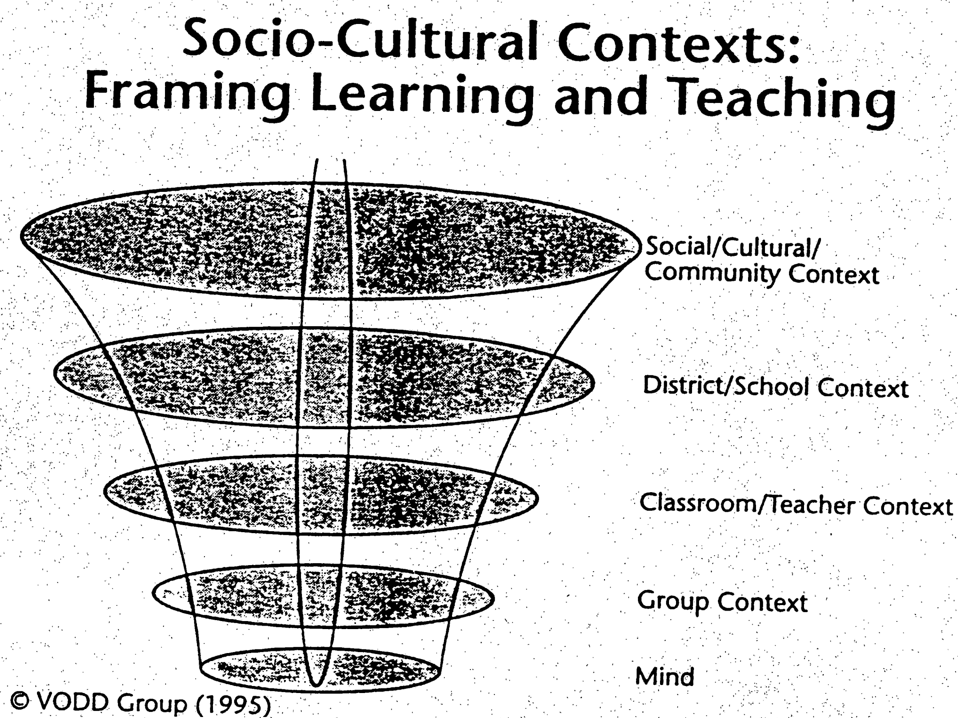
Theoretical Framework

The theoretical framework utilized in this paper is entitled "sociocultural contexts" and is based on an article entitled; "Looking forward: using a sociocultural perspective to reframe the study of learning disabilities" (Teft-Cousin, Díaz, Flores, & Hernández, 1995). By using a sociocultural perspective on teaching and learning, the authors emphasize that an individual's learning can only be understood by addressing the social, historical, and cultural contexts surrounding the individual. The model is depicted as five interconnected circles, stressing the fact that student learning is affected by variables from a multitude of contexts (see Figure 1). Students develop within these different contexts and as such both act upon and are acted upon by these contexts. It is only by analyzing these other contexts that one can construct a clear picture of variables affecting teaching and learning. Below is a summation of the five contexts depicted.

The first context is the <u>social/cultural/community</u> context. It is here that fundamental learning occurs because what is learned on the individual plane (intrapsychological) is first learned on the social plane (interpsychological). This viewpoint stems from a Vygotskian perspective, stressing that what a learner internalized is first understood socially. For example, over the years many ELL's have "learned" who can and cannot be scientists. Furthermore, the sociocultural perspective also understands that historical events play a central role in developing what a person learns. A clear example of a historical event that changed what people learn can be visualized as one imagines the lessons "learned" by people who grew up during the depression as compared to the subsequent "baby boom" generation. The depression altered how an entire

Figure 1

Sociocultural Contexts Model



generation of people viewed the world, not unlike the changes that occurred with the launching of the first satellite, Sputnik.

The district/school context is next, entailing those elements which comprise a school culture. These elements can include the attitudes and training of staff members (including their science knowledge and attitudes), and the socioeconomic status of the school and/or district. The third context is the classroom/teacher context, the manner in which a teacher organizes instruction. The teacher is the mediator of knowledge in a classroom (both formal and informal) whose responsibility is to organize zones of proximal development that foster student learning. This context is analyzed in the project; the lessons, techniques, and scaffolds used by the teacher in teaching a unit on insects using the science processes.

The fourth context is the group context. Classrooms for many years were viewed as a teacher-dominated endeavor with sole authority and knowledge resting with the teacher. The sociocultural perspective, on the other hand, emphasizes that student-teacher and/or student/student interaction is vital in moving children to new levels of development. As Vygotsky stated, "more capable peers" are important classroom elements. The final context, the mind, is literally a product of the previous four, an "internalization of all social interaction" (Teft-Cousin et al. 1995, p. 659). The internalization of what a student's social/cultural/community context teaches, added together with what the student's district/school, classroom/teacher, and group teaches students is appropriated in the mind.

Summary

The historic underachievement of Hispanic students entails many variables that occur in different contexts. The focus of the project is to analyze only one of these contexts, the classroom/teacher context. The science education of Hispanics and ELLs in America has not been a positive experience. Therefore a teacher-constructed unit was used and the project analyzes the lessons that focused on teaching students the processes of science. In addition, analysis is also done on the scaffolds used to teach the processes themselves. This is not to say that an examination of the classroom/teacher context is the most important element. However, analyzing one "slice" of the circles may lead to more understanding of how the classroom teacher can facilitate a positive science experience for ELLs.

Chapter Two

Review of Related Literature

The purpose of the project is to analyze whether English Language Learners (ELL) in a third-grade class learn science using a thematic process-oriented approach to science teaching. The underachievement of Hispanic and English Language Learners in elementary school science indicates that the methods of instruction which have been used historically have been ineffective with these students. The literature review will consist of two sections in order to examine this issue. The initial section will be devoted to the history of science education in America. This will enable the reader to understand how science education for elementary students has evolved in America. The second section will consist of research pertaining to the teaching/learning of Hispanics and ELL in America. The motivation for examining a teacher-constructed unit is an outgrowth of these two areas. That is, traditional science methods have been ineffective in educating Hispanics and ELLs because they are contradictory to the manner in which Hispanics and ELLs learn most effectively.

American Science Education: Eighteenth and Nineteenth Centuries

Withing the institution of American education, there has been some consistency and not all of this consistency is positive. For example, the emphasis on "men", to the exclusion of minorities and women in schools has been a constant. C. Johnson (1904) writes:

> In most of the old district schools little was imparted beyond a few bare rudiments, the teachers were often ignorant, and sometimes brutal, the methods mechanical and dreary. Notable men have come from "the little red schoolhouses," but this was because of their own native energy and thrifty acquisitiveness, and was not

due to any superlative virtues of the schools themselves. (p.134)

While some consistency in elementary education has remained, what is known today as elementary school science has changed. In the late eighteenth and early nineteenth centuries schooling was a teacher-dominated endeavor and science in the elementary schools consisted of reading science selections embedded in children's literature. The books used during this period were basically literature that included science material that was to be read to children by parents and/or tutors, books from home that made their way into schools (Underhill, 1941).

During this period a new phenomena began; literature was introduced into the schools that was specifically for the purpose of instruction. "Materials shifted from books for children which might be used in the schools to texts for school use which might be used in the home." (Underhill, 1941, p 48). Science was interjected as collections of facts pertaining to entities of a story. For instance, a section of facts about hares and tortoises would be included as an introduction to the story "The hare and the tortoise" (Rillero & Rudolph, 1992). During this period in American history, religious institutions had a profound influence on education, and "The hare and the tortoise" would also be utilized to teach such American ideals as honesty, hard work, and perseverance (Rillero & Rudolph; Underhill, 1941).

As both science and textbooks became more popular in schools, the amount of science in schools drastically increased. In the beginning of the nineteenth century, the mean science content of the average textbook was 3.9 percent of the pages. During the years 1840 to 1859, this average peaked to a percentage of 19.6 (Rillero & Rudolph, 1992). However, this increase in the amount of science in textbooks did not translate into increased scientific awareness nor better teaching. In fact, the domination of the textbook changed the manner in which science was taught. "The development of the school reader, supplementary-reading materials, and texts tended to shift the emphasis almost completely from a study **of** things and phenomena to a study **about** things and phenomena." (Underhill, 1941, p.48). Teaching and learning became centered more on teachers simply reading science information to students with minimal student interaction with scientific materials. The lecture-discussion method of science education had become the norm.

American Science Education: Object Teaching

While American education became more dependent on textbooks, many educators were dissatisfied with the education of American students. In 1860, Edward Sheldon began an innovative program which focused on using a sensory and experiential approach to learning. Sheldon's theoretical premise was rooted in the Enlightenment movement, a philosophy which stressed the power of human reasoning and emphasized learning from experience rather than from authority. Sheldon's school, the Oswego Primary Teachers Training School, taught teachers how to use materials and living things in the classroom as opposed to relying on the sole authority of the textbook. This was the first example of teacher-education and was called Object Teaching due to its emphasis on using real science objects as part of instruction (Rillero, 1993).

Sheldon soon introduced another important component. The education of teacher-educators soon evolved and the influence of the Oswego Primary Teachers Training School was felt throughout America. Many subject areas were affected such as art, vocational education, and mathematics. However, the subject area most affected was science. Teachers were now bringing in flowers, rocks, and animals into the classroom in order for children to study and/or observe first-hand, a change from a previous reliance on textbooks. Many educators lauded this transformation and because of its usage of natural science materials object teaching soon turned into Nature Study and subsequently into what is now considered Elementary School Science (Rillero, 1993).

Although lasting only twenty years, the impact of object teaching is prevalent today. Field trips, children studying and observing objects first-hand, and discovery and inquiry learning all contain their roots in the object teaching revolution. There are many explanations given for the short life-span of object teaching. First, many educators felt teaching/learning in this manner lacked order and direction. Still others felt that the teachers did too much talking and that many teachers had simply memorized lessons and did not maintain nor understand the philosophy behind object teaching. Nevertheless, the development of teacher education, educating those who instruct future teachers, and elementary school science are all positive outcomes of the object teaching era.

As the nineteenth century came to a close, more changes took place in science education in the elementary schools. Science began to emerge as an independent subject for several reasons. First, many felt it necessary to use "literature" in the readers in order to teach reading and wanted to delete the science material. Second, science teaching increased from an average of 4.6 percent of classroom time to roughly fifteen percent (which is the average today) (Rillero & Rudolph, 1992). Finally, recommendations by the Committee of Ten in 1893 stated that science was to be studied as a formal subject in both elementary and secondary schools. The Committee recommended, "that the study of simple natural phenomena be introduced into the elementary schools and that this study, so far as practicable, be pursued by means of experiments carried on by the pupil" (National Education Association, 1893, p.118). The Committee further stated that "the study of books is well enough and undoubtedly important, but the study of things and phenomena by direct contact must not be neglected" (National Education Association, 1893, p.119). Finally a decisive point was written in regards to the best methodology to be used in teaching students, a statement that conflicted with the emphasis on textbook education. "That the study of natural history in both the elementary school and the high school should be by direct observational study with the specimens in the hands of each pupil, and that in the work below the high school no text-book should be used (National Education Association, 1893, p.141).

American Science Education: Twentieth Century

As the twentieth century began, elementary school science had been established as a part of the American school curriculum. An outgrowth of object teaching and the importance of active student participation was the project method of learning in which students were assigned tasks to be completed at home and/or in gardens that were related to school projects (Haury & Rillero, 1994). John Dewey added that the project method of learning engage students in "purposive, problem-solving activity carried on in its natural setting" (as cited in Haury & Rillero, 1994, p. 9). It appears as though American science education had become a student-centered, activity-based endeavor. However, future global events caused the American education community to reexamine what was actually taking place in American science classrooms.

In the first half of the twentieth century, America had emerged as a world superpower and America's elementary school science education went unquestioned. Testing during this period had suggested that weaknesses existed in mathematics and science, yet due to America's victory in World War II school and government officials paid little notice (Prather, 1993). Even though the turn of the century had suggested a move toward a more activity-oriented curriculum for elementary students, many researchers submit that this did not occur. For example, William Kyle writes that "Science classrooms of the 1990s look remarkably like science classrooms of 50 years ago" (Kyle, 1991, p. 403), implying these classrooms teach low-level skills as teacher-dominated discussions prevail. Another researcher noted that although calls for student-activity and a lack of textbooks in the elementary schools was heeded (e.g. Committee of Ten), studies indicated that in the middle and late 1950s a single textbook was the basis of science instruction for eighty percent of primary teachers and ninety percent of intermediate teachers (Helgeson, Blosser, & Howe, 1977). America was the sole possessor of nuclear energy and even though Russia was close to this achievement many Americans felt Russia was simply "following the leader". Added to this confidence was the plethora of scientists who were choosing to continue their work and research in America. The basis was set for a shocking realization of the strength of America's elementary school science (Prather, 1993).

In October, 1957, the Soviet Union launched Sputnik, the earth's first artificial satellite. During the previous decade the relationship between the United States and the

Soviets had become tense and this accomplishment by the Soviets caused a panic throughout America. A new scrutinization of America's science education began as the nation searched for answers as to why Russia had beaten America into space. Special attention was given to science education and its improvement was now a matter of national defense. Money was channeled into schools for the first time in great quantities through the National Defense Education Act in hopes of improving American education in general and science and mathematics in particular (Myers & Myers, 1990).

In the years that followed, much attention was given to what should be taught and how it should be taught. Many advocated an emphasis of the processes of science, a reduction in the content in order to allow for more depth, less reading about science and more hands-on pedagogy, and a greater variety of materials and media in science teaching (Helgeson et al., 1977). It was apparent that the earlier reforms called for in the scientific community had not been accomplished. A new reform movement was needed, a move away from the previous teacher-dominated approach to science. "Scientists, teachers, and other educators believed strongly that few of the goals of science education could be achieved through the traditional methods of lecture, memorization, and recitation" (Howe & Jones, 1993, p. iv).

The "reform" movement in elementary school science created by the launching of Sputnik in many ways modeled the initiatives mandated at the turn of the century. The curriculums of the 1960's and 1970's emphasized the use of hands-on pedagogy in science education (Helgeson et al, 1977; Hodson, 1990; McAnarney, 1978; Prather, 1993). However, studies were conducted that indicated that the subsequent reforms did not have the positive impact on science education that was anticipated. For instance, many teachers continued to teach science only if time allowed, and equipment purchased to bolster science programs remained unused (Pratt, 1979). Further studies showed that although stressing hands-on activities, many teachers continued to stress basic skills and reading/lecture of the textbook (Peterson, 1993). While the scientific processes, hands-on activities, and new materials were all part of the reaction to Sputnik, their overall impact was limited. "Some maintain that these efforts of the last 10-15 years have had relatively little impact on the educational scene. There appears to be mounting evidence that even certain adopted programs are not being utilized fully and often remain in boxes or on shelves" (McAnarney, 1978, p. 31). McAnarney further states that; "There appears to be, though there have been many proposals for change, little evidence that instruction has improved" (McAnarney, 1978, p. 37).

As was the cases with the object teaching revolution and the recommendations of the early twentieth century, the reform movement caused by Sputnik did not prove to be a panacea for elementary school science. Numerous elements were involved which undermined the effectiveness of the new reform movement. J. Prather (1993) provides five reasons for the ineffectiveness of the reform movements caused by Sputnik, reasons which may have also been responsible for the lack of success of the previous reform movements:

> ... 1.) lack of central involvement of classroom teachers and local administrators, who must function at the front-lines of educational change, in the planning of reforms; 2.) a subject-specific emphasis, with many instructional materials written by content specialists; 3.) little relevance of the materials to student needs and interests; 4.) limited adoption of the new programs and materials by the schools, probably for the reasons just cited; and 5.) retention of traditional textbook-

> oriented, teacher-centered teaching methods by many teachers using the new materials (p. 58).

Although all five in combination are critical, the initial element listed is vital. "Teachers must be empowered to participate actively in the process of intellectually honest and ethical reform and research in science education" (Kyle, 1991, p. 405).

The movement in elementary school science that is occurring in today's classrooms is based on the constructivist theory of education. From this perspective, no longer are students perceived as blank slates with knowledge disseminated by all-knowing adults. Children come to school with their own conceptions of how the world operates, particularly in science. At times the conceptions that students bring to the classroom are not accurate, differing from a factual or total understanding of the concept. Vygotsky called concepts learned in the classroom scientific concepts which "originate in the highly structured and specialized activity of classroom instruction and impose on a child logically defined concepts" (Vygotsky, 1986, p. xxxiii). These are opposed to spontaneous concepts, which "emerge from the child's own reflections on everyday experiences" (Vygotsky, 1986, pp. xxxiii-xxxiv).

The constructivist theory on education supports this viewpoint, and the teaching/learning process of science is now envisioned with teachers organizing activities and dialogue so that students have an opportunity to alter their spontaneous concepts. Therefore the constructivist theory of education is two-fold; teachers must not only understand what scientific concepts they are to teach but must also assess the current spontaneous concepts of children and organize instruction to allow children the opportunity to alter these conceptions for themselves.

Hispanics and English Language Learners in Education

The utilization of the sociocultural contexts model underscores the viewpoint that the teaching/learning of Hispanics and ELL's is effected by variables that occur in many contexts. This project focuses on one of these contexts, the classroom/teacher context. The initial portion of this section concentrated on how science has historically been taught to elementary students. Emphasis will now center on the rational for using a thematic process-based approach of science teaching to Hispanics and ELL's.

In order to maximize student learning, it is vital that teachers understand how students learn. For years many teachers worked under the assumption that all students learn in the same manner. However, research in the last two decades proclaims that this is not the case. Research on different socialization patterns has been done which indicates that learners exhibit different cognitive styles due to these different patterns of socialization (Ramirez, 1973; Ramirez & Price-Williams, 1974A; Witkin, 1967). The term "cognitive styles" describes "the characteristic self-consistent modes of functioning found pervasively throughout an individual's cognitive, that is, perceptual and intellectual, activities" (Witkin, 1967, p. 234). Two different cognitive styles, an articulated cognitive style and a global cognitive style, differentiate how one perceives the world. Cognitive styles tests have revealed that two learning styles are prevalent; (1) field independent (analytical/differentiated) which coincides with the articulated cognitive style, and (2) field dependent (global/integrated), which corresponds with the global cognitive style.

These learning styles, field independence and field dependence, are two dimensions on a continuum with many individuals falling somewhere in the middle. As teachers organize instruction, it is important for them to remember that certain groups of students have a tendency to exhibit some of the characteristics of these styles. A field independent mode of perception is defined as the ability "to perceive items as discrete from the organized field of which they are a part" (Witkin, 1967, p. 236). The literature describes several learning style elements which are fairly consistent and closely related. Field independent learners value independence and are inductive learners (Dunn, Griggs, & Price, 1993). Generally, field independent learners are high in cognitive restructuring skills but low in interpersonal competencies (Griggs & Dunn, 1989; Witkin, 1979), tend to emphasize individual competition and achievement for the individual (Anderson, 1988), and learn material analytically (Jamieson, 1992).

As opposed to field independent learners, field dependent learners perceive the world in a different manner. "In a field-dependent mode of perception, the organization of the field as a whole dominates perception of its parts; an item within a field is experienced as fused with organized ground" (Witkin, 1967, p. 236). Like the former cognitive style, field dependent learners generally contain similar attributes. Field dependent learners have been shown to be deductive and have a group orientation (Dunn et al., 1993). They tend to be high in interpersonal competencies but lower in restructuring ability (Griggs & Dunn, 1989; Witkin, 1979). Finally, field dependent learners emphasize group cooperation, achievement is group oriented (Anderson, 1988), and these learners are better on structured tasks (Jamieson, 1992).

The differentiation between field independent and dependent learners is extremely important in an educational context only if one understands the purpose of education.

Formal schooling is designed to teach values and mannerisms that depict what a society deems worthy and the American education system is no different. Cohen (1969) states that "... the overall ideology and learning environments of the school embody requirements for many social and psychological correlates of the analytic style" (p. 830). That is, the typical "school" environment, including the methodologies historically utilized, is geared toward those whose learning style can be classified as field independent. Research also indicates that field independence is favored by some educators. In interviews with teachers, research found that there is a tendency for teachers to overestimate the abilities of field independent children while underestimating the abilities of field dependents (Saracho, 1991). Furthermore, this study found that field independent children were perceived as more socially competent than their field dependent counterparts, a finding not uncommon to other researchers. In speaking of field dependence, Cohen (1969) states that; "the cognitive characteristics of this style and its sociobehavioral correlates have been considered deviant and disruptive in the analytically oriented learning environment of the school" (p. 830).

If education in general is viewed as preferential to field independent learners, science education in particular also favors these learners (Stansfield & Hansen, 1983). It must be remembered that although reform had been called for in the past, the lecture-discussion method of teaching science has continued to dominate. This means that abstraction (theory) usually precedes any practical application, a manner of science teaching which is more conducive to the analytical field independent learner (Anderson, 1988).

The propensity of education (specifically a lecture-discussion method of science teaching) to favor field independent learners has positive implications for some learners and negative connotations for others. According to research studies, the differences in learning styles does have a general tendency to follow patterns of ethnicity which do not favor Hispanics and ELL's. Research indicates that Anglo-Americans generally are socialized into a field independent cognitive style while Hispanics and ELL's tend to be field dependent (Cohen, 1969; Dunn et al. 1993; Ramirez & Price-Williams, 1974A; Ramirez & Price-Williams, 1974B; Spangler, (1982). Other tests have shown that Anglo children tend to be more competitive that Mexican-American or Mexican children with the latter being more cooperative in comparison (Kagan & Madsen, 1971). The idea that education has traditionally favored some students and not others is not a new concept in education. "Schools in the United States, like many other aspects of life, serve the needs of the European American middle class" (Grossman, 1995, p. 8).

The fact that ethnic groups generally favor field independence or dependence must be viewed with a certain amount of caution. Many have justly indicated that not <u>all</u> Mexican Americans are field dependent, nor are <u>all</u> Anglo-Americans field independent (Grossman, 1995; Saracho, 1991, Spangler, 1982). Any classroom teacher, bilingual or not, is probably able to select students in the class who exhibit some and/or a combination of both learning styles. However, the possibility of these differences is the important factor. For too long, instruction, especially science instruction, was geared toward one cohort of students (Anglo-Americans who tend to have a field independent learning style). "What we **are** saying is that learning style preferences vary among individuals and that efforts should be made to (1) understand these differences and (2) alter instructional style in those areas and at those times that modifications are possible" (Smith & Renzulli, 1984, p. 47). By matching the preferred learning style of Hispanic and ELL's with different teaching methods, the historic underachievement of these groups may be impeded. "Research has consistently indicated that educators can enhance students' learning and success in school by accommodating their instructional techniques to student's communication, learning, and motivational styles" (Grossman, 1995, p. 22).

In the past, the utilization of thematic teaching in science has not been prevalent and this may have contributed to the underachievement of Hispanics and ELL's. Furthermore, research done on three different types of bilingual classes (ESL, Sheltered English, and transitional-bilingual) indicates that even in these bilingual classrooms the method of instruction was not conducive to those students (Barba, 1993). For instance, in these classrooms the level of peer activity was low and instruction was mostly a teacher-dominated endeavor. In addition, the interaction with manipulatives was also minimal (twelve percent of the classrooms). Therefore, although classified bilingual classes, the methods used did not promote positive learning experiences for these groups of students (Barba, 1993).

Language in the Instruction of Hispanics and ELL Students

The issue of which language to use in science instruction is one which evokes great debate. However, as one analyzes the role of language in science education it becomes apparent that using a students' primary language maximizes learning. Research by John Cummins (1989) states that language proficiency can be measured in two manners. The first is a student's Basic Interpersonal Communicative Skills (BICS), the ability of a student to engage in normal, everyday conversation. This conversational ability usually takes two years to learn and is different from the language ability needed to succeed in academics. A student's Cognitive Academic Language Proficiency (CALP) is what is needed in order for a student to succeed in school and usually takes between five to seven years to develop. Cummins describes academic language proficiency as the capability to succeed in; "both reading and writing abilities and in content areas where students are required to use their language abilities for learning (e.g. science, social studies, etc)" (Cummins, 1989, p. 27).

Although primary language instruction in general is advocated by Cummins for the initial years of schooling, the subject of science itself exacerbates this need because the nature of science discourse can create problems for students (even for those whose primary language is English). In fact, many believe that part of the "inclusion" of some groups in scientific endeavors and the exclusion of others (e.g. language minority students) is due to the "scientific" usage of language. "In the field of science, the curriculum tends to insure that only students with privileged social and linguistic backgrounds master the genre structures through which the thematic-semantic content of the subject is taught" (Lemke, 1987, p. 1).

When introducing science to English Language Learners, the utilization of their primary language is necessary. Language is a "bridge" to learning and students who are using a second language literally have a bigger distance to travel, having to first learn English and then the nature of scientific discourse (Roseberry, Warren, & Conant, 1990).

From a Vygotskian perspective, it is important to remember that the interactions that occur between teacher and student are intended to move students as effectively as possible through zones of proximal development. Vygotsky felt that language is a higher psychological process and that it is a tool used in guiding individuals from their present to their potential levels. The language of instruction is literally a mediational device in the ZOPD and can be represented pictorially as such:

MA (mediated action)

S <-----------------------------------> O

In the above diagram MA is "mediated action", an incorporation of the materials, curriculum, and language used to communicate meaning from the adult and/or more capable peer to the object/student (Wertsch, 1991). The "S" represents the student. The "O" signifies the object, or in the case of this project the scientific processes to be learned. Furthermore, research suggests that when teachers are using students' primary language they are more likely to use culturally relevant examples with the students. That is, teachers will use more culturally appropriate mediational devices when assisting students as they move to their potential levels of development. "In these classrooms teachers used more culturally familiar examples when speaking in Spanish than when speaking in English. Additionally, culturally familiar elaborations were used by teachers far less often than generic or mainstream American elaborations" (Barba, 1993, p. 1064). The utilization of the students' primary language (in this project, Spanish) is the most effective mediational device.

Summary

The current attention being paid to science education in America is very different from the attention that followed the launching of Sputnik. Then, the intent was to improve the science education of the elite. Today the intent is on providing quality science education for everybody, including minority students (Loucks-Horsley, et al., 1990). For years, science education has been a teacher-dominated subject which relied heavily on the lecture-discussion method. However, the current constructivist method of organizing teaching and learning may prove to be better for Hispanic and ELL's, more effective in moving these students through ZOPDs to a heightened scientific awareness. "Constructivism includes the important hands-on part of science instruction, but enriches learning by promoting concept development and higher order thinking skills through ample opportunities to engage in dialogue with the teacher and peers" (Loucks-Horsley, et al., 1990, p. 49).

The constructivist theory of education, along with the knowledge regarding learning styles and primary language instruction, may enhance the future science achievement for Hispanics and ELL's. Unfortunately, the literature review has shown that the following excerpt is an example of the past science education of Hispanics and ELL's. "The elementary science learning environment experienced by Hispanic/Latino students in the study may be characterized as a monolingual English-speaking environment in which culturally familiar teaching strategies, instructional materials, and contexts are missing" (Barba, 1993, p. 1065).

Chapter Three

Design/Methodology

Research Design

This project is an analysis of selected lessons of a teacher-developed thematic unit on insects. The analyzed lessons were those that dealt specifically with the science processes. In addition, analysis was done on the student work samples and devices that were utilized in teaching the processes. The lessons were taught in a third grade class using the student's primary language (Spanish).

The unit focused on utilizing five processes of science: observing, communicating, comparing, ordering, and categorizing. These five are recommended as the initial processes in the Science Framework for California Public Schools Kindergarten Through Grade Twelve (California Department of Education, 1990). The focus on the these five was based on a lack of science exposure afforded this group of students in first and second grades. In interviews with the first and second grade teachers, they indicated that "science" had consisted of language arts themes centered around topics such as water and plants. The activities of those thematic units consisted mainly of either; (1) reading **about** scientific (e.g. water and plants), or (2) art projects without a consideration on using the processes of science.

Data Needed

Data were collected which show how each of the five processes was implemented in the unit. The data for each process is comprised of three entities: (1) lesson plans that describe both the mediational and the final activities for the process; (2) the observational notes taken by the teacher; and (3) the students' work. The lesson plans and corresponding work sheets may be found in appendices A-L.

The student data for the process of observing were the results of a two-page work sheet derived from a lesson entitled "Ant Detective". This activity was found in the Nature Scope series (see Appendix B for the original English version). In this activity, the class was taken outside and completed a work sheet as they observed ants in their natural environment. Data for the second scientific process, communicating, is based on an analysis of papers written before and after completing the unit. The first was based on the question "what I know about insects" (lo que sé de los insectos), and the second question was "what I have learned about insects" (lo que aprendí de los insectos).

The third scientific process, comparing, was evaluated by means of Venn diagrams in which students compared and contrasted two insects. For the fourth process, ordering, students measured the sizes of six insects and were required to re-write the insect's names in an order, either by size or alphabetically. Data analysis was done on the corresponding work sheets "what is the order" (¿Qué es el orden?). Finally, the process of categorization appeared in the work produced on the work sheet "Grupos de Insectos" (groups of insects)..

In order to provide a quantitative evaluation of student-growth, a teacher-constructed test in Spanish was administered both before and after the insect unit. The questions were designed to review material presented during the unit. A sample of the test is provided in Appendix M.

Subjects

The subjects were Spanish-speaking third graders in a bilingual class. The students were designated as Non-English Proficient (NEP) or Limited-English Proficient (LEP), based on an administration of the Language Acquisition Scale (LAS) examination. Thirty students participated in the entire process-based instruction unit (insects), twelve boys and eighteen girls.

Methodology

The methodology employed was an in-depth analysis of student performance in science lessons to a students who are English Language Learners. These lessons were part of a thematic process-based science unit on insects. For the processes of comparing, ordering, and categorization it was necessary to include lessons that instructed the class on the processes themselves; therefore lesson plans were included that served as mediational lessons for the final student products.

Data Collection

The unit was completed during the first two months of the 1995-1996 school year (July and August), and the work produced by the students was kept in individual folders. In the unit, twenty-nine of thirty-three students completed the assignments that utilized the scientific processes and the pre-post examination (one student remained and completed all the assignments except the second portion of the communication exercise. Therefore, his data was included in all analyses).

Type of Analysis

Two types of analysis were conducted. The first and most important was a qualitative analysis pertaining to the teaching methodologies utilized. Descriptive in nature, the focus was on the interventions used by the teacher to facilitate an understanding of the concepts. In many cases these include the mediational lessons that helped explain a scientific process. In other instances, these include ethnographic vignettes that stimulated the teaching-learning interactions. All qualitative analysis focused on those activities and/or lessons that utilized the five scientific processes. The student results follow with an analysis of the products produced by the students. Here, analysis is both quantitative and qualitative. A percentage is given as to the number of students who successfully demonstrated a utilization of the process. Also included is a descriptive analysis of how the students completed the assignments. Finally, and error analysis was conducted.

The second type of analysis is quantitative. A pre and post teacher-developed test was given to assess student performance. The test data was analyzed to see whether or not group and individual scores changed.

Chapter Four

Analysis and Results

Two analyses were done on each of the five scientific processes. First, a qualitative analysis focused on the lessons and on how student work/results were completed. Qualitative analysis was also done on the mediational lessons, devices, and techniques utilized in teaching the processes. Student results were also examined quantitatively. Percentages were given regarding how many students successfully utilized each process. While some scientific processes are prevalent in more than one lesson, specific lessons/products were intended to focus on a single process. Each science process lesson is described below.

Observing

The lesson that examined if students utilized the scientific process of observing was the "Ant Detective" (see Appendix A for lesson plan). This lesson was taken from the magazine, Ranger Rick's NatureScope: Incredible Insects (1984). In the lesson students were given hand lenses and asked to observe ants. The original lesson was to be completed in two phases. The first phase instructed students to examine ants and answer questions. The second phase of the original lesson focused on the introduction of sugar near the ant nests and the ants' reactions to the sugar (see Appendix B for the original English version of the work sheet). Therefore the original work sheet instructed students to complete the work sheet at two different times: (1) during the initial observation, and (2) after the introduction of sugar near the ant nest.

The work sheet was translated into Spanish for the students. Questions were added that instructed students to predict the reaction of the ants to the sugar before the final observational session (see Appendix C for the work sheet utilized by the students). This amended work sheet asked students to answer questions at three phases: (1) during the initial observation, (2) before the introduction of sugar near the ant nest, and (3) after the introduction of sugar near the ant nest. Six hand lenses were distributed to randomly selected students (who were instructed to share). The initial observation session outside lasted approximately one hour and during this time the first portion of the work sheet was completed. The following day, students were given time to complete the second set of prediction questions, and the second observational phase also lasted one hour.

Mediational Lesson

Teacher modifications to the original lesson demonstrate the power of the observational process in constructing new levels of understanding for students. The original work sheet in Ranger Rick's NatureScope: Incredible Insects asked students to answer questions at only two junctures. However, the translated version of the work sheets includes questions which ask students to predict what will happen. These added questions proved to important in assessing the spontaneous concepts of several students.

The third question on the original work sheet on the "After the sugar" portion (second phase) asked students "How do ants communicate with each other?" The fourth question was; "Are the ants carrying food back to the hill? If so, how are they carrying it?" (see Appendix B). By asking students to predict how ants communicated and how ants carry food before the second observational phase, the teacher recognized spontaneous concepts that some students held. It was noticed by the teacher that seven students felt that the ants were going to communicate by "talking". Furthermore, seven other students wrote the ants would take the sugar back to the ant nest using their "hands". As Vygotsky notes, students bring prior conceptions of how the world works into the classroom. The introduction of the prediction questions served as a mediational device in changing students' spontaneous concepts. These students were monitored by the teacher during the second observational phase and questioned during the activity about how ants communicated with each other and carried food. In every instance these students changed their previous spontaneous concepts in a constructivist manner. That is, it was unnecessary to explain that what they thought before was incorrect. The students could <u>observe</u> how the ants communicated and carried food, a more powerful way of constructing new knowledge. The prediction questions proved to be a valuable mediational device in the construction of new knowledge because it elicited students' prior knowledge. The teacher was thus able to assess the current knowledge levels of these students and help them move through their particular ZOPD's in a non-threatening manner.

<u>Student Results</u>

As stated in the introduction, this particular lesson was primarily an opportunity for students to observe ants at work, and all the students were able to complete the work sheets successfully. As noted above, the scientific process of <u>observing</u> was extremely important for those students who had alternative conceptions of ants. By allowing students to observe ants and by assessing their prior knowledge, the teacher was able to successfully monitor students and help them alter their spontaneous concepts.

Comparing

The final product that measured the students' ability to compare and contrast insects consisted of constructing a Venn diagram of two insects (see Appendix D for "Comparing Two Insects" lesson plans). The initial Venn diagram was unlabeled and students were allowed to compare and contrast the insects of their choice by properly placing those insect characteristics that were similar in the interconnected portion of the circles and placing those characteristics which were unique to each insect in the outer portions of the circles.

Mediational Lesson/Device/Techniques

In order to teach students the process of comparing, it was first necessary to assess if the students understood how to construct a Venn diagram. This was done in the lesson entitled "Ants and Humans" (see Appendix E for lesson plan). Two students (one boy and one girl) were randomly selected to be analyzed. The teacher modeled how one would place characteristics of these students in a Venn diagram in front of the class. The class was successful in selecting words that described each student (e.g. "boy", "girl", "third-grader") and demonstrated an understanding of Venn diagram construction.

The second phase in teaching the concept of comparing insects using a Venn diagram was by having students compare a familiar entity (humans) with an entity they were currently studying (ants). As the Science Framework for California Public Schools suggests, many times scientists learn a new concept by comparing it with an object already well-known. "To find out more about an unfamiliar natural phenomenon, scientists often compare it to something they know well. They learn more about the unknown -the ways in which it is similar and the ways in which it is different- from the known." (California Department of Education, 1990, p. 147). Ants were the first insect the class studied in depth. Comparing ants and humans allowed students to practice Venn diagram construction. It also assisted students as they moved through their ZOPD's by using familiar and new (ants) objects, a step toward the final activity of comparing two new insects.

Although the mediational lesson on comparing ants and humans was done to enhance the students' ability to compare, this was not the only teacher-constructed device aimed at this concept. In the Science Framework, the authors call for students to participate in "active reading" (California Department of Education, 1990). As indicated earlier, the first and second grade teachers stated that science reading occurred mainly in a language arts context. That is, science reading consisted primarily of reading stories with science themes. However, extracting specific information was not part of this activity. Therefore a page was constructed for students to use as they read science material (see Appendix F). The work sheet entitled "Lo que aprendimos de los insectos" (what we have learned about insects), helped students see the similarities and differences that existed between insects. Furthermore, it provided students with a new manner in which to engage with text. The reading materials was used during the unit were primarily informational text. These books were much different from the literature this group had used in prior grades, literature primarily consisting of big books, picture books, and predictable books. Constructing this work sheet was done to help students engage with text in a new manner and move to higher knowledge levels in terms of their knowledge of insects and their familiarity with literature.

The teaching/learning process is one in which teachers are constantly evaluating the knowledge level of students and organizing instruction to help move students to higher levels. The construction of both; (1) the Venn diagram of ants and humans, and (2) the work sheet "Lo que aprendimos de los insectos" was done specifically for this purpose. Additionally, teaching ELL's requires an understanding of their prior experiences and culture. As Barba suggests (1993), many times teachers use unfamiliar references in their instruction of bilingual students particularly when they are speaking in English. Using culturally relevant examples enhances student learning and this was evident during a class discussion prior to the final venn diagram activity. The class had analyzed flies (moscas) and was engaged in a conversation regarding mosquitos. During the conversation the question arose as to where mosquitos lay their eggs. Understanding that: (1) all the students enjoyed visiting Seccombe Lake in San Bernardino, and (2) they did not refer to it by this formal name, helped the teacher incorporate the students' cultural experiences into their science learning. When the teacher asked the class; "¿Quíen ha visitado el parque de los patos?" (Who has visited the park of the ducks?) every student responded yes. The students made the immediate connection between the lake and the mosquitos and realized that mosquitos put their eggs in that body of water.

The importance of this culturally relevant example was clarified two days later. First, the teacher tested if the students knew the "name" of the lake (Seccombe Lake) and was given that blank stare teachers dread. However when the phrase "parque de los patos" was used all the students understood. The knowledge that this group of bilingual students referred to the lake from a culturally given name not only helped in disseminating the knowledge that mosquitos lay their eggs in water. It also showed students that their language and culture was an important part of the class, not something that needed nor should be left at the door.

Student Results

Twenty-three students (seventy-seven percent) successfully compared and contrasted two self-selected insects. The analysis of their Venn diagrams revealed two patterns of responses. Eight students used specific criteria and then explained how it pertained to each insect. For instance, in comparing ladybugs and mosquitos Rosa wrote that ladybugs place their eggs on leaves while mosquitos put their eggs in water (see figure 2). The second pattern that followed a "yes/no" pattern. That is, one insect would be used as the insect of reference and the other insect would be compared to that insect. For example, Angie used a butterfly as her reference insect, stating that "mariposas" like flowers (le gusta las flores) but that flies do not (no le gusta las flores) (see figure 3). Five students followed this general pattern. Another student used both ladybugs and mosquitos at different times was the reference insect.

Three students combined the methods of; (1) focusing on specific criteria, and (2) using a specific insect as the focus. In addition, three students used criteria specific to that insect with no reference to the other. For instance, Maribel wrote that flies have many eyes, yet makes no reference to eyes in her circle on butterflies. As was anticipated, the interconnected portion generally consisted of the physical properties of insects.

Seven students (twenty-three percent) did not produce a Venn diagram that

Figure 2

Rosa's Venn diagram: Comparing Two Insects

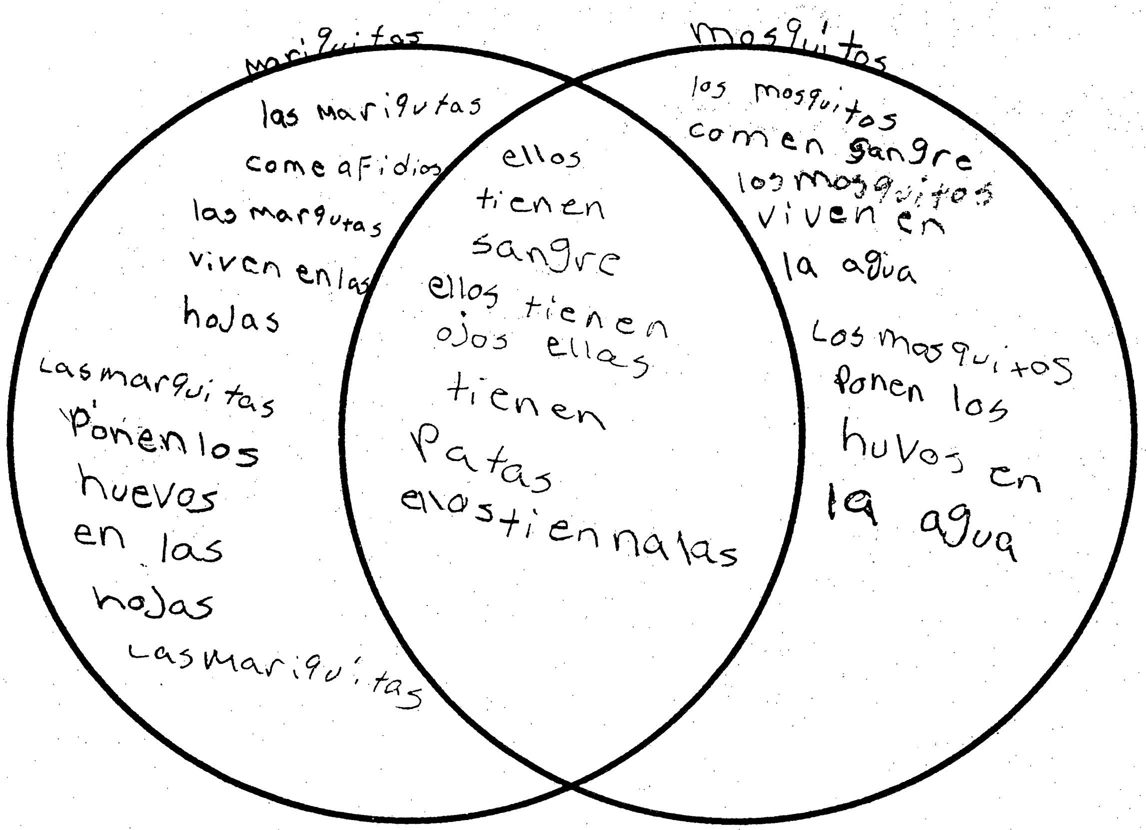
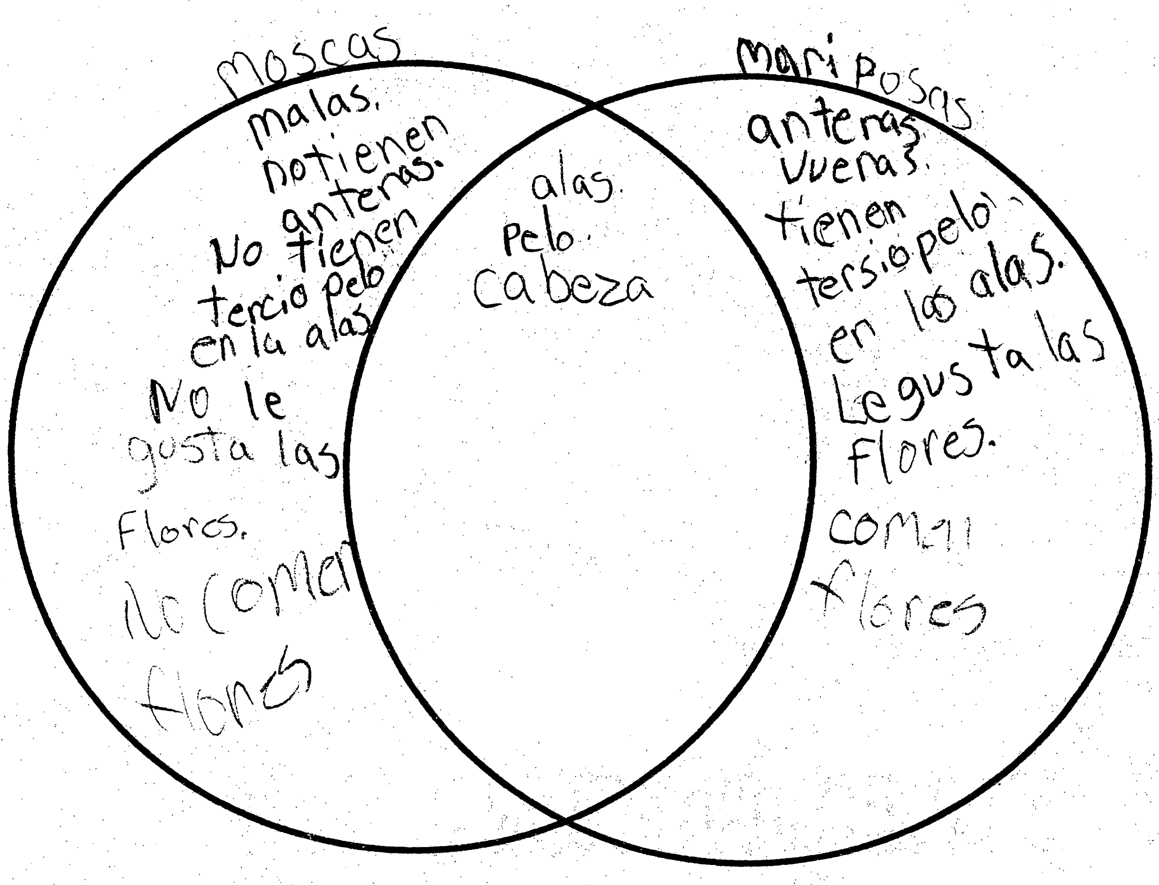


Figure 3

Angie's Venn diagram: Comparing Two Insects



showed they understood the process of comparing. In analyzing what mediational devices could have enhanced their understanding, an error analysis is necessary. Four students listed many facts that were correct but did not distinguish between the insects. These four showed that they knew about insects in general but did not write specific characteristics of each insect. Reviewing the class-constructed Venn diagram and/or using these students as subjects in a Venn diagram could have reinforced the need to include items specific to each insect. Furthermore, two students could have benefitted by having more capable peers as assistants. One student had difficulty with writing and was reluctant when given written assignments. The second student needed assistance in structuring the final Venn diagram. This Venn diagram on ants and butterflies showed a knowledge and understanding of the similarities and the differences yet lacked proper placement of ideas. Finally, one Venn diagram was simply mislabeled. The student wrote flies above the information regarding mosquitos, and mosquitos above the information on flies.

<u>Ordering</u>

The scientific process of <u>ordering</u> refers to placing objects or events in a linear format based upon a common variable. The final lesson in which students demonstrated their knowledge of ordering was titled "What is the order?", or "¿Qué es el orden?" in Spanish (see Appendix G for lesson plan). In the science station, dead insects (cockroaches, bees, worms, a butterfly, ants, and crickets) were placed on separate index cards. Students were asked to identify each insect, measure the insects with metric tape measures and then select an order (either by alphabetizing the names or by size) in which to rewrite the insect names. The two-page work sheets are provided in Appendix H.

Mediational Lesson

The mediational lesson, "sizes and names" (see Appendix I for lesson plans) taught students the process of ordering. This lesson entailed a demonstration in which students were lined up in order by size and by their last name. The intent of the exercise was to show that the same items could be placed in different orders according to the criterion used. The students were placed in order from smallest to largest and then rearranged according to their last name.

Student Results

The students were allowed to select a criterion by which to order the insects. Twelve students (forty percent) wrote the names in alphabetical order and eighteen students (sixty percent) wrote the names according to size. The students who chose alphabetizing as their criterion were analyzed first.

Of the twelve who used alphabetizing as their variable, fifty percent (six) were successful and arranged the lists accordingly. The six unsuccessful students wrote their lists in similar orders, suggesting that their knowledge levels of the alphabetizing process were at similar levels. Three of these students wrote the insect names in identical order; two other students also had duplicate incorrect lists. The initial three students participated in the activity together, as did the pair with identical incorrect lists. The sixth student was in a separate group and did not replicate another list.

Even though alphabetizing is not a scientific process, better instruction needed to be done in order for student to understand the process of ordering by alphabetizing. More capable peers could have served as assistants for these students. Due to the fact that this activity was done within the first two months of the school year, the teacher understanding of the knowledge levels of the class was still evolving. For instance, three students who completed the task successfully would have served as positive peer helpers due to an advanced language arts ability. Furthermore, in retrospect not enough practice was done in simply writing items in alphabetical order. The outside activity of arranging the class in alphabetical order became dominated by two students who; (1) recognized that the class needed to be placed in the same order as the student roll, and (2) relied primarily on their knowledge in language arts.

Out of the eighteen students (sixty percent of the class) who chose to write the order of the insects by size, ten wrote the insects correctly according to size. It is interesting to note that not all these lists are identical due to a mishap in the science station. During rotations the cricket was knocked to the floor and crushed. Another cricket was substituted but it turned out to be the same size as the butterfly and the bee. Therefore, three students have different but properly ordered lists. Of the correct responses only one wrote listed the insects from smallest to largest while the others listed the largest insect first.

Eight students (three boys and five girls) did not write the names correctly in order of size. In analyzing their results, it appears that while they had some understanding of how to order they were unable to justify it. For instance, seven of the eight students had the cockroach first (biggest insect) and the ants last (smallest insect). However, their results indicate that the insect names written between do not correspond to the sizes. Two students had lists that appear correct but do not correspond to the sizes they listed next to each insect on the work sheet. As was the case with two of the students who successfully completed the task, this group of students had to measure the insects with the second cockroach, and its proximity in size to the butterfly and the worm may have caused confusion.

Of the five scientific processes, the process of ordering was the least successful. Sixteen out of thirty students (fifty-three percent) completed the activity successfully. An analysis of the data suggests that many alterations could have been made. First, the initial intention was to have students use size as the ordering variable. The mediational lesson that demonstrated ordering to the students may have focused too much on alphabetical ordering. Furthermore, the directions on three occasions reminded students that they could write the words "por alfabeto o tamaño" (by alphabet or size). The ordering of the key words in these directions could have been interpreted by students that alphabetizing was the "first" choice and size the second. Finally, the follow up activity in the mediational lesson challenged the class to try and reproduce the class roster; that is, put themselves in alphabetical order. This focus on ordering alphabetically may have influenced students to prioritize that process of ordering. Both the focus of the mediational lesson and the written instructions relied too much on alphabetizing and not enough on using size as the ordering variable.

As for those students who failed to order the insects by size correctly, analysis of the activity suggests that there were too many components for them to accomplish at once. Students had to; (1) identify the insects; (2) measure and label them correctly, and

(3) transfer these entities to a second page. These students may have had a conception of how the order should be by looking at the insects but their measurements and subsequent listings did not correspond to their intuitive conceptions. More practice in measurement and labeling of insects may have enhanced the results.

Categorizing

The process of categorization, or putting items or events into groups, was done in the activity "Grupos de Insectos" (Groups of Insects). The students were allowed to select both the insects and the variables, and the assignment was completed in the science station with other students during rotations (see Appendix J for lesson plans and Appendix K for copy of the work sheet).

Mediational Lesson

The mediational lesson used to instruct the class about forming groups used candy (specifically, M & M's) and is explained in detail in the lesson "Candy Categorization" (see Appendix L). Each student was given approximately twelve M & M's (six plain and six peanut) and was asked to differentiate the candy into groups. The first category the class used was according to size (plain versus peanut). Subsequently, the students were given the opportunity to categorize the candy according to color, and finally using both size and color.

Student Results

The following day the class was provided the work sheet "Grupos de Insectos" and instructed to complete the assignment in the science station. An examination of the final products revealed that twenty-four (eighty percent) of the students successfully grouped insects into categories. Five of these students did make one error in their products but showed an understanding of categorizing. For example, one student mistakenly listed a butterfly as an enemy of humans; however, except for this mistake the insects correspond to the categories listed. Furthermore, an analysis of the student results revealed specific patterns utilized by the students. For instance, only three different categories were utilized by the class: (1) the ability to fly or not to fly; (2) friends or enemies of humans; and (3) like or dislike of eating aphids. The first two categories were always done together. The work sheet provided the students the four locations to put insects (Appendix K), and in eighteen instances those groups were; (1) the ability or non-ability to fly, and (2) insects that as friends or enemies of humans. Six other students used only the propensity to eat aphids as the single method of categorization.

While the manner in which the students completed the task followed particular patterns, occasionally students displayed more specific knowledge of insects. For example, students at times wrote that an insect could be both a friend and an enemy of people. When asked about the double appearance of ants, one student explained that ants are friends of man when they eat aphids but enemies when they eat our food. Bees also were an insect that students described as a friend and enemy of people. For instance, one student commented that bees are friends of humans when they make honey but enemies of humans when they sting people. In one instance a student used prior experience from the "Ant Detective" activity to specify the black ants as friends but the red ants as enemies (they had bitten several students). In addition, this student exhibited further knowledge of ants, including ants in her category of insects that could fly with the qualifier "a veces" (at times).

While eighty percent of the students did complete the activity successfully, six provided lists that did not show a scientific utilization of the categorization process. Three students constructed four lists that categorized the insects alphabetically. Their first list was of insects that began with the letter A, the second list was of insects that began with B and subsequently C and D. These three students were at the science station together and thus may have shared misinformation. One positive aspect was the emerging English skills, as two students included the words ants and butterflies in their categories.

The alphabetizing of insect names was not the only misinformation revealed in the data. One student used friend/enemies of humans and flies/does not fly as categories and correctly identified insects as part of these groups. However, this student became over zealous and included non-insects (cats, dogs, birds, frogs, and turtles) in the categories. Two other students may have become confused with the assignment. One student listed "friends of humans" and "likes to eat aphids" twice, and another students' category of "friend of human" was not substantiated in the results. However, even with these student errors the class was successful in creating categories of insects.

<u>Communicating</u>

The process of communicating occurred in many different forms during the unit. For instance, students communicated their understanding of the concept of <u>comparing</u> in their Venn diagrams. However, one particular assignment communicates best what the students learned. In whole language classes teachers often utilize a "K-W-L" activity, a class discussion of what the class knows (K) pertaining to a subject, what the group wants

(W) to learn, and what the class has learned (L). In order to try and assess individual student growth, the students produced individual papers in the K-W-L format and a qualitative analysis of the first (K) and last (L) portions of the assignment was used.

In analyzing the papers, a comparison of each student's products was done. Two patterns emerged in the students' written responses. First, the volume of writing increased dramatically and for some this meant literally doubling the amount of written text they usually produced. This is not surprising due to the focus the class had given to insects, and this is particularly evident in students whose academic strength is in language arts. This activity provided them with a comfortable forum in which to demonstrate what they learned which may or may not have been present during some of the activities.

While the volume of text increased for the majority of students, another noticeable change was the inclusion of specific facts about insects. For example, Isabel in her paper "lo que sé de los insectos" (what I know about insects) wrote about butterflies, explaining that they go through changes as they evolve (see Figure 4). However, in her paper "lo que aprendí de los insectos" (what I learned about insects) Isabel is much more specific. Here she mentions eight different insects and relates information she remembers about each insect (see Figure 5). Steven even showed a move from spontaneous to scientific concepts. In the "Ant Detective" assignment, Steven suggested that ants communicated by talking. In the second portion of that assignment and the paper regarding what he learned, Steven wrote that insects do not talk. Angie provided only general statements as to what she knew in her first paper. She wrote that insects have antennas, eyes, a mouth, a head, and some do not sting. However, her follow-up paper on included specific .

Figure 4

Isabel's writing sample: what she knew (K) about insects

B-3

Lo que se de los insectos

Lo que se de los insectos yo se
que los insectos se hasen de
muchas Formas por ejemplo, la
mariposa es el gusanito. Una
mariposa es gusano, luego el
gusanito ba creciendo, y
come y come, luego se ase
un capullo, dura una o dos
semanas el capullo, Despues
el capullo se ba qebra-
ndo y la maripasa sale
de su capullo y la mari-
posa lla no es gusanito.

Figure 5

Isabel's writing sample: what she learned (L) about insects

Student-selected 8/23/95

Lo que aprendí de los insectos

Yo aprendí que los insectos tienen 3 partes en el cuerpo. Que las hormigas tienen 2 estomagos en el cuerpo. Que todas las hormigas son mujeres. Que todos los insectos se bar formando para que ellos ellos lla puedan se un o una adulto. Yo se que una abeja tiene un pico y con ese pico ella te pica. También se que el gusanito tiene muchos abujeros por los lados y con esos ellos respiran. Las cosas que tienen dentro las mariquitas paiecen cables de teleforo. El mosquito pone los huevos asta adentro del agua. El mosquito cuando pone sus Huevos adentro sus huevos Flotan. El grillo no tiene como donde los tenemos los oidos ellos los tienen en las patas. La mosca puede ver todo completo con los ojos que tienen. La mosca tambien respira como el gusano tiene abugeritos a los lados. Los cables de la mosca se llaman sacos aéreos de la mosca. La mosca saborea la comida con las patas. La mosca le gusta estar mucho en el sol para estar calientita. La mosca puede andar boca abajo por los sitios. Los ojos de la mosca estan formados por cientos de lentes diminutos. Los insectos no Hablan. El zumbido lo producen mobiendo las alas muy deprisa.

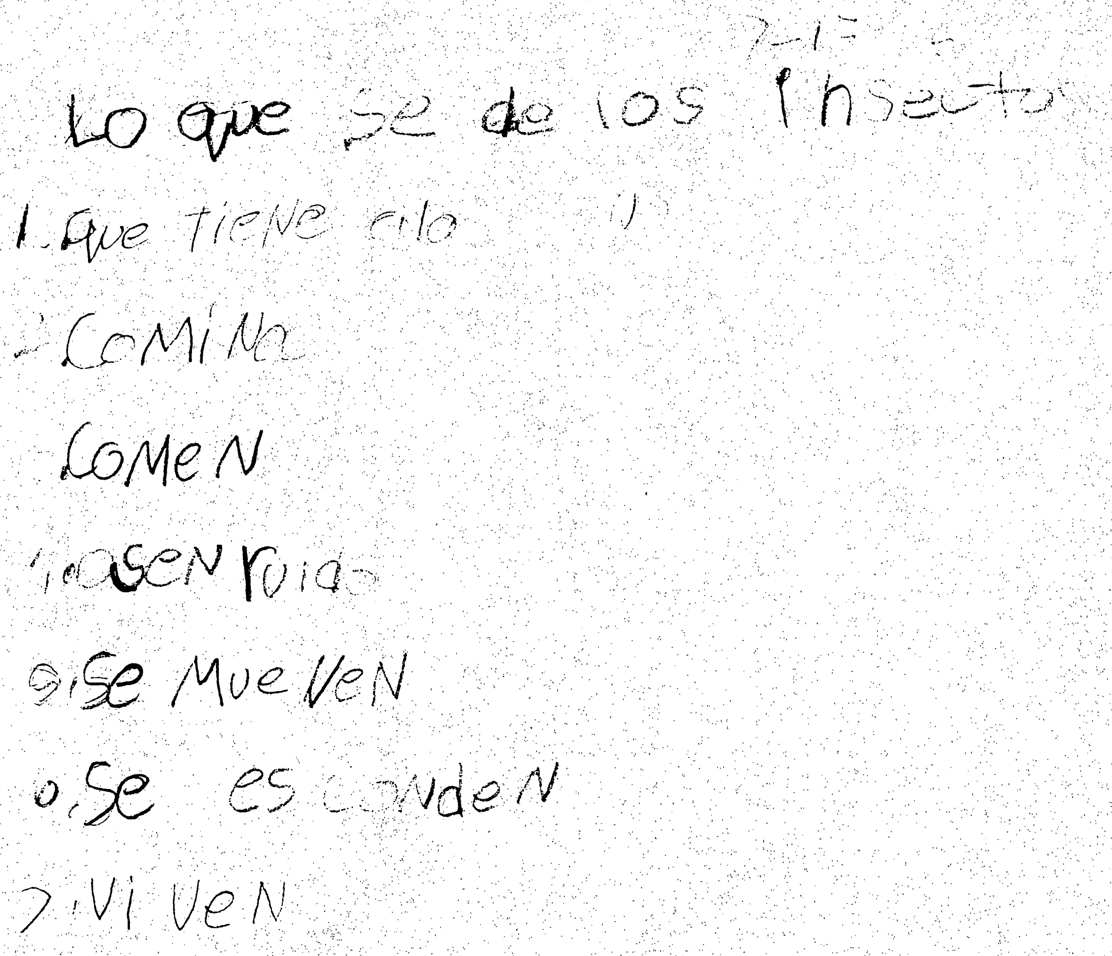
examples of new knowledge. "Como por egemplo las mariquitas son amigos de nosotros Comen afidios". (For example, ladybugs are our friends. They eat aphids).

The change from general statements about insects to specific facts also occurred in students who did not produce a great quantity of text. For instance, Marta wrote that some insects were pretty, others ugly, and some sting and some don't. However, her second paper reflects what she has learned; some insects fly for protection, and the larvas of flies appear to her like little elephant trunks. David was a student who was not particularly confident with writing, yet the manner in which he wrote about insects was also transformed. David "knew" that insects had six feet, were small, bit, and were ugly. However, David learned that insects change like butterflies, have four wings, three body parts, two eyes, and that those nasty red ants encountered in the "Ant Detective" activity bite (a testimony to the power of personal experience for David). Another illustration of the change in the manner in which students spoke of insects appears in the work of Israel. In "lo que sé de los insectos", Israel wrote that insects eat, walk, make noise, die, move, hide, and live (see Figure 6). However, in his second work Israel provided the scientific names for the three body parts, names that required Israel to use a dictionary on insects. Although not great in volume, his product again exemplifies the move from spontaneous to scientific concepts, a move that required additional research on his part (see Figure 7).

The first and last papers of the "K-W-L" assignment, done before and after the unit respectively, were used in the analysis of <u>communicating</u> for two reasons. First, it was the last product compiled and provided closure to all of the science processes. The analysis of student work revealed that the manner in which the students viewed insects had changed.

Figure 6

Israel's writing sample: what he knew (K) about insects


Lo que se de los insectos

1. Que tiene alo

2 Comina

Comen

hasen ruido

Se mueven

Se esconden

7 Viven

Figure 7

Israel's writing sample: what he learned (L) about insects

Lo que aPrendi de
los insectos

Yo aPrendi Que
los insectos tienen
3tarte tiene 6 Patas
CaveSa lorex
acdomeN UNoS
tienen MuNnos
oJos UNos Ses
Fizen deN Peliando

Insects went from moving to flying for protection, from being ugly to having distinguishable qualities. In the majority of assignments students were allowed to select and analyze the insects of their choice and this may have helped them to come to know some insects in depth. Some students described particular entities such as what was eaten by certain insects. Others provided items they remembered about certain insects, such as mosquitos putting their eggs in the water or flies in dead animals. However, the communication that occurred allowed each student the opportunity to write what they had learned. Although for some this did not entail much text, the manner in which they wrote certainly changed.

Insect Quiz Results

A pre and post test was given at the beginning and end of the unit (see Appendix M). This was done for two reasons. First, from a non-scientific standpoint students needed to experience and gain understanding of a "test". Secondly, students understanding of specific information about needed assessment. The results of the test are discussed below.

Thirty students (twelve boys and eighteen girls) took both examinations (see Appendix M for a copy of the test). The first test was administered on July 13, 1995. The second examination was given on August 24, 1995. There were twenty-five items on the test, one point given for each correct response. The first two items were fill in the blank, while the remaining portion of the examination being true/false. The mean score of the first examination was 12.67, with the boys averaging 13.08 and the girls averaging 12.39. On the post examination, the mean for the class was 19.40, with the boys averaging 20.83

while the girls averaged 18.44. In only one instance did a students' performance decrease (Jackie scored 13 and 11 on the pre and post tests respectively). The tests were designed so that students could be successful if they remembered information provided in texts that students could read (e.g. books from public libraries that were placed in the class library for reading during their leisure). The information did require that students focus on certain insects and was not used in evaluating the success of the scientific processes.

Results

The ultimate question to be answered is; did the students learn? By using the scientific process as a focus for instruction, this group of students learned a great deal about insects and about the scientific processes. In only one activity did the class fail to demonstrate a consistent implementation of the processes, primarily due to lack of teacher instruction. However, using a method of instruction that: (1) engaged the students; (2) used their preference for cooperation; (3) assessed their prior knowledge of both insects and processes; (4) utilized their primary language; and (5) did not rely on a text book (none was present) this group of students learned that insects are much more than small and ugly.

The second question to be answered by the research is what mediational devices in the teacher-interventions provide a scaffold and/or ZOPD for students as they move to new levels of understanding and utilization of the scientific processes? In order to answer this question, it is necessary to understand that each intervention is particular to a group of students due to culture, their current knowledge level, and the materials a teacher used.

For instance, referring to the "parque de los patos" (park of the ducks) now is relevant to these students as they talk about mosquitos, a culture scaffold that may or may not work in other situations. Nevertheless, the mediational lessons ("Ants and Humans" and "Candy Categorization"), the work sheet "Lo que aprendimos de los insectos" (what we have learned about insects), and the translated version of the Ant Detective work sheet all enhanced the learning of the students. As discussed above, the teacher interventions used worked in all instances but one (the activity of ordering). These interventions were done so that students could move through ZOPD's in two ways, both in what they knew about insects and what they knew about the processes of science. Teaching involves moving children to higher levels of development. Doing this effectively implies setting up the support, or scaffolds, that allows this to occur.

Chapter Five

Discussion

This project was designed to focus on an alternative method of science instruction for English Language Learners. The prevalent practice of textbooks was surpassed in favor a constructivist approach. The constructivist focus provided children with the opportunities to construct new knowledge as they interacted with each other and with the insects of their choice in different and meaningful activities.

The method of instruction was different from the traditional lecture-discussion method. The Vygotskian perspective of providing scaffolds to help students move through zones of proximal development is an component. These scaffolds are mediational devices, entities such as instruction, language, and peer guidance designed to assist students learn both new processes and appropriate new knowledge. In this project, the level of effectiveness of individual lessons can be attributable to those mediational strategies. Differences that exist linguistically, culturally, and cognitively were used as positive attributes and taken into account in the formation of the mediational devices.

Using students' primary language (Spanish) was also an important component. The introduction of new concepts is more effective in a student's primary language. As Cummins reminds us, student generally need five to seven years for their Cognitive Academic Language Proficiency (CALP) to develop in their second language (Cummins, 1989). Therefore primary language instruction avoided the possibility that students would not understand content due to a language difficulty. In addition, using the student's primary language allowed for more relevant cultural examples to be used. Finally, instruction in student's primary language told them that their culture, language, and experiences were an important part of their science education.

Limitations

The effectiveness of the thematic based-process unit on insects was hampered in two different manners. First, the lack of students' success in ordering could have been avoided by better scaffolding devices. For instance, the overemphasis on alphabetizing instead of measurement was revealed in the data. Altering the wording in the instructions for the activity may have moved students away from alphabetizing. Concurrent with this idea is the need to effectively instruct students in measuring. Lack of measuring skills resulted in errors that could have been avoided with more interventions in this regard. Furthermore, the combination of (1) an emphasis on alphabetizing, and (2) unfamiliarity in measuring objects may have directed many students to use alphabetizing as the ordering variable.

A further limitation of the project is due to its context-specific nature. This project was done on one group of students at one specific time and school, and replication of the lessons, mediational devices, and content may be difficult. However, the empowerment proved the teacher in modifying the methodology is noteworthy. The job of future science teachers is to organize instruction so that students are provided the opportunity to learn the processes and content of science.

Conclusions

The data suggests that using a thematic process-based unit helped this group of students learn both the processes of science and the content related to insects. As educational tides shift, some advocate a back to basics movement with a focus on facts, while others advocate a move toward teaching students the processes of science. Utilization of a thematic process-based method of instruction accomplished both of these outcomes. This approach has great potential if opportunities for science learning of Hispanics and ELL's increase. It is important that these students were given access to information, the means for finding the information, and new approaches in which to demonstrate knowledge. This cannot be done using a lecture-discussion method of science teaching. Remembering facts from a textbook and reading about science is not doing science. This is extremely important for elementary students whose inclination to learn by doing is stifled in a lecture-discussion education.

Implications

The historic underachievement of Hispanic and English Language Learners in science will not change unless the methods used to educate these students also change. The focus of education on white middle-class students has bypassed others students in terms of using their strengths, culture, and language as positive entities in education. Furthermore, the utilization of the lecture-discussion method in education has not focused on the necessary elements to enhance student learning regarding student of diverse linguistic or ethnic backgrounds. That is, it does not address what is necessary for students to move to levels of higher development, and the historic underachievement of Hispanics and English Language Learners is testament to this. Using alternative teaching strategies will provide Hispanics and ELL's with more opportunities to construct their own knowledge. It is important that teachers are empowered to accomplish this. This entails using mediational lessons, techniques, and devices that are designed to move students successfully to new zones of proximal development.

If all students are to become successful in science, it is apparent that the introduction of the processes be done early in their education. They must become involved with what it means to act like a scientist and use those devices, (e.g. processes) that scientists use. The most effective manner would be to allow them to use their natural strengths, to work cooperatively and enjoy success as a group. Furthermore primary language instruction will help ELLs understand the work of scientists. Allowing students the necessary time for their cognitive academic language proficiency to develop does not mean they must forego science. The utilization of primary language instruction is a powerful mediational tool in moving to new, higher zones of proximal development in science.

Historically a predetermined method of science instruction has existed and students whose culture, language, and experiences are different from the mainstream have been at a disadvantage. That is, the readiness of schools to teach all learners has not existed, and in ignoring the differences between children schools have restricted their academic success. The ability to develop a thematic process-based unit on insects was founded in the idea that a teacher could modify lessons, techniques, and devices to provide more efficient scaffolds for ELLs. It is hoped that other educators will be empowered to do the same.

Appendix A

Lesson plan - Ant Detective

Performance Objectives

Students will be able to:

1. Properly use a hand-lens in observing ants.

2. Write down and draw what they observe.

3. Predict the reaction of the ants to sugar.

Processes utilized:

#1 - observing: using the hand-lens (when possible) to study the ants.

#2 - communicating: writing and drawing their observations and answers.

#3 - comparing: analyzing the sizes of the ants for consistency (are they all the same size?).

Materials:

- 1 copy per student of modified "Ant Detective Work sheet" taken from Ranger Rick's NatureScope: Incredible Insects (1984).

- one pound bag of sugar

- six hand lens

Procedure: (phase I)

1. The teacher models how to use the hand lens for the class. The hand lenses are distributed to six randomly selected students and the class is told they will be observing ants. The first page of the work sheet is distributed and the class is instructed to only answer the first five questions. The class then chooses a location on the school site in

order to observe the ants.

2. (phase II) - The next day, the class is told that they will be watching what happens if sugar is placed near the ant holes. The class is then instructed to answer the questions on the work sheet "Antes de usando el azúcar" in order to predict what each student thinks will happen. The class is then taken to the ant holes and their observations are recorded. The students have the second page of the work sheets "Después de usando el azúcar" and are encouraged to answer the questions outside. After the class has reconvened, a discussion is held regarding what was observed and the students answers.

Application:

Students are required to complete the two-page activity sheet.

Appendix B

Work Sheet - Ant Detective (original)

Name________________________________ Date______________

1. What color are most of the ants?________________________________

2. Does an ant have hair?________________________________

3. Are the all the same size and shape? If not, how are they different?

____

____

4. Draw a picture of an ant antenna in the space below.

5. Draw something that might eat an ant.

After the sugar....

1. Did the ants find the sugar? ________________________________

2. How long did it take them to discover it? ________________________

3. How do ants communicate with each other? ______________________

____

4. Are the ants carrying food back to the hill? If so, how are they carrying it?

____

5. Do the ants seem to follow a path or randomly walk back and forth into the ant nest? ____

____

Appendix C

Work Sheets - Ant Detective

Nombre_____________________________ Fecha________________

1. ¿Cúal color son las hormigas? ____

2. ¿Las hormigas tienen el pelo? ____

3. ¿ Más o menos, es el tamaño y la forma de todas las hormigas igual? Si no, ¿son diferentes? ____

____

4. Haz un dibujo de una antena de las hormigas abajo.

5. Haz un dibujo de una cosa que las hormigas comen, y escriba lo que es.

Antes de usando el azúcar

1. ¿Piensa que las hormigas encontrarán el azucar? ______________________________

2. ¿Cuántos segundos o minutos es necesario por las hormigas encontrar el azucar?

____

3. ¿Cómo comunicarse las hormigas con otras hormigas?

____

____

4. ¿Piensa que las hormigas traerán la comida a casa? ¿Cómo? __________________

____

5. ¿Cómo caminarán las hormigas? ____

Después de usando el azúcar

1. ¿Las hormigas encontraron el azucar? ______________________________

2. ¿Cuántos segundos o minutos fue necesario decubrir el azucar? ____________

3. ¿Cómo se comunicaron las hormigas con otras? ______________________

____

____

4. ¿Las hormigas están llevando la comida a la casa? ¿Cómo? _____________

____

5. ¿Las hormigas caminan en una linea, o caminan en no orden especial a casa?

____

____

____

Appendix D

Lesson plan - Comparing Two Insects

Performance Objectives

Students will be able to:

1. Create a Venn diagram which depicts the similarities and differences between two insects.

Processes utilized:

#1 observing: Each student will observe the process and/or work needed to create the Venn diagram "Ants and Humans".

#2 communicating: Each student will communicate what they have learned regarding two different insects.

#3 comparing: Each student will compare the similarities and difference between two insects in a Venn diagram.

Materials:

- Venn diagram copy
- pencil

Procedure:

1. Before center and station rotations, the class is reminded of the work done to create the "Ants and Humans" diagram. The class will review the work done with the student volunteers and offer some of the responses placed on the individual Venn diagrams. The teacher draws two Venn diagrams and has students in the class tell the teacher where in the circles each response should be placed.

2. The class is shown the page with the two Venn diagrams and instructed to pick any two insects they want, comparing the insects by showing the similarities and differences in the circles.

3. The class is reminded that information about different insects can be shared and/or found in books, what they previously knew or what they have learned. The class is told to complete this assignment in the science station with their groups and that the finished product would be part of their finished science journal.

Application:

Completion of the Venn diagram comparing two insects.

Appendix E

Mediational Lesson plan - Ants and Humans

Performance Objectives

Students will be able to:

1. Create a Venn diagram depicting the similarities and differences between ants and humans.

Processes utilized:

#1 - observing: Each student will observe the process used to compare two objects and observe the construction of a Venn diagram.

#2 - communicate: Each student will draw similarities and differences between ants and humans.

#3 - comparing: Each student will compare ants and humans.

Materials:

- 2 pieces of butcher paper/marker (for teacher)
- white drawing paper
- markers/pencils

Procedure:

1. The class is brought to the front and is told that they will be learning how to compare objects, a scientific process that is used by scientists.

2. Two student volunteers (one boy and one girl) are brought to the front of the class. The students are encouraged to suggest words or phrases that describe each student and the responses are written on the butcher paper.

3. The teacher then draws a Venn diagram and writes the student names above each circle, explaining that words and/or phrases that describe both students are to be placed in the middle of the intersecting circles, while words/phrases that only describe each individual student are to be written in the circles in the portions not intertwined.

4. After this had been completed, a new Venn diagram is drawn on the second piece of butcher paper with the circles labeled "Ants" and "Humans".

5. The class is told their assignment is to construct a Venn diagram showing what they have learned are the similarities and differences between ants and humans.

Application: Each student will make a Venn diagram which depicts the similarities and differences between ants and humans.

Appendix F

Mediational Work Sheet - Lo que aprendimos de los insectos

Lo qué aprendimos de los insectos

	Hormigas	Moscas	Mariquitas	Mariposas	Mosquitos
¿Cúantos partes hay en el cuerpo?					
¿Dónde viven?					
¿Puedan volar?					
¿Tienen alas? ¿Cúantas?					
¿Cómo se protegen?					
¿Son amigos o enemigos de la gente?					
¿Dónde ponen los huevos?					
Haz un dibujo de los huevos.					
Haz un dibujo de la larva.					
Haz un dibujo de la crisálida.					
Haz un dibujo de un adulto o de los adultos.					

Appendix G

Lesson plan - ¿Qué es el orden?

Performance Objectives

Students will be able to:

1. Identify the names of five insects.
2. Measure the size of each insect.
3. Arrange the insects into an order.

Processes utilized:

#1 observing: Students will use their sense of sight in order to identify the insect(s) on each card.

#2 communicate: Students will write down what they believe is the name of each insect, the size of each insect, and their manner of ordering the insects.

#3 comparing: Students will compare the sizes and/or names of the insects.

#4 ordering: Students will write down the names of the insects in an order.

Materials:

- metric tape measures
- copy of "¿Que es el orden? work sheet"
- (A) one dead cockroach (cucaracha)
- (B) one dead bee (abeja)
- © one dead worm (gusano)
- (D) one dead butterfly (mariposa)
- (E) several dead ants (hormigas)

- (F) one dead cricket (grillo)

Procedure: (teacher preparation)

1. Each insect(s) is placed on 3 by 5 index cards with a letter (A through F) visibly written on each card and placed in the science station along with two metric tape measures.

2. (class instructions) First, the class is reminded of the "sizes and names" activity. The teacher reviews the concept of order and how items can be placed in different types of orders such as by size.

3. Next, two metric tape measures are passed out to each table of students (four students at each table). The class then reviews how to properly measure objects, paying close attention to the difference between millimeters and centimeters.

4. The work sheet "¿Qué es el orden?" is distributed and the instructions are read aloud by the teacher. The students will write what the name of each insect and measure its size with the metric tapes. On the second page of the handout the students will rewrite the names of the insects in an order and indicate what type of order they were utilizing. The class is instructed not to touch the insects because everyone needs an opportunity to use the insects in the science station.

Application: Students will complete the work sheet, "¿Qué es el orden?".

Appendix H

Work Sheet - ¿Qué es el orden?

Nombre____________________________ Fecha____________

¿Qué es el orden?

Muchas veces, un científico necesita escribir información a otras. Ahora, todas las personas de la clase son científicos, y es tiempo escribir información de insectos como un científico. Hay 6 insectos diferentes en la estación de ciencias. Es necesario escribir los insectos en un orden. Cual orden no es importa; aprendimos que hay diferentes maneras escribir información, como orden alfabeto o por tamaño. Escriba los nombres y los tamaños de los insectos en las líneas, y en la segunda página escriba los insectos en un orden, por alfabeto o tamaño.

Nombres	Tamaños
1.____________________	____________________
2.____________________	____________________
3.____________________	____________________
4.____________________	____________________
5.____________________	____________________
6.____________________	____________________

Ahora, escriba los nombres en un orden abajo. Me explica que tipo de orden usó. Por ejemplo, ¿hay los nombres escrito en orden de alfabeto, o por tamaño?

____

1. ____

2. ____

3. ____

4. ____

5. ____

6. ____

Appendix I

Mediational Lesson plan - Sizes and Names

Performance Objectives

Students will be able to:

1. Arrange students in order from shortest to tallest.
2. Arrange students in order from tallest to shortest.
3. Arrange a list of names in alphabetical order.

Processes utilized:

#1 observing: Each student will observe the heights of other classmates.

#3 comparing: Each student will participate in an activity that compares their own height to the heights of others.

#4 ordering: Each student will assist in placing students in order in terms of height.

#4 ordering: Each student will place students in alphabetical order.

Materials:

Student volunteers (five)

Class list

Procedure:

1. The teacher asks for five volunteers and selects students of different heights.

2. The teacher then asks the class which name was read first during morning role and placs that student first in line; then whose name is second, etc... The teacher asks why, and students respond that it is because the last names on the class role sheet are in alphabetical order. The teacher explains that this is an example of an order and that

scientists often place things in order to better explain scientific facts and relationships.

3. The teacher then asks the class which of the five students is the shortest, who was the next tallest, etc... After the five volunteers have been placed in order according to size the teacher asks why the volunteers are standing in different positions. The class responds that the orders are different, one is by names and one is by height.

4. The teacher explains that these are two examples of ordering and that scientists not only must know how to place things in order but must be able to choose what they are to measure. The class is then asked what other kinds of orders are used in science.

Application:

The class was taken outside and challenged to place themselves in alphabetical order. This activity took approximately ten minutes.

Conclusion: An individual understanding of the concept of <u>ordering</u> will be evaluated by analyzing the results of "¿Qué es el orden?".

Appendix J

Lesson plan - Grupos de Insectos

Performance Objectives

Students will be able to:

1. Categorize insects into either two or four groups based on one or more variables.

Processes utilized:

#5 - categorizing: Each student will group insects based on similar attributes.

Materials: - "Grupos de insectos" Work Sheet.

Procedure:

1. The class will be reminded that as scientists it is important to begin doing the same type of work that other scientists perform. Putting insects into groups based on one or more variable is one such function.
2. The teacher will review the candy categorization activity, noting that each student will explain what differentiates one group from another.
3. The students will be provided the "Grupos de Insectos" work sheet and the teacher will read the instructions aloud. The students will complete this work in the science station with other members of their groups.

Application: Each student will complete the work sheet "Grupos de Insectos", explaining the variable(s) used for categorization.

Appendix K

Work Sheet - Grupos de Insectos

Nombre________________________

Fecha_________________________

Grupos de Insectos

Todas han aprendido que insectos tienen cosas que son similares. Sin embargo, insectos son diferentes, y su trabajo como un científico es escribir los insectos que hemos estudiado en grupos. Después de terminen la página <Llo que aprendimos de los insectos>>, trata de pensar que es similar y que es diferente de los insectos. Por ejemplo, muchos insectos mueven similares, o comen la misma comida. Escriben los nombres abajo, y me diga el razón que hizo los grupos.

GRUPO #1	GRUPO #2
____________________	____________________
____________________	____________________
____________________	____________________
____________________	____________________
____________________	____________________

GRUPO #3	GRUPO #4
____________________	____________________
____________________	____________________
____________________	____________________
____________________	____________________
____________________	____________________

Appendix L

<u>Mediational Lesson plan - Candy Categorization</u>

Performance Objectives

Students will be able to:

1. Group M & M's by color.
2. Group M & M's by size.
3. Group M & M's by color and size.

Processes utilized:

<u>#5 - categorizing:</u> Each student will place the candy into corresponding groups.

Materials:

- One pound bag of M & M's (plain)
- One pound bag of M & M's - peanut

Procedure:

1. The teacher informs the class that scientists often classify insects into groups based on similar attributes and that the candy will help them visualize this process.

2. First, the teacher asks the class to describe the candy.

3. Students are then asked to group the candy by size (plain are small, peanut are big). This will allow the students to see that size can be used to differentiate objects and this variable separates the candy into two groups.

4. The students will then be asked to place the candy into groups by color. This will show the groups that the variable "color" separates the candy into several groups.

5. Next, the teacher will orally ask them if there are differences between the groups

by "size" and by "color". The teacher is looking for comments that state that the first variable ("size") gives the class two large groups while the second variable ("color") provides the students with more groups candy with less candy in each group.

6. Finally, the class will be instructed to put the candy into groups by size and color. This will demonstrate that two variables places the candy into more groups with even less in each group.

Application:

The students will be asked to group insects in the activity "Grupos de Insectos". This lesson is designed to teach them how to categorize objects by a common variable.

Appendix M

<u>Insect Examination</u>

Nombre ____

Fecha ____

Prueba de los insectos

1. ¿Cúantos partes tienen los insectos?

2. En general, ¿cúantos piernas tienen?

Instrucciones: Lea las oraciones. Si la oración es cierto, haz un circulo alrededor la letra C. Si no es cierto, haz un circulo alrededor la letra F (falso).

1.	Un insecto tiene ojos como nuestros.	C	F
2.	Un insecto tiene el pelo.	C	F
3.	Durante la vida, un insecto se cambia.	C	F
4.	Si mirando un insecto que se vuele, habrá cuatro alas siempre.	C	F
5.	El ciclo de desarrollos es exactamente el mismo por todos los insectos.	C	F
6.	Hay insectos que son amigos para la gente.	C	F
7.	Los huevos de insectos parecen similares.	C	F
8.	Insectos se pongan los huevos en lugares similares.	C	F
9.	Los huevos mastican la comida siempre.	C	F
10.	Los insectos se protegen contra los enemigos por luchando siempre.	C	F
11.	Los esqueletos están adentro el cuerpo.	C	F
12.	La mosca puede ser peligrosa para la gente.	C	F

13. La mosca necesita mucho tiempo para aprender volar. C F

14. La mosca tienedos alas. C F

15. Las mariposas se vuelan durante la noche. C F

16. Un mosquito le gusta el agua. C F

17. Hay muchos tipos diferentes de hormigas. C F

18. Una hormiga puede tener trabajos diferentes durante la vida. C F

19. Todas las hormigas son buenas. C F

20. Cada hormiga tiene un trabajo. C F

21. La reina de las hormigas tiene muchos trabajos. C F

22. Los trabajadores de las hormigas son hombres. C F

23. Las mariquitas viven por muchos anos. C F

24. Las mariquitas son nuestras amigas. C F

25. Las mariquitas tiene el mismo calor por toda la vida. C F

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