Language, Discourse, & Learning in Science:

Improving Professional Practice through Action Research

The SOUTHEAST EISENHOWER REGIONAL CONSORTIUM for MATHEMATICS and SCIENCE EDUCATION at SERVE

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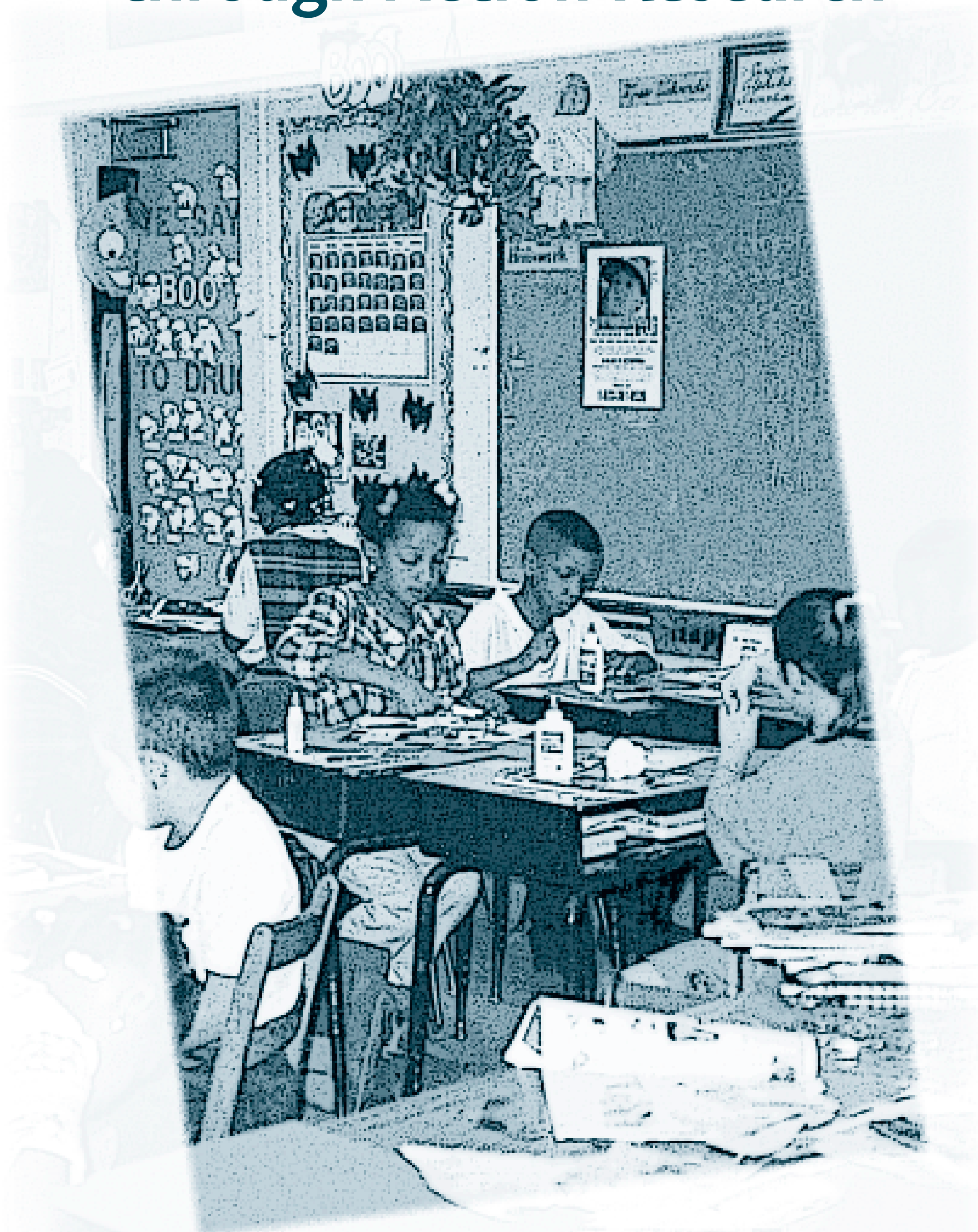

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SERVE
Improving Learning through Research & Development

Associated with the School of Education
University of North Carolina at Greensboro

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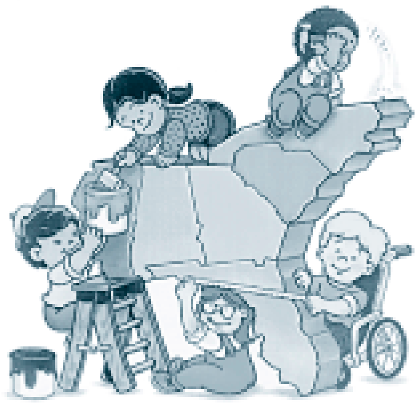

The Southeast Eisenhower Regional Consortium for Mathematics and Science Education at SERVE

The Southeast Eisenhower Regional Consortium for Mathematics and Science Education at SERVE is one of ten regional consortia created by Congress to improve mathematics and science education throughout the nation. The Consortium has three objectives:

- Coordinating mathematics and science resources
- Disseminating exemplary mathematics and science educational instructional materials
- Providing technical assistance for the implementation of teaching methods and assessment tools for use by elementary and secondary school students, staff, and administrators

The Consortium frames its work through the following focus areas:

- **Collaboration and Communication**. Joining forces with other mathematics and science education organizations at the national, state, and local levels
- **Programs and Curricula**. Identifying and disseminating exemplary mathematics and science materials with and through the Eisenhower National Center and other educational agencies
- **Professional Development**. Providing for the training of teachers, administrators, and other trainers in the use of exemplary mathematics and science materials, methods, and assessments
- **Curriculum Frameworks**. Assisting in the development and implementation of standards-based state curriculum frameworks
- **Technology**. Facilitating the use of telecommunications technology as a tool for mathematics and science instruction
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We offer the following services to promote our objectives:

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- Collaborating with existing networks of mathematics and science educators
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For more information about the Consortium, contact the main office:

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About SERVE

SERVE, directed by Dr. John R. Sanders, is an education organization with the mission to promote and support the continuous improvement of educational opportunities for all learners in the Southeast. The organization's commitment to continuous improvement is manifest in a cycle that begins with research and best practice. Building on theory and craft knowledge, SERVE staff develop tools and processes designed to assist practitioners, to refine the organization's delivery of technical assistance to schools and educational agencies, and, ultimately, to raise the level of student achievement in the region. Evaluation of the impact of these activities combined with input from affected stakeholders expands SERVE's knowledge base and directs future research.

This critical research-to-practice cycle is supported by an experienced staff strategically located throughout the region. This staff is highly skilled in providing needs-assessment services, conducting applied research in schools, and developing processes, products, and programs that inform educators and increase student achievement. In the last three years, SERVE staff have provided technical assistance and training to more than 18,000 teachers and administrators across the region and partnered with over 170 southeastern schools on research and development projects.

SERVE is governed by a board of directors that includes the governors, chief state school officers, educators, legislators, and private sector leaders from Alabama, Florida, Georgia, Mississippi, North Carolina, and South Carolina.

At SERVE's core is the Regional Educational Laboratory program. Funded by the U.S. Department of Education's Office of Educational Research and Improvement, SERVE is one of ten organizations providing services of the Regional Educational Laboratory program to all 50 states and territories. These Laboratories form a knowledge network, building a bank of information and resources shared nationally and disseminated regionally to improve student achievement locally. Besides the Lab, SERVE is the lead agency in the Eisenhower Mathematics and Science Consortium for the Southeast and the Southeast and Islands Regional Technology in Education Consortium. SERVE also administers a subcontract for the Region IV Comprehensive Center and has additional funding from the Department to provide services in migrant education and to operate the National Center for Homeless Education.

Based on these funded efforts, SERVE has developed a portfolio of programs and initiatives that provides a spectrum of resources, services, and products for responding to local, regional, and national needs. Program areas include Assessment, Accountability, and Standards; Children, Families, and Communities; Education Policy; Improvement of Science and Mathematics Education; Initiative on Teachers and Teaching; School Development and Reform; and Technology in Learning. SERVE's National Specialty Area is Expanded Learning Opportunities, which involves researching and identifying promising practices that result in improved student outcomes on the national, state, and local levels.

In addition to the program areas, the SERVE Evaluation Department supports the evaluation activities of the major grants and contracts and provides evaluation services to state and local education agencies in the region. The Technology Support Group provides SERVE staff and their constituents with systems, technical assistance, and software applications. Through its Communications and Publications Department, SERVE publishes a variety of studies, training materials, policy briefs, and program products. Through its programmatic, technology support, evaluation, and publishing activities, SERVE also provides contracted staff development and technical assistance in many areas of expertise to assist education agencies in achieving their school improvement goals.

SERVE's main office is at the University of North Carolina at Greensboro, with major staff groups located in Tallahassee, Florida, and Atlanta, Georgia. Unique among the ten Regional Educational Laboratories, SERVE maintains policy analysts at the state education agencies of each of the states in its region. These analysts act as SERVE's primary liaisons to the state departments of education, providing research-based policy services to state-level education policymakers and informing SERVE about key educational issues and legislation.

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EDITORIAL FOREWORD

Teachers as Researchers in Science Education

Kenneth Tobin
University of Pennsylvania

Twenty-five years ago, in a chapter entitled "The Teacher as Researcher," the late Lawrence Stenhouse (1975) proposed that teachers should become researchers in their own classrooms. Over the ensuing years, the idea of the teacher-as-researcher progressively became more widely accepted, and there now are numerous studies published by teacher-researchers.

I began to consider teachers undertaking research on their own practices when I was introduced to the power of interpretive research during a visit to Michigan State University back in 1984. At that time, I met Fred Erickson for the first time, listened to him speak about ethnography, and clutched a "thick" pre-publication version of his seminal chapter on interpretive research (Erickson, 1986). Jim Gallagher, also from Michigan State University, and I were about to begin a collaborative effort that would launch our interpretive research programs in science education (Tobin & Gallagher, 1987). Erickson's notions about participatory research were difficult for me to grasp initially because of my long history in undertaking process-product research in science classrooms. However, with the assistance of Jim Gallagher, I learned that it was O.K. to sit alongside students in the classroom and speak to them about their work, it was a good strategy to volunteer to assist the teacher, and if students asked for assistance or wanted to examine our fieldnotes, it also was acceptable to interact with them and share what we were writing and doing.

Changes in the way I thought about research did not happen suddenly but evolved over three to five years of continual research in classrooms. For many years I was in turmoil, particularly in relation to inconsistencies in the theoretical frames I used to make sense of teaching and learning and the methods I used to undertake my research. A search for coherence led me to consider many changes, and my approaches to research appeared to be in a constant state of flux. Within that context of change (a process that continues to the present time), I began to emphasize the significance of practitioner research in 1986 following a series of studies in Georgia in which I had investigated peer coaching as a means of improving the quality of teaching.

In those studies, it turned out that the coach was most advantaged by peer coaching. Opportunities for teachers to view and review teaching and learning and then to be reflective on their own practices were powerful catalysts for improving teaching (Tobin & Espinet, 1990). At about that time, a series of events occurred that led me to reconsider the use of laboratory schools. Jane Butler Kahle, with whom I was collaborating on an interpretive study in Western Australia (Tobin, Kahle & Fraser, 1990), was about to assume a position as Dean of the College of Education at the University of Northern Colorado, and I was about to relocate to Florida State University. Both universities had laboratory schools, and she and I discussed the potential of using these schools as sites for research for prospective teachers. It appeared desirable to us that prospective teachers should learn to teach by undertaking research on their own practices and those of more experienced teachers at the laboratory schools.

When I commenced my decade-long appointment at Florida State University, I collaborated with Sarah Ulerick, Nancy Davis, and others to develop a science teacher education program that incorporated interpretive research and constructivism as essential components. During that 10-year period, we included practitioner research as a part of learning to teach in our teacher preparation courses and in staff development programs. The methods we advocated changed progressively as we began to understand the nature of interpretive research from a constructivist perspective (Guba & Lincoln, 1989) and personal narrative methods of exploring teacher knowledge and change. In 1995, we commenced a major degree program in science and mathematics education for practicing elementary and middle school teachers in Dade County, Florida. That program was built around the principles of practitioner research that we had carefully honed over more than a decade.

The papers included in this monograph are all part of the teacher-as-researcher studies undertaken by middle and elementary teachers from Dade County Public Schools as they participated in a seven-semester advanced degree program which allowed them to graduate either with a master's or specialist degree in science education. More than 250 teachers participated in a first wave of study that enabled teachers to learn about science teaching and learning by participating in a community of learners that collaborated with me and my colleagues at Florida State University through the aegis of the Internet and in intensive face-to-face sessions in Miami. One of the most desirable outcomes from the program was a set of studies that focused on the teaching and learning of science in Dade County, Florida.

What is learned from undertaking research such as is described in these chapters is of most benefit to the teacher and students who participated in the research. Hence, in the reading of these chapters, it is not so much the findings of the studies that are most likely to benefit readers but the processes employed by a teacher undertaking research on teaching and learning in his/her own class. The research in this monograph has been written by practitioners for practitioners, and I expect that readers will find the descriptions rich and compelling in their authenticity. ◆

Kenneth Tobin
University of Pennsylvania
December 4, 1999

INVITED FOREWORD

Foreword

Okhee Lee
University of Miami

What is easily said is often not easily done. The idea of teacher research, action research, or classroom research—whichever term is used—has been proposed as a key vehicle for professional development and teacher leadership. It makes perfect sense—teachers are researchers in their own classrooms as they observe, analyze, reflect, critique, revise, and construct theories and explanations for instructional practices and students' learning outcomes. The challenge consists of putting this idea into action.

There are major difficulties in teacher research. Let us think of a few such difficulties. First, the language of formal "research" is not the language of classroom practice. It is not part of teachers' daily routine to read about educational research and literature, talk about the research process, gather and analyze data, and write about results. In Jim Gee's (1991) terms, teacher research requires teachers to develop a new "identity kit" as members of a research community. Second, even when teachers have the intuitive knowledge of the research process, developing it into formal knowledge is a demanding task. It is one thing to learn and know about research; it is quite another to *do* research. Third, even when teachers develop a new identity kit and formal knowledge of research, the reality of classroom teaching is not readily conducive to systematic inquiry.

The teacher research studies in this monograph are remarkable, considering the school district and the student population providing the contexts for these studies. Because of the high proportion of students who are in the process of learning the English language and developing general literacy, school and district policies emphasize language arts instruction, often at the expense of other subject areas, including science. In elementary schools, 30 minutes of instructional time daily is usually allocated to science. This limited time is further reduced because science is often scheduled in the afternoon when special school activities tend to occur. Unlike language arts and mathematics, there is currently no accountability system in science. Science supplies and materials are often not available in the classroom or the school building. Most elementary teachers are uncomfortable with science and science teaching. Although science instruction is a challenge for many teachers, it presents a greater challenge to those teachers who work with students in the process of developing English language and literacy while simultaneously learning science (Lee & Fradd, 1998).

The studies in this monograph defy the odds in teaching science for students who are in the process of learning English as a new language. They demonstrate that these students who might be perceived as not being "ready" to learn science are indeed successful learners of science. The teacher researchers were pleasantly surprised at how much students enjoyed learning science and made personally meaningful connections in science. Through learning science, students also improved English language proficiency and general literacy.

Although there were great variations, the studies in this monograph addressed several common topics. Many examined conceptual change teaching and learning as students developed an understanding of key science concepts. Many also examined student learning through hands-on activities. In addition, others dealt with the intersection of science discourse and language development. Some studies examined these topics across instructional settings, such as small group discussion and collaborative learning. All of the studies tried to relate science and language learning to students' everyday experiences.

The studies have other commonalties. As several teacher researchers pointed out, science instruction was provided for a limited time period according to school and district policies. Because of this constraint, some had to combine instructional times for language arts and science, at least during the period of their research studies. Science concepts and hands-on activities were within the district's science curriculum frameworks. Although the teacher researchers promoted students' participation and initiative in their own learning, science instruction was generally teacher-directed.

Some readers may consider the points noted in the previous paragraph as being limitations of the studies. It might be considered that research focusing on conceptual change as a key component of science learning, hands-on activities, teacher-directed or guided instruction, and "meaningful" science within district curriculum guidelines does not sound innovative or provocative. These very aspects, however, may be the power and significance of these studies for teachers in this school district or other districts with similar kinds of challenges. Because the teacher researchers are real people and live in the real world of day-to-day classroom teaching, they can effectively communicate their experiences and insights with others in similar settings.

The contributions of the teacher research studies in this monograph are many. The most immediate impact is improved student achievement in science, literacy, and related subject areas. The studies also highlight the need to consider students' language and cultural experiences in promoting achievement, which is critically important for these students who have often been marginalized in schools and mainstream society. The most significant impact may be with the teacher researchers themselves. The teachers demonstrate teaching as a process of inquiry that involves careful observations, critical analyses, reflections, insights, self-assessment, and construction of personal meanings and theories. The teachers also demonstrate an awareness of social, cultural, linguistic, and political influences on classroom teaching and student learning. The teachers have become advocates on behalf of their students and families, as well as more effective teachers. Inspired by the studies in this monograph, other teachers reading this document may be motivated to conduct research in their own classrooms.

The teacher researchers communicate effectively with the research community and contribute to narrowing the research-practice gap. They have learned how to use the language of research, to systematically gather and analyze data, to provide evidence in support of assertions, and to combine "hard" data with personal insights and reflections for richer understanding. In the research process, they expressed a sense of joy, appreciation, and pride, while also acknowledging frustrations and uncertainties. In addition to demonstrating their accomplishments, the teacher researchers also recognized limitations of their studies. These emotions and reactions sound real and genuine. Just as researchers marvel at exemplary teaching, these teachers have learned to develop an appreciation and respect for pedagogically useful works of research.

In celebrating the achievements of the teacher researchers, I would like to acknowledge the work of the project staff, especially the editors of this monograph. Again, what is easy to say is not necessarily easy to do. It takes a great deal of time, energy, and commitment to assist teacher researchers with their studies. Based on personal experience of teacher research studies from planning to publication, I cannot imagine the number of hours and the extent of thought that the project staff and the editors have committed to this ambitious and massive project with a large group of teachers over several years.

The studies in this monograph invite opportunities for further research. Some of the ideas that I would like to propose for consideration are as follows. First, I would ask the teacher researchers to address how language and cultural experiences of the students and the teachers influence science teaching and learning. In the education community, there is an increasing interest in the notion of “culturally responsive pedagogy” or “culturally congruent instruction.” For example, do Haitian teachers interact with Haitian students in culturally specific ways that promote the students’ participation and engagement? On the other hand, do they also interact in ways that may pose difficulties in teaching and learning science? What may be strengths and limitations of culturally responsive pedagogy with teachers and students who come from the same language and cultural background? What may be strengths and limitations when teachers and students come from different language and cultural backgrounds?

Second, the studies in this monograph describe instructional practices in which teachers guided students through hands-on activities or through discussion of key science concepts. If educators expect students to become independent learners as they pose questions and find answers on their own, what does effective instruction involve? In particular, what does effective instruction require with students who often have had limited prior knowledge and experience in science, as well as limited literacy development?

Finally, now that a large group of teachers has successfully completed teacher research studies, what do the teachers as a collective group do to make a difference *beyond* their classrooms? What implications can this project provide for policies and practices in science education at the school, district, state, and national levels?

The teacher researchers featured in this monograph should be commended for their accomplishments and contributions. This work will serve to improve the quality of science education for students from diverse backgrounds in the schools, the district, and the state. ◆

INTRODUCTION

Introduction to the Monograph

Aldrin E. Sweeney
University of Central Florida

This monograph describes and exemplifies action research studies undertaken by practicing elementary and middle school science teachers enrolled in an asynchronous, web-based science education distance learning graduate program at Florida State University (FSU). The FSU-Dade County distance learning program in science education is a collaborative effort between the Department of Curriculum & Instruction at FSU and Dade County Public Schools (DCPS), with the goal of assisting practicing elementary and middle school science teachers in DCPS improve their professional practice, both in the areas of science content knowledge and instructional pedagogy. Teachers enrolled in the program were required during the Fall Semester 1996 and the Spring Semester 1997 to undertake their own classroom-based research, using techniques and insights gained from a course in interpretive research methodology, taught by science education faculty in the Department of Curriculum & Instruction at FSU.

In this monograph we highlight those teacher research papers which examined various aspects of the development of a scientific discourse in elementary and middle school classrooms and which also investigated the mediational role of the teacher in facilitating science learning. Often, such facilitation was attempted under what may best be described as challenging circumstances. In the context of the classrooms in which the teacher research studies were performed, all involved the teaching and learning of students for whom English was not a native language and who had limited English proficiency.

What is the Importance of Teacher Action Research?

The action research studies reported in this monograph exemplify the development and establishment of a community of teacher/researchers who, from the perspectives of teachers and learners, have examined—and continue to examine—the teaching and learning of elementary and middle school science in sociocultural contexts regarded as being educationally challenging. Consequently, the significance of a monograph of this nature is based on the premise that systemic change should be informed and can be enhanced by participants engaging in interpretive research on their own practices and using what they learn to adapt practices throughout a community.

Such an undertaking may be considered as being "action research." The definition offered by Bogdan and Biklen (1992) aptly summarizes the intent of these interpretive teacher research studies, where they define action research as being the systematic collection of information, designed to bring about social change. Stenhouse (1975) has pointed out that action research and the notion of "teacher as researcher" are closely related. Kemmis (1983) defines action research as being a form of self-reflective inquiry undertaken by participants in a social (including educational) situation in order to improve the rationality and justice of their own social or educational practices, their understanding of these practices, and the situations in which these practices are carried out.

With reference to the action research studies exemplified in this monograph, Shelly (1997) perhaps best describes the quintessence of this form of research:

> *Teachers are in the best position to see the effect of classroom practices and programs on student learning. For teachers, "doing action research" means generating questions and systematically collecting data over time. This data can be collected through student journals, teacher observations, and samples of student work. The results of this inquiry process might be answers to research questions or might result in more questions. As teacher/researchers reflect individually or collaboratively on the data, they assess the effectiveness of their own practice. They become more proactive, making changes in classroom practice with a greater sense of the impact of those changes.*

Whether termed as "action research," "classroom research," or "practical inquiry," the genre formalizes an aspect of teaching that expert teachers have known about and employed for a long time: they observe situations in their classrooms that are less than optimal, they identify the problem, they think about what and how to change, they make the change, they evaluate the impact of the change on the situation, and they begin again (Spiegel, Collins & Lappert, 1995; Spiegel, Collins & Gilmer, 1995). By utilizing various interpretive approaches, the studies presented in this monograph foreground the importance of teacher-based action research in seeking to examine and understand the teaching and learning of science in schools that are situated in educationally challenging contexts. A major educational challenge for the teacher/researchers engaging in these action research studies consists of the ethnic, cultural, economic, and in particular, linguistic diversity of students served by these schools. Accordingly, the action research studies comprising this monograph focus on studying the relationships between language, discourse, and the learning of science in urban environments and within varying contexts of learner diversity.

Theoretical Aspects of Language, Discourse, and Science Education

Demographic projections make it clear that as we approach the 21st century, employers and the American economy will become increasingly dependent on a workforce drawn from urban, inner-city communities, where growing proportions of poor, cultural, and language minority children are concentrated. Because these communities depend on urban schools to provide them access to improved economic opportunities, and because government and corporate policymakers see education as the key to America's well-being and international competitiveness, urban school districts are considered central to the nation's prospects. In recognition of this situation, policymakers and the business community have given sustained attention to the improvement of urban schooling and education, yet there is abundant evidence that efforts toward improvement from the mid-1960s on have had only marginal success (Lytle, 1992; Rothstein, 1993).

Related to these matters is an increasing concern about issues centering on the diversity of students in science classrooms. A major issue in American science education identified by scientists, science educators, and leaders of government and industry has been the general failure of school systems (often located in inner city, urban areas) to produce students who are scientifically literate. In addition, poor test results have further fueled the drive toward systemic educational reform necessitated by the increasing need for scientific literacy and the need to situate science education in contexts which are increasingly diverse in terms of ethnic, economic, and linguistic diversity.

These concerns are clearly exemplified in the Dade County Public Schools system, which forms the educational context in which the action research studies reported in this monograph were performed. Recent statistics show that Dade County Public Schools enrolled over 330,000 students in the 1995-1996 school year, and during the preceding five years, nearly 53,000 new students were added to the system. Approximately 48% of these students were Hispanic/Latino, 34% of the students were African-American, and the remaining 18% were White, Asian-American, and Native-American. Additionally, 16% of the total student population was classified by the State Department of Education with limited English proficiency (LEP). Recent student performance on achievement tests reflects an unacceptably low rate of learning. For example, on the mathematics applications subtest of the *Stanford Achievement Test*, administered in grades 2-8, there was a 50% gap between African-American and White average normed scores, and a 30% gap between Hispanic/Latino and White students (Wongbundhit, 1996). It is here that equity issues emerge as a critical problem.

In addressing these issues of equity in science education, it is important to note, as do Gallard, Viggiano, Graham, Stewart and Vigliano (1998), that educational equity goes beyond the notion of equal opportunity and freedom of choice. Examination needs to be made regarding the manner in which learning is facilitated, and it needs to be established not only whether the pedagogical means fit the needs of all students, but also whether students are allowed to use all of the intellectual tools which they bring with them into the classroom. School culture, teachers' attitudes, and classroom environments also must be scrutinized to determine if all students (regardless of class, gender, race, ethnicity, and linguistic background) are participating in an equitable learning environment.

McLeod (1994) has argued that educational solutions depend on the definition of the problem, and that educational programs or strategies to counteract academic failure are always based on assumptions about the reason for failure. Theories to explain differential achievement always conflict with each other, partly because educational success and failure—like other aspects of human behavior—are determined in a multiplicity of ways. Concerning issues of linguistic diversity, several reasons have been offered to explain the generally low academic achievement of students from non-English language, minority, urban backgrounds, including inadequate language services, lack of access to a standard curriculum, cultural discontinuity, outmoded instructional models, inappropriate assessment and evaluation, structural inequality, and insufficient student ability and motivation. While the scholarship of the 1960s and 1970s concerning language development and corresponding sociocognitive levels of proficiency tended to be generally theoretical (e.g., Halliday, 1978), the contemporary focus has been for scholars interested in language development, cultural diversity, and the teaching and learning of science (e.g., Tobin & McRobbie, 1996; Lee, 1997; Sweeney, 1997a) to shift from a linguistically oriented, theoretical focus to one in which language, literacy, and science education are viewed as the products of socioculturally mediated discourse processes among individuals and groups in both formal and informal instructional settings.

Most educational discourse and learning environments traditionally have tended to reflect the discourse practices of mainstream society, with often unfortunate results for non-mainstream students, including many language minority students (Cazden, 1988; Gee, 1990). Using the term "match-mismatch," some linguists (e.g., Cook-Gumperz and Gumperz, 1982; Mehan, 1991; 1994) have postulated that language minority students do not prosper academically in such contexts because the discursive practices of their homes do not match the discursive practices of the school environment. In turn, such mismatches between the discursive practices of the home and those of the school tend to limit language minority students' access to and participation in higher educational and occupational activities. In other words, while children from middle- and upper-class cultural and speech communities are sociolinguistically advantaged in the school environment (Bourdieu & Passeron, 1990), children from poor, non-English and nonstandard-English-speech communities are more likely to be disadvantaged and even at risk of being marginalized in school environments (Minami & Ovando, 1995).

The concept of science as a "discourse community" (and scientific achievement as being a function of facility within such a discourse community) is useful in describing the difficulties of teaching and learning science in urban contexts associated with minority students of diverse ethnic, cultural, economic, and linguistic backgrounds. Gee (1989; 1990) defines a "discourse" as being a sociocultural and political entity which subsumes ways of saying, writing, doing, being, valuing, and believing. A "discourse" may thus be understood to be a social and cultural function of a particular "discourse community," which serves to facilitate communication and establish social and cultural identity. Two broad types of social discourse exist: primary discourses (those learned in the home environment) and secondary discourses (those which are associated with institutions or groups that one might later encounter). All discourses and discourse communities are not socially regarded as being equal in status, and some are socially dominant and conventionally are associated with social power and access to wider economic and political success.

It is anticipated that what is learned from the teacher action research endeavors presented here will have potential implications in systemic reform efforts across the educational panorama.

Using this concept of science as a discourse community—and of achievement in science-related activities as a function of facility within this discourse community—an explanation may be proposed for the difficulties associated with the science teaching and learning of these students. Such difficulties may conceivably be held to arise from incongruities between the modes of primary discourse with which they are familiar and the modes of secondary discourse with which they are not.

Academic discourses (such as the particular types of discourse characterizing formalized science) embody certain ideologies (that is, systems of values, beliefs, and social practices). Thus, learning to "talk science" involves more than just learning a set of linguistic forms; it also involves learning (and internalizing to an appreciable degree) beliefs and values associated with that particular discourse community (Lemke, 1990). Both Gee (1990) and Lemke (1990) point out that the ideologies embodied in such academic discourses may be in conflict with the home and community discourses of some students. Such students seemingly are faced with insurmountable obstacles in terms of their perceived lack of the social, cultural, and linguistic prerequisites deemed necessary to "allow entry" into the science discourse community.

A focused interest in the relationships to be found between discourse, language, and the meaningful learning of science in urban contexts consequently underpin the purposes and rationales of the studies presented in this monograph. It is anticipated that what is learned from the teacher action research endeavors presented here will have potential implications in systemic reform efforts across the educational panorama, relating especially to continuing research on equity and diversity, the development of viable communities of scientific discourse in urban instructional environments, and the greater involvement of cultural and linguistic minorities in the teaching and learning of science.

Methodological Designs and Procedures in the Action Research Studies

Due to the diversity of the teacher-researchers and the variety of data sources used in their respective action research studies, Guba and Lincoln's (1989) *Fourth Generation Evaluation* has been extensively employed to ground the research methods. Put simply, *Fourth Generation Evaluation* argues that researchers are participants in any authentic evaluation and cannot set aside their belief systems during the course of their study. Therefore, the researchers have a stake in their study and should be considered stakeholders as much as those within the systems being evaluated. The researchers have their own individual lenses through which they observe and interpret the data before them. As such, the researchers' biases and opinions, try as they might to set them aside, cannot ever be completely divorced from the interpretations they make.

To overcome this constraint, *Fourth Generation Evaluation* argues that researchers should engage in a hermeneutic-dialectal process. Put briefly, this is a sense-making process that attempts to include the voices of stakeholders in the investigative and evaluative mission. There are simply too many variables in any educational study to identify exactly where a specific problem or solution might lie. What can be done, however, is to surround the issues at question with as many points of view and data sources as possible, in order to inform the negotiation and discourse of the ongoing reform agenda. The epistemological framework that guides *Fourth Generation Evaluation* is constructivism. From the constructivist perspective, researchers are attempting to make sense of the data, the emerging patterns, and the relevance for teaching and learning. Moreover, findings are not regarded as objective truths, but rather as one viable picture of what is occurring in classrooms, schools, and the larger systems related to the science education reform that is occurring.

Overview of the Action Research Studies

The 14 action research studies featured in this monograph span a broad range of depth and writing genres. Some adopt a narrative, almost "story-telling" style, while some are much more similar in their design and presentation to that of a formal academic research report as is typically seen in the conventional scholarly science education journals. Some studies adopt styles of expository writing, which exhibit several interesting variations of both. Given that the studies presented here represent the respective teachers' first encounters with "doing" action research, it is perhaps fair to point out that the formally trained educational researcher will no doubt identify procedural weaknesses in some of the methodologies and also in the viability of the conclusions drawn in several of these studies. Our decision to include the range of studies in this monograph is based on the fact that all of the studies exemplify teachers taking the time to design a study to look more closely at some phenomenon of concern in their classrooms, subsequently validating their practice by making data-based instructional decisions (see Fueyo & Koorland, 1997). The teachers conducting the studies have been honest in their accounts of the successes and failures associated with their studies; however, whatever the degree of "success," all of the teachers indicated that the process of undertaking their research studies was a valuable learning experience in itself which contributed significantly to their professional development as teachers.

Language, discourse, and the learning of science is the theme which unifies all of the studies presented in the monograph. It is our hope that the following studies will encourage other teachers to develop and undertake their own classroom studies, which investigate the roles of language and discourse in the effective teaching and learning of science for *all* students.

Denelle Britton's *Facilitating Conceptual Change in Science: A Case Study* describes the ongoing process of a second grade LEP student's scientific conceptual change in the context of a lesson unit on weather. Although written with a specific focus on language minority/LEP students and the development of conceptual change and scientific discourse, Britton's study emphasizes that all children enter formal learning environments with prior knowledge and experiences which influence *how* and *what* they will learn.

In a study which investigates conceptual change and the development of science discourse, **Laura Capshaw Fink's** research, *Middle School Students' Perspectives on Collaborative Learning, Group Size, and Conceptual Change*, addresses the pedagogical strategy of collaborative grouping as a means of developing scientific communities of discourse in the classroom and initiating conceptual changes in science understanding with middle school students.

In her research study, *Does Teaching Science to Limited English Proficient Students Through Cooperative Learning and Hands-on Activities Increase Language Proficiency?*, **Rose Bagley** investigates whether the science language acquisition of her first grade LEP students increases if science instruction is given using cooperative learning and hands-on activities. Using both a pre-test/post-test evaluation instrument and a weekly checklist, the development of critical thinking skills in science (including the processes of predicting, classifying, observing, communicating, experimenting, and inferring) also were evaluated.

In her research study, *How Urban Children Learn about Their Natural Environment,* **Carol Reiter** broadens the commonly accepted notion of discourse to provide descriptions of how her students utilized artwork, literature, music, and popular television programs in their development of a scientific discourse.

Dana Kelly's research study, *Semiotics and the Construction of Meaning in Science*, utilizes semiotics as a theoretical framework for investigating the ways in which students from diverse cultural backgrounds use language to describe scientific concepts and hence construct scientific meaning. The findings from her study provide support for the current findings reported in the sociolinguistics research literature suggesting that the discursive practices of the home environment play an important role in determining the extent to which students are able to employ the discursive practices of the science classroom and that of canonical science.

Mayda Martin-Olazabal and **Aurora Romero's** parallel research study, *Writing as a Tool for Learning Science: Perspectives of a First and a Third Grade Teacher*, examines how writing is related to achievement in science and seeks to establish whether an improvement in the writing skills of their first and third grade students (respectively) may be used to support and enhance science learning.

Eva Wich's research study, *Poetry as a Vehicle for Teaching Science*, explores whether the teaching of science through poetry better enables her second grade students to retain and understand scientific concepts. Based on the premise that the use of language is essential in understanding science and in the creation of a scientific discourse, Wich's thought-provoking research suggests that the use of more diverse language forms by scientists and science students enriches science learning and allows science to become more widely popularized.

In *Children's Literature: An Effective Integrative Strategy for Teaching Elementary Scientific Concepts and Vocabulary*, **Rebeca M. Valverde's** research study describes her efforts to improve her third grade students' understanding of scientific vocabulary and scientific concepts by integrating children's literature into the science curriculum. While Valverde cautions that there are many misconceptions and inaccuracies in children's literature related to content areas such as science, her study advocates the role of children's literature in the development of science vocabulary, conceptual understanding, and a scientific discourse community.

Based on current theoretical understandings concerning the nature of reading and comprehension, **Laura Vogl's** research study, *How Does the Use of Conversation Affect the Learning of Science?*, focuses on the evaluation of different discussion and conversational strategies as a means of enhancing the level of scientific discourse and science learning occurring in her seventh grade science class.

Lizette Aladro and **Olga Suarez's** research study, *How Do LEP Students Acquire and Develop the Language of Science?*, explores the extent to which LEP students in their second grade classroom acquire and develop the language of science. By employing various strategies associated with the use of a "Science Talk" board in the classroom as one means of data collection, Aladro and Suarez describe the challenges and successes experienced in initiating and maintaining a science discourse among these students.

The development of scientific understanding and scientific discourse using small group discussion is the focus of **Dolores M. Rodriguez's** research study, *Does Small Group Discussion Contribute to the Understanding of Scientific Concepts?* Using a social constructivist theoretical framework on which to base her research with her third grade students, Rodriguez's study suggests that although hands-on science activities are an excellent way for students to actually experience science, small-group discussion in addition to hands-on activities is the vehicle by which scientific discourse may be developed and, hence, allow for a greater understanding of scientific concepts.

Raquel Casas and **Isabel Tamargo's** research study, *Constructivism and the Teaching of Science to Limited English Proficient Students,* describes how the adoption of a constructivist approach in their science classroom was used to simultaneously enhance science learning and English language instruction with LEP students.

In *Ciencia en Español: Effects of Bilingual Education in Kindergarten Science Construction,* **Yadira Y. Cano** and **Mary R. Wagner** present case studies of two English monolingual kindergarten students participating in an extended foreign language program delivered in Spanish and English. Findings from their study indicate that the encouragement of a bilingual, bicultural classroom environment acted as a positive vehicle for the development of science conceptual understanding.

Celia Ormes' research study, *The Impact of Science and Technology Instruction with Hispanic Illiterate Children at Riverside Elementary School,* concludes this monograph dedicated to language, discourse, and the learning of science, by presenting a powerful narrative of the day-to-day challenges commonly faced by many teachers in Dade County. Although it is commonly assumed that language minority or LEP designated children are not able to communicate adequately (that is, read and write) using the English language, instructional interventions are made all the more complex if students are functionally illiterate not only in the language of the mainstream society, but also in their native language. As Ormes vividly portrays in this paper, "bilingual illiteracy" forces teachers to consider alternative and often innovative means to effectively educate these students. The case study presents and describes the success of a teacher-generated initiative based on science instruction as a vehicle for achieving bilingual English/Spanish literacy and the development of a viable scientific community of discourse in the classroom with these students. ◆

CHAPTER ONE

Facilitating Conceptual Change in Science: A Case Study

Denelle Britton
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Denelle Britton is currently employed at Gratigny Elementary School, Miami-Dade County Public Schools as a Reading Leader, responsible for coordinating the Reading Curriculum (PreK-6) at the school. Over the last 11 years, she has taught kindergarten through fourth grade, after earning a Bachelor of Science Degree in Early Childhood and Elementary Education in 1988 and a Master of Science Degree in Exceptional Student Education in 1992 from Barry University. In 1998, she received an Educational Specialist Degree in Science Education from Florida State University. Denelle is presently enrolled in a doctoral (Ph.D.) program in Science Education through Curtin University.

Abstract

In this study, I describe the ongoing process of a second grade limited English proficient (LEP) student's scientific conceptual change in the context of a lesson unit on weather. Although written with a specific focus on language minority/LEP students and the development of conceptual change and scientific discourse, findings from the study emphasize that all children enter formal learning environments with prior knowledge and experiences which influence *how* and *what* they will learn.

Background and Theoretical Rationale

As the nation's demographics continue to change, the population of students of non-English speaking background in the schools continues to grow. This shift from a predominantly monolingual classroom setting to an increasingly multilingual classroom brings with it many challenges for the regular classroom teacher. One of the greatest challenges, in my opinion, is in finding ways to effectively teach the content areas to LEP students. The ideal solution to this problem would be to provide well-educated, bilingual science teachers capable of addressing the needs of this populace. The reality, of course, is that demand exceeds supply. Thus, the task of educating these LEP students often passes to the regular classroom teacher.

Engaging in the action research project was an eye-opening experience.

During the time in which this study was performed, I was in my second year of teaching second grade students who had been classified as limited English proficient. This group was comprised of Levels I-IV with Level I as the lowest level of English language acquisition. The dominant first/home languages were Haitian Creole and Spanish. While I was not an ESOL (English for Speakers of Other Languages) teacher, I did teach these children in the content areas. Other teachers in the bilingual program also taught the students. My first whole-class experience with such a group was in the year prior to undertaking this study, and my challenge then, as now, continues to be to find ways to effectively teach and reach these students across the curriculum content areas.

In the summer of 1996, having become aware of my teaching assignment for the following school term, I set out to become more knowledgeable and better equipped about how to teach science to LEP students. I conducted a review of the literature available on teaching science to LEP students, which proved to be quite informative. Consequently, I made a conscious effort to implement several of the strategies I had read about.

Soon after, I became interested in finding out if and how my students were making sense of the concepts presented to them in science. In my review of the literature in this area, I was reminded that children come to school with their own ideas about certain phenomena. These ideas often do not mirror current scientific thought. These "misconceptions" (Miller, Steiner & Larson, 1996; Eaton, Anderson & Smith, 1983), "preconceptions" (Stepans, Beiswenger & Dyche, 1986), or "alternative conceptions" (Minstrell & Smith, 1983), as they have been called, represent their attempts to explain things in the world around them. While it is reasonable to expect children to form these ideas, sometimes they can interfere with the learning of canonical science concepts. The challenge for the science teacher, then, is to be able to help students reconstruct these alternative conceptions. This can prove to be a difficult task as children will often choose to retain these alternative conceptions if they do not understand, or if an explanation conflicts with their beliefs (Stepans, Beiswenger & Dyche 1986). Minstrell and Smith (1983) and several others have suggested that the key to facilitating conceptual change is for teachers and students to recognize these alternative conceptions and deal with them directly. I identified several approaches aimed at addressing this problem, although one in particular caught my attention.

> It takes more than reading a book or doing one hands-on activity to facilitate conceptual change.

In an article titled "Strategies for Science Learning," the authors (Miller, Steiner & Larson, 1996) offer four strategies for improving science understanding in students. The first step is to identify misconceptions. This can be accomplished through large/small group discussions, interviews, and responses to open-ended questions. Once the misconceptions have been identified, the next step is to confront these through inquiry. Miller, Steiner, and Larson (1996) suggest presenting a discrepant event (that is, an event that has an unexpected outcome). This could be as simple as reading a fiction book on the topic or presenting a demonstration. The purpose here is to encourage the children to begin to think about the feasibility of their alternative conceptions. The third strategy is to provide as many varied experiences as possible to challenge the children's beliefs. As the authors note, it takes more than reading a book or doing one hands-on activity to facilitate conceptual change. Exposing the children to evidence that supports the validity of the concept, as well as discussing the evidence in a logical manner, is the fourth strategy. Children's literature also is a good vehicle for accomplishing this goal.

Curious, I decided to implement the above approaches in my classroom. The report that follows is the story of this venture.

Methodology

The site for this action research study was an elementary school in metropolitan Miami. The population was approximately 1,486 (PreK-6), with a student ethnic distribution of 3% White, 81% Black, 14% Hispanic, and 2% other. During the time in which the study was conducted, the school served over 180 LEP students.

In selecting a topic to investigate, I wanted to ensure that my research would not interfere with the regular curriculum and the education of my students. As a result of the various pullout programs, our time together was limited. Thus, in keeping with the county's *Competency Based Curriculum* (CBC) for second grade science, I chose rain as the subject area around which I would design my study. The subject area of rain was easily integrated into a unit on weather. Since the study was implemented as part of the regular classroom curriculum, all of my students participated and were aware of the study. However, for the purpose of this report, I chose to focus primarily on one student's experience. Data collection activities included audiotaping, formal and informal interviews, teacher observation, and journaling. Due to the nature of my classroom, my primary concern was to find a student who would not be afraid to express what he/she was thinking, hence, the selection of Mona Lopez, a seven-year-old Hispanic/Latina female.

An eager learner, Mona was an active participant in class. She not only answered questions, but also was constantly asking questions and offering suggestions or opinions based on the topic under discussion. She also was a "thinker," and sometimes expressed frustration with her inability to communicate her ideas in English. To her credit, though, she did not let this stop her from trying. Curiously, when prompted to answer in Spanish, she preferred to try to respond in English. Sometimes she admitted to not knowing how to answer in Spanish either. I explained my project to her and asked if she would like to help me with it. She readily agreed. I then spoke with her mother, requesting permission to audiotape conversations with her child and to document the latter's progress. In addition to granting permission, the mother readily agreed to a personal interview.

Mona was born in Miami and lived with her parents, a brother (15 years of age), and two sisters (6 and 8 years old, respectively). Both of Mona's parents were from Nicaragua. An interview with Mrs. Lopez revealed that this second grader had been at the school since kindergarten. Further questioning also revealed that Spanish was the language spoken in the home. Mrs. Lopez indicated that although Mona was always addressed in Spanish, sometimes she was allowed to respond in English. Curious, I asked why this was done. The mother replied that it helped Mona to learn English and also helped her to maintain her Spanish (Mrs. Lopez expressed some concern over the child "losing" her Spanish). At school, Mona spoke English with most of her classmates. She also conversed at times in Spanish with her Spanish-speaking classmates.

Implementing the Strategies

My first task was to discover what the students knew about weather and, in the process, identify any alternative conceptions they may have held about rain. I began the unit by asking the children what they knew about weather, and we subsequently created a list. Next, I solicited from them what they wanted to know. There were questions about hurricanes, comets, the sun, snow, rainbows, earthquakes, volcanoes, air/wind, clouds, lightning, and thunder. Several of the questions concerned rain, including Mona's:

> How the rain come down? Why do the sky get different colors—white, blue, black? Why do lightning come from?

Later that day, while the other children were out of the classroom, I conducted my first taped interview with Mona. I explained again that the tape recorder would be on as we spoke so that later I could write down what was said. Mona did not appear to mind. The purpose here was to solicit her initial thoughts on rain and any stories she might have heard from her friends or other adults. The following is an excerpt from that conversation:

Ms. B.: Mona, I'm going to ask you some questions about rain. You said you want to know more about it, right?

Mona: Yes.

Ms. B.: Where do you think the rain comes from?

Mona: I think it, it come from the sky?

Ms. B.: Okay. How does it come from the sky?

Mona: Um…I don't know…I…my mom sometimes she told me that, um…that maybe God with one finger he, he put the rain down… And Alicia told me that when…I don't know but she didn't tell me who put water in the sky and then when the water, when the sky cannot hold the water, it let it, it…it let it fall down. I think of that.

Ms. B.: Who puts the water in the sky?

Mona: I don't know. She …um Andrea, Alicia didn't told me.

Ms. B.: She didn't tell you? (No.) What do you think? You know what your mom told you and what your friend Alicia said. But what do you think?

Mona: …Um…um…um…that…I think that that somebody that died is up there and they put water and then that's I think like that it fall down the water.

Ms. B.: So you think someone died and is up there in the sky and they pour the water down?

Mona: Yeah…I think. I don't…I'm not sure.

Many LEP students have a hard time verbalizing their thoughts. This inability to express themselves in English, however, is not to be confused with not knowing.

I found her reference to her friend Alicia quite telling. Alicia had transferred to another school a few months earlier. Obviously the children had been discussing the subject long before it had been formally introduced to them. As the conversation continued, we discussed her fear of storms. Mona was particularly frightened by "something she heard." This turned out to be thunder. While she had difficulty explaining what she heard, she had a plan to help *me* understand:

Mona: That when I hear some of um…I hear storm then it make me scared!

Ms. B: What do you hear?

Mona: Um…like…um, I don't know, um…I hear something but sometimes but sometimes um…I don't know, but, um…I don't, um…I'm going to do this for I could show it to you. I'm going to tape it and then I could bring it to you.

Ms. B: So I can hear what you hear?

Mona: Yes. (She said this with a sigh of relief and a smile.)

Like Mona, many LEP students have a hard time verbalizing their thoughts. This inability to express themselves in English, however, is not to be confused with not knowing. This is why I think it is so important to provide as many means as possible for these children to express themselves. At this point, I was about ready to conclude our interview when Mona made the following comment:

Mona: Cathy question, it was I…um, that was a good question because she said that…that how did the, um…how you call it? That the news, how they know if a rain gonna come or stuff like that or if…it going to be sunny or not sunny…if it going to be cold or not…stuff like that.

I had a choice to make: I could either agree and end the conversation or further explore what she was thinking. I decided to seize the moment:

Ms. B: You're right. She did ask that question. She wanted to know how the news people knew what the weather would be like. Well, what do you think? How do they know?

Mona: I think, um…I was remembering, I think that they stick a stuff that you have inside there (She points to the science kit.) and then that if it goes up I think it's…I don't know, but it's a red thing you have in the class. And then I think that's the stuff.

Ms. B: What red thing? Did we use it in class?

Mona: No. In the…the person who brought you things that it was there. (She points to the kit again.)

Ms. B: You saw something in there? (Yes.) Can you go and get it?

Mona: (Goes over to kit and gets a thermometer) Here.

Ms. B: Do you know what this is called? (No.) It is a thermometer. Can you say "thermometer?" (She tries to pronounce it.) Right. So you think they take a thermometer and put it down. Then what happens?

Mona: Maybe it go up because you see it going up.

Ms .B: Okay. If it goes up what do you think that tells them?

Mona: Um…it's going be cold I think.

Ms. B: You think if it goes up it's going to be cold? (Yes.) What if it goes down? What do you think that tells them?

Mona: That it's going to be hot.

Ms. B: So you think if this red thing goes up, it's going to be cold and if it goes down it's going to be hot?

Mona: A little bit. Like here I think it's cool.

Ms. B: Well I just want to know what you think. Then we can find out if what you think is the way it is. Right?

I had originally planned on having the children investigate temperature at a later stage. Mona however was ready now. As I mentioned earlier, she was a rather inquisitive child.

Mona: You know…I was thinking ah right now if you could do a experiment. If you go outside, you get a paper with a book and then a pencil. Then you could write what happen and if go down or up and how many it is. (She looks at me expectantly.)

Ms. B: Would you like for us to do that? (She responds enthusiastically with a "yes.") So let's see, you think if the red thing goes up, it's cold. If it goes down, it's hot. Right? (Yes.) So is it hotter outside or inside?

Mona: I think it's hot outside.

Ms. B: So if you think it's hotter outside, then you think the red mark is going to go down. And if it's colder, it's going to go up. (Yes.) Okay. Let's go do your experiment.

A short while later …

Ms. B: Do you remember what this is called? (She holds up the thermometer.)

Mona: A ther..mom..eter?

Ms. B: Very good! This is a thermometer. Now before we went outside you made a prediction. You said the red thing was going up or down?

Mona: I think it going to go down.

Ms. B: What actually happened?

Mona: It went up to…how you say?…90! It went here and here and then here (indicating upward movement).

Ms. B: When we came back into the room, what happened to the red thing?

Mona: In here? I think it went down.

Ms. B: Why do you think it went down when you came back into the room?

Mona: Because maybe, maybe it was like cold?

I could tell by the uncertainty in her voice and the look on her face, that she was trying to assimilate these findings. I wondered if she would decide to cling to her original theory or adjust it in the face of these findings. Several researchers have pointed out that learners do not readily give up their preconceptions even in the face of "hard evidence."

Ms. B: So, when it was colder (in the room) the red thing went down? (Yes.) When you went outside, was it hotter or colder?

Mona: Um…it was hotter with a little bit cool.

Ms. B: And the red thing did what?

Mona: It went up.

Ms. B: Okay. So before we did the experiment, you made a prediction about what was going to happen. Now do you know what happens when it's hot? Does the red thing go up or down?

Mona: Up.

Ms. B: And when it's cold?

Mona: It go down.

For the moment at least, it appeared that Mona understood what happened to the alcohol in a thermometer as the temperature increased or decreased.

Mona's Record of the Temperature Experiment

In addition to interviewing Mona, I also had her draw a picture to show where rain came from. I wanted to have a written record of her initial ideas for comparison at the end of the unit. Having solicited Mona's ideas on rain, I wanted to find out if her classmates shared similar ideas about rain.

The next day, I engaged the entire class in a conversation about where rain came from. As we were discussing their ideas and stories they had heard, I was amazed at how serious they were with their ideas. I did not have a hard time soliciting ideas from the children. All ideas were respected.

The following is a list of some of the children's ideas on where rain comes from:

- Maybe God have water then fills the sky, and then it comes down.
- Maybe God was drinking a glass of water, and it fell.
- I think God was taking a bath.
- God was crying.

- When people die, God cries...that makes rain.
- God is washing his hand...rain starts to fall.
- Mary, Jesus' mother, is crying.
- Someone has a stick that has power, and they use it to make rain.
- Angels put lots of water in clouds, and it falls down.
- Clouds get full, can't take no more, the water falls down.

Obviously, Mona was not alone—many of the children's ideas were "unscientific." Having identified some of the ideas about rain held by the students, the next step was to get the children to realize and accept that their ideas were either incorrect or incomplete. At this juncture, Miller, Steiner, and Larson (1996) recommend the presentation or demonstration of a discrepant event. To this end, I read two stories to them. The first was *Bringing the Rain to Kapiti Plain* by Verna Aardema (1981). It is an African folk tale about a boy who shoots an arrow through the clouds to make it rain. When asked whether they thought this was a true story—if it could really happen—the response was mixed. Some of the children insisted that it was make believe because "you can't shoot a hole in the cloud to make it rain." Others felt that maybe it could happen. This was Mona's reaction:

> Maybe, maybe it could happen. Maybe you (pointing to me) could...shoot...how you call it...the thing in the cloud and it could rain, I think.

This response was not surprising given the alternative conceptions that had previously been voiced. What is more, young children generally have a difficult time distinguishing between fantasy and reality. I also read to the class Judi Barrett's (1978) *Cloudy with a Chance of Meatballs*. It is a story about a town, Chewandswallow, where the weather comes three times a day—breakfast, lunch, and dinner. During these times, food fell from the sky. The response to this story was more decisive—it was definitely make believe. As Mona put it, "It can't come food from the sky!"

The important thing was that they were beginning to reflect on the difference between things that could or could not happen, given their life experiences. This reflection would hopefully carry over to an analysis of their own ideas.

In addition to multiple copies of *Bringing the Rain to Kapiti Plain*, I had secured a collection of fiction and nonfiction books from the school library that I made available for the children to look at and read at their leisure. We also read and discussed a few of these together. Over the next three weeks, several hands-on activities were conducted in the classroom. Included were activities through which we investigated the presence of water in the air, evaporation, temperature, and cloud formation. We also created our own water cycles. The weather was very cooperative during this time, and it rained on several occasions! On the first day it rained, we were in the middle of a reading lesson. We stopped what we were doing and went for a walk (under cover). Upon our return to the classroom, a lively discussion ensued as we talked about what they had seen and heard.

Activity: Water in the Air

The original purpose of this activity was to discover what happens to water in the air when the air cools. It also became an investigation/verification of the actual presence of water in the air

The children were first asked to predict what they thought would happen to the outside of a glass that was filled with water and ice cubes. They wrote their predictions on a record sheet. The following was Mona's prediction:

> I thing bate is get ments. (She thinks the ice is going to melt.)

Knowing that there were some who understood very little English, in addition to giving step by step directives, I also demonstrated each step using the actual materials. The groups were also arranged so that a peer translator was available for help. Previous research in this field (see for example, Fathman, Quinn & Kessler, 1992) has indicated that being able to discuss ideas in the home language is an aid to learning for LEP students. At several sites in the classroom, we filled a glass jar half full of water, added two drops of blue coloring and stirred. Enough ice to fill the jar was then added. We were careful to avoid spills, having established at the onset that the outside of the jars were dry.

The first thing the children noticed was that the jars were colder. Mona said it was because of the ice and that the water looked like the ocean. Several others agreed. They watched in amazement as droplets began to form on the outside of the jars. Their conversations indicated that they were trying to decide where the water was coming from. As I walked by Mona's group, I engaged her in the following conversation.

Ms. B: Where do you think the water is coming from?

Mona: From inside.

Ms. B: Did any of your water spill over the sides?

Mona: Um…no.

Ms. B: So how did the water from inside get on the outside?

Mona: Oh…maybe it come through the glass?

Ms. B: Does the glass have holes in it?

Mona: Um…no…

Ms. B: So how did the water get out?

Mona: Um…I don't know.

At this point she still seemed to think the water had to have come from inside. I needed to get her to see that it could not have come from inside the jar.

Ms. B: What color is the water inside the jar?

Mona: Blue.

Ms. B: What color are the droplets on the outside?

Mona: White.

Ms. B: Are they white or clear? Clear means you can see through them and they have no color.

Mona: They are clear.

Ms. B: So if the water came from inside, what color do you think the droplets out here should be?

Mona: Oh, blue.

To verify I dipped a white paper napkin into the water and it turned a light blue. Then I wiped the outside of the jar with another napkin and it stayed white.

Mona: Maybe it come from the air?

Ms. B: What do you mean?

Mona: I don't know.

Ms. B: Were you guessing, or do you mean you can't explain?

Mona: Guessing.

Ms. B: Well, that was a good guess.

I then went on to explain that water in the form of gas is always in the air and is called water vapor. When the air around the glass cooled, the water vapor turned into a liquid on the side of the glass. Clouds form when air cools and water vapor turns into liquid droplets. Billions of water droplets make a cloud. I then asked Mona (and the others) to write down what she thought happened when the water droplets become so heavy that they cannot float in air. This is what she wrote:

> They fudad on the grs. (They fall down on the grass.)

This and subsequent conversations with Mona allowed me to see the importance of verifying that children had indeed drawn sound conclusions based on the evidence before them.

Activity: What is Rain?

In this activity we created a simple water cycle. We took four jars and put equal amounts of blue-colored water into them. We used a funnel to avoid wetting the walls of the jars. Activity sheets were distributed, and after carefully observing the contents of the jars, the students completed their first observation. The fact that the walls of the jars were dry was emphasized. We then took the jars outside, placed them on a sunny window ledge (away from pedestrian traffic), and asked the teacher in that room to keep an eye on them for us. An hour later, after having been warmed by the sun, the children examined the jars again and completed a second observation.

The following is a transcript of Mona's spoken observations:

Mona: There is water on the walls. They were…not there before.

Ms. B: Where do you think those droplets came from?

Mona: From the air around got on it.

Ms. B: Feel outside the jar. (I wanted her to see that the droplets were inside the jar.)

Mona: Oh…it's dry…I think of something. Maybe when you…close it, it got air inside.

These comments seemed to indicate that she was trying to tie in the information she had gleaned from the water vapor activity to help make sense of this new phenomenon. One of the students suggested that maybe the air tried to evaporate and it got stuck. Mona's curiosity was apparently piqued by this suggestion:

Mona: Ms. Britton, I have a idea. Maybe we can do a experiment and take the cover off one and put them back outside.

Many of her classmates thought this was a good idea. This was not a part of my plans but this was of interest to them and helping them was, after all, the purpose of this study. I must confess, I was also curious about what she was thinking.

Ms. B: Okay. What do you think is going to happen?

Mona: It's going to evaporate?

Ms. B: What do you mean?

Mona: The air is going to go out and the water is going out?

Ms. B: Why don't we do what you suggested and see what happens?

I took one of the covers off and put the jars back outside. Later on that day we recovered them and made observations. More droplets had accumulated on the walls of three of the jars. Several of the children likened the formation of droplets to sweating and crying. As for the fourth opened jar:

Mona: The walls are dry. The air went out.

Ms. B: What happened to the droplets?

Mona: It evaporated?

Unfortunately, it was the end of the day and dismissal was upon us. Our conversation had to be postponed until the next day. Ideally, we should have left the jars outside until the next day. However, to prevent tampering, we brought them back inside. The following morning, we put them back out for a few hours. Later that day we recovered them and discussed what had happened.

Ms. B: What happened to the opened jar?

Mona: Is not the same as them. (She points to other jars.)

Ms. B: What is different?

Mona: The water is not the same.

Ms. B: What happened to the water?

Mona: It…it…turn like air…then it um…it go up up.

Classmate: It evaporated.

Mona: Yeah, yeah. (She smiles.)

What followed was a discussion of the earth's water cycle. We then compared our water cycles to the earths' water cycle. As I mentioned earlier, it rained several times during the implementation of this unit. As a result, the children had an opportunity to observe the water cycle in motion. After one particular downfall, we went out to the physical education (PE) court, marked puddles with chalk, and followed their progress throughout the day (PE was held indoors due to the wetness).

The end of the unit coincided with the school's spring break. I decided to wait until we returned to school to ask the children to again draw pictures to show why it rained. This was not an arbitrary decision. I had hoped that the interim would give them a chance to reflect upon the ideas we had discussed. After their return to school, I found that their responses varied. Some of the pictures were almost exactly the same, including the ones who had drawn angels above the clouds pouring water down. There were also a few who had incorporated some notion of the water cycle into their drawings. Mona's was one of these. Before discussing the pictures with the whole class, I had taken the opportunity to ask Mona to explain hers to me. This was her response:

> When there's an ocean or river or something, maybe water evaporates, it gets up. When it evaporates it turn like…air…how you call it? (Gas.) Yeah, it turn like gas, then it go up and up. When it get the clouds they say come here. Water drops get together, and when they get too full the water falls down.

In her explanation she used all of the key terms and her drawing was an accurate representation of her explanation. It would appear that she had a good grasp of

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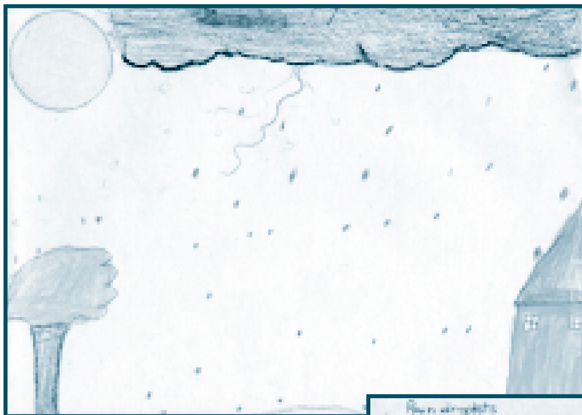
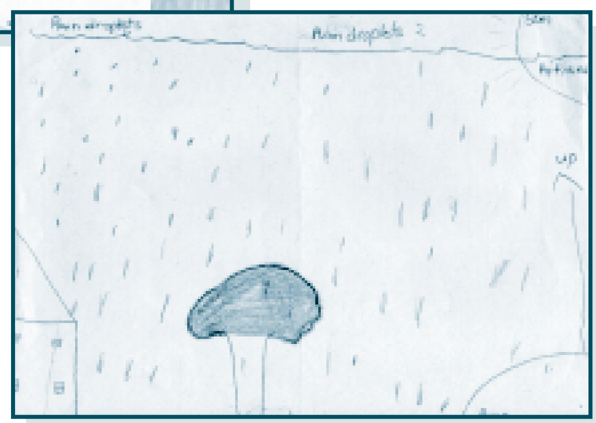
the scientific reasoning behind the phenomenon of "rain." Upon closer inspection, however, one notes the use of the word "maybe" as she explained the evaporation process. While willing to construct and offer official explanations, she was apparently still trying to reconcile the viability of those ideas against her own beliefs about the causes of rain. Only time would tell whether or not she would choose to integrate these new ideas into her existing constructions.



Mona's picture at the beginning of the unit



Mona's picture at the end of the unit

Reflection

As the research unfolded, I noticed that, in addition to Mona, the other children had become more aware of their surroundings. At least they had become more verbal and willing to express their ideas about the things that were going on around them. In the mornings, students would come to me with news about what the "news people" had to say about the weather or their own predictions based on observation. On our way to lunch, they would try to figure out what kinds of clouds were in the sky. They also appeared to be listening more closely to each other as evidenced by their questioning of each other and their commentaries on observations voiced by their peers.

Children come to school not with clean "mental slates," but with prior knowledge and experiences that affect how and what they will learn. Providing them with opportunities to express their thoughts acknowledges and gives credence to their abilities and ideas. In seeking the alternative constructions that students may hold, the teacher can gain valuable insights. These insights can be used to create a forum where children can change—or at least build upon—their existing ideas. ◆

CHAPTER TWO

Middle School Students' Perspectives on Collaborative Learning, Group Size, and Conceptual Change

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Abstract

Middle school students value the opportunity to participate in collaborative learning groups. In the students' opinion, greater learning is accomplished when they have the freedom to share and discuss concepts with a peer. This study suggests that a group size of four is preferable to a group size of two. The larger group allows for greater interaction between members and assists the incorporation of lower-achieving students into the learning process. Greater concept reconstruction is accomplished in a collaborative group of four as opposed to a group of two. The size of collaborative groups has an effect on the extent of conceptual change of science ideas that occurs within the middle school student. Practicing science teachers might enhance the middle school classroom learning environment by utilizing a quad grouping arrangement for collaborative activities.

Background and Theoretical Rationale

Research in science education has focused on science teachers' beliefs about knowledge acquisition and teaching styles (Hashweh, 1996), yet few of these studies have been conducted by practicing science teachers. Individuals removed from the realities of the classroom conduct the majority of research in science education. The perceived separation of the researcher from the actual classroom may diminish the significance of the findings for the practicing teacher. It is easy to discount a researcher's findings citing the inapplicability of the research situation to the practicing teacher's situation; it is the practicing teacher's classroom that serves today's students as the formal domain for the learning of science. The teaching methodologies and epistemological beliefs of these practicing science teachers have a strong influence on the effectiveness and quality of learning taking place in the classroom (Pajares, 1992; Tobin, 1998a). This paper is the result of a practicing science teacher's research that explored collaborative group size and conceptual change of middle school students.

The operational theoretical framework for this paper contends that conceptual change is the foundation of science learning. Students possess previously constructed perspectives about the interrelationships between themselves, their environment, and school science. These previously constructed perspectives

Early adolescents relish opportunities to interact with their peers and to enhance their understandings of academic material (Hicks, 1997). Conceptual change occurs through discussion and debate among peers.

provide the framework for the students' connections to school science. It is the avocation of the teacher to encourage and challenge students to evaluate their personal constructions in relationship to canonical science. The teacher is to create meaningful experiences for the students to assist their conceptual changes. Lonning (1993) summarized this dilemma of a practicing science teacher:

> …teachers now have a greater power in understanding how their students learn new concepts; they also realize how much more difficult the task of meaningful learning is (p. 1097).

This is echoed by Basili and Sanford's (1991) statement that educators need to design instruction to effectively promote conceptual change in students.

Conceptual change does not occur through the solitary pursuit of a subject, particularly for the middle school student. Developmentally, middle school students as early adolescents begin to value peer relationships (Hicks, 1997), which encourage academic attainment (Patrick, Hicks & Ryan, 1997). Early adolescents relish opportunities to interact with their peers and to enhance their understandings of academic material (Hicks, 1997). Conceptual change occurs through discussion and debate among peers. The social interactions provide a medium in which concept redevelopment can be accomplished. Roth and Lucas (1997) contend that meaningful learning occurs when a student's perspectives and the enacted curriculum are parallel. Discourse among early adolescent peers augments the meaningfulness of learning. If, as Erickson (1998) expounds, qualitative research should be focused on the everyday social interactions that may exist to alter students' conceptualizations of topics, then it is relevant to focus on the size of a collaborative group and associated learning of the involved students. The size of a collaborative group may be considered an insignificant component of the learning environment, yet this small decision in instructional planning has many ramifications. Size may promote or limit the extent to which conceptual change occurs.

Collaborative learning groups provide many opportunities for a gathering of students to challenge and adjust prior conceptualizations about science. Lundeberg and Moch (1995) reported that collaborative groups were highly successful in resolving students' alternative conceptions and found greater verbal interactions focusing on the "why" of a phenomenon as opposed to the "what." Peer collaboration can assist students to surmount previous alternative conceptualizations and accommodate current canonical science views (Lumpe, 1995). Lonning (1993) reports in his research that conceptual change of low-achieving high school students was enhanced through collaborative grouping. These student-student interactions were beneficial and valued by the students as a means of learning. Jacob, Rottenberg, Patrick, and Wheeler (1996) delineate the language acquisition benefits of collaborative groupings for students designated as limited English proficient (LEP). In addition to learning academic language, the LEP students were socially included in the classroom through these group interactions.

If learning science is to be viewed as an enculturation (Tobin, 1998a; Alexopoulou & Driver, 1996) into the meanings of scientific phenomena as accepted by the scientific community, then this occurs best through peer interactions. Students are given opportunities through peer interactions to negotiate, defend, and redefine their conceptualizations about a science topic. Basili and Sanford (1991) refer to the absences of the authority figure in these small-group settings as the factor that allows the students freedom to discuss and explore different viewpoints without fear of punitive reprisals. These small groups provide a haven for discourse to proceed. It is as if these groups are incubators for imagination and mental exercise: allowing students opportunities to struggle with conflicting information. These discursive struggles within collaborative groups are the seeds for learning (Tobin, McRobbie & Anderson, 1997). Basili and Sanford (1991) suggest that science instruction include direct instruction by a knowledgeable source and very active participation and conceptual restructuring by the student. Research by Lumpe (1995) validates this perspective that peer interaction assists students in learning higher-level concepts. Jones and Carter (1994) reiterate that higher cognitive functions are the result of inter-psychological processes. These small group interchanges assist the student to move to a higher individual cognitive level.

The quality of the peer discourse and the subsequent acceptance of alternative conceptual frameworks are impacted by the social perceptions of the students. Social motivation and social goals are a main focus of early adolescent students (Hicks, 1997). This is quite evident in the middle school student who is searching for identity and peer acceptance. The quality of interactions is dependent on the group dynamics and the perception of the group about its collective ability and the abilities of individuals in the group (Alexopoulou & Driver, 1996; Cohen, 1990). These perceptions can even result in the regression of conceptual development through the persuasive arguing of a perceived more powerful peer in the group.

The size of groups for collaborative interactions has been investigated, but with conflicting results. Jones and Carter (1994) report the effectiveness of dyad grouping, while Alexopoulou and Driver (1996) refute this idea with their research on group size. Their research suggests that students prefer—and that conceptual change occurs more often in—collaborative groups of four students. Lumpe (1995) chose triads with whom to conduct research on conceptual change, yet did not offer a rationale for a group size of three.

The purpose of this study was to identify the students' perceptions of appropriate size for collaborative learning groups and their ideas about collaborative group work. Another aim of this study was to investigate whether the size of a collaborative group influenced the extent of learning concerning the formation and occurrence of earthquakes.

Students' Conceptual Knowledge of Earthquakes

Students' knowledge about earthquakes is rooted in alternative constructions begun in early childhood through the viewing of these natural disasters on television and other media. These alternative constructions persist even after direct instruction. One common alternative construction of upper elementary school students is the correlation between earthquakes and volcanoes (Ross & Shuell, 1993).

Students seem to equate the activity of earthquakes and volcanoes as occurring simultaneously. In their study, Ross and Shuell (1993) report that few students could identify the underlying causes of earthquakes and relate their occurrence to plate tectonics. It is difficult to alter students' prior constructions, particularly when the terminology, or semantics, for describing a phenomenon do not exist. There is, in this situation, a lack of shared language. Additionally, Ross and Shuell (1993) hint at the possibility that different groups in their study had different responses relative to the geographic locales of the schools involved in the research. The students in Utah were much more likely to report a connection between volcanoes than were their New York cohorts. In Miami, many of the students could not relate to the concepts of volcanoes, earthquakes, or even mountain formation due to the unique terrain of south Florida. A lack of appreciation for geographic diversity is a challenge when presenting earth science concepts. On the other hand, the rich cultural diversity of some students who had lived through earthquakes in Colombia and Mexico provided their peers with unique and different perspectives.

Data Collection

The physical constraints of the classroom in which this study was conducted predetermined the size of the student collaborative groups. Eight students sat on each side of a long laboratory table. These tables were divided into student work and storage areas. A two-person workstation was separated from the next workstation by under-the-counter cabinets. A group of four students—two on each side of the table—formed naturally as a result of the design of the table. This pattern existed for all workstations, except for the first and last positions where single workstations existed opposite each other. Since the workstations were extremely cramped, the students were in close physical contact with their laboratory partner. This proximity of another middle school student increased the opportunities for collaboration. Beyond default and acquiescence to the peculiar physical layout of the room, collaborative grouping is an integral component of my epistemology.

The students who participated in the study were 12- to 13-year-old seventh graders in an urban middle school in Miami. The ethnic backgrounds of the students were African-American or Hispanic. The class that participated in the study was considered "regular" with a wide mixture of abilities and attitudes. Four groups were identified: two dyads and two quads. The students had been working together in that particular collaborative group for four weeks prior to the beginning of the study. Criteria that were used to form the groups earlier in the semester were based on academic ability and gender. The groups were gender specific but had mixed academic abilities. Single-sex groups were used so as to allow the females opportunities to be actively involved in the manipulative activities. One dyad and quad grouping was entirely female, while the other dyad and quad grouping was entirely male. Many of the students wanted to participate in the study and were eager to give their opinions. The students were informed at the beginning of the purpose of the study and were given the choice to participate or not participate according to their individual inclinations.

Collaborative group work is a common activity in my classroom, and the students are encouraged to share, assist, and argue within their group. This method of instruction is not common among the other teachers that comprise the team of teachers for the seventh grade. Indeed, science is the only core class where students are actively engaged in peer discussion and interactions. As one student stated, "Science is the only class in which we get to laugh and argue with each other."

During the data collection stage of the project, students' ideas about the formation of earthquakes were elicited through large- and small-group discussion and journal entries patterned after the study conducted by Ross and Shuell (1993). The questions were: "What is an earthquake?" and "What causes an earthquake?" All responses were accepted. Direct instruction about earthquakes followed the elicitation process and the students were then asked to describe their concepts after the formal instruction. Data were collected through teacher journal entries, student written work, and audiotapes of group interactions. All of the audiotapes were transcribed and analyzed relative to the concepts presented and the social interaction between group members.

Analysis of the Students' Conceptual Knowledge about Earthquakes

Initially, when asked for the definition of an earthquake, the students were able to identify that it was a movement in the Earth. In one group, the idea of the crust was mentioned, but not fully upheld by all the group members. In response to the second question concerning the causes of earthquakes, the majority of the group members replied "volcanoes," and one group vehemently stated that both of these events occurred simultaneously.

One group tentatively ventured the concept of plate tectonics because of a recent viewing of a *Bill Nye, The Science Guy* television program about the subject, but many other members in the class did not support this idea. At the conclusion of the elicitation, the groups had decided that earthquakes and volcanoes occur at the same time and that the cause of earthquakes was volcanic activity. As the response to the elicitation varied between small and large group discussions depending on the need to validate their alternative conceptualizations, there was little difference noted between the different groups involved in the study.

After direct instruction involving readings, manipulatives, and video and laserdisc presentations, the groups were asked to review and clarify their initial responses. These responses were analyzed for their science reasoning and their social interactions. The two groups of two made little progress in conceptual redevelopment about earthquakes. In both dyads, there was a lack of understanding about the concept. Some transcribed responses from the dyads included:

> T: Come on, let's get this done. Earthquakes are caused by plate tectonics or something like that. Now I know, it is the movement of the earth's plates that causes earthquakes or is it faults? I can't remember…
>
> Ch: Whatever. I think it is the plates, but it could be the faults.
>
> T: Let's choose something so we can go on to the next question....It's the plate acting up that makes earthquakes. She (the teacher) said something like that.
>
> Ch: You know best.

An assertive member, T, whose main goal is to complete the material without giving full attention to the concept, dominates this dyad group. The student T wants to complete the required activity to be able to say "I'm finished" without making any alterations or adjustments in his conceptual framework. Being done is more important than mulling over a difficult question. On the other hand, Ch is a timid group member who struggles to understand the concepts but does not perceive himself to be an equal with his partner. Ch wants to speculate about the question at hand but is hindered by his passivity and perceptions of inequality. This dyad does not function well and is limited to the students' constructions of alternative thoughts about the concept being studied.

From another dyad's perspective:

> C: I think earthquakes are caused by volcanoes and those plates.
>
> De: Well, that could be it. I don't remember.

C: It is something to do with that.

De: It is good enough for me.

C: (deep sigh) Can you remember anything about this?

De: Whatever.

It is evident in this interchange that De is unwilling and unable to confront her partner with any information. De does not want to be wrong, so she does not comment in any manner about the topic. To her, no comment is better than the wrong comment; safety exists in being neutral. Synergy and discourse does not exist in this dyad either. In neither dyad did any of the group members alter their previous conceptions about earthquakes. A collaborative community did not exist. These students were engaged in a sterile interchange. Needless to say, both groups desired to work with other students in the class.

On the other hand, in quad groupings, students were able to explore the issue more and try to reach a consensus. An excerpt from a transcription illustrates this point:

M: I think that earthquakes are caused by plates moving, colliding together underground.

K: The movement is underground.

D: The plates break, and that is what causes volcanoes.

J: It is the colliding together of the plates.

K: The shifting of the ground or plates that cause earthquakes.

The students were able to reach a consensus, even if one member's conceptualization of the interactions of plates and volcanoes was inaccurate. The students J, K, and M continue with their discussion even after the interjection of student D's thoughts. Throughout their interactions, D listens intently and contributes rarely and inaccurately. The other group members acknowledge her statements but do not assimilate them into their own constructions. D's social position in the group is to be the "sponge": she listens and absorbs the information from the other members who enjoy discussing the science concept. As this is a quad grouping, the student D has opportunities to be a member of a discourse community that is involved in concept redevelopment.

The interplay among all four members and the negotiation of the appropriate response was far greater than exhibited in the dyads. One of the students in a dyad continued to believe her misconceptions that were evident in the elicitation phase. Direct instruction and group work had not altered her concept of the relationship between volcanoes and earthquakes. Ross and Shuell (1993) also note this observation with the remark that classroom instruction in a topic does not necessarily lead to a reduction in students' alternative constructions. It is evident in the transcriptions that the students had acquired some of the canonical science language, yet were unable to fully conceptualize these words. The abstraction and differentiation of faults and plates were fuzzy in their minds. Even though plate tectonics and continental drift were introduced prior to the earthquake topic, it was evident that the students were having a difficult time with these abstract concepts. The quad groups had more opportunities than the dyads to elaborate and confer with other peers about the topic. The dyads did not provide enough diverse peer interactions and thus little concept redevelopment occurred. In addition to the lack of concept redevelopment in the dyads, there was a marked lack of progression in negotiation skills.

Negotiation within Group Settings

The students' abilities to negotiate answers in the group setting greatly related to the groups' respective abilities to reach a higher level of cognition about the topic. The dyads tended to have a dominant and a passive member. In both groups, the dominant member held erroneous thoughts but was not confronted by the other group member. The reluctant peer allowed the discussion to end without raising any objections. On the other hand, in quad groupings, students were able to negotiate and clarify statements by some of the members to reach a consensus. The following transcription of a quad group's discussion on the appropriate emergency action to take in the event of an earthquake illustrates this principle:

K: If there is an earthquake, you go under a table.

D: …or another safe place such as a desk.

J: …or an open area.

K: Yes, or under the doorframe.

D: …or find inside a closet in your house.

K: …or go outside if you have time.

J: No, no that is not it.

K: Oh, yes, or everything drops on you, and that's not very safe.

J: No, the entire building will fall on you.

K: Well, if the door is right next to you, and there is ground just over there, then you need to go out.

M: No, the tree will fall on you and everything else, so you might as well get under your desk.

D: …or a table or a bed.

J: No. If you go under the bed, then the bed is going to fall on you, and you are going to die.

M: You might as well get under the table.

J: Yeah.

K: Oh, well.

M: You must try to get into a safe place as quickly as possible.

J and K: O.K.

In several interchanges the students were able to negotiate and clarify their ideas about the appropriate response to an earthquake. Even though one of the members of the group wanted to close the conversation, another refused and continued to challenge that student's response. The community would not allow the student to give up and pretend to accept the explanation. The other group members demanded further exploration of the topic. The group felt K's discomfort and refused to allow her to accept the response that was alternative to her own construction. The community encouraged K to struggle with the concept.

In addition, the groups did not allow the remarks by student D about the bed to go unnoticed. Even if student D contributed erroneous responses, her remarks were heard and discussed. All remarks were valid in their discussion community. All objections were considered and negotiation between the group members continued until everyone agreed.

This group was extremely capable of negotiating and viewed group work as a collaborative experience. Even though student D contributed little (and when she did it was incorrect as evidenced by her remarks about the bed), she remained as part of the community. Student D made some progress in her concepts of earthquakes and her emerging ideas due to the nature of this collaborative group work. Since this group had worked together for a month, there was a tendency for them to finish each other's spoken thoughts. The group had reached a comfort level that enabled them to work collaboratively. The interrelationships of this group and their joint effort at problem solving became a positive factor. They were able to use disagreements and subsequent resolutions to increase their knowledge. Even though the quads had more perspectives to incorporate into their discussions, these discussions were more constructive for concept development. The dyads, as opposed to the quads, did not have enough learner diversity to support this constructive element of concept development. Alexopoulou and Driver (1996) conclude that a quad group size is able to diffuse social interaction problems and negotiate a meaning or conceptualization of a science topic.

Students' Perceptions of Group Size Efficacy

The students' conceptual development was enhanced in a quad group as opposed to a dyad. Alexopoulou and Driver (1996) report that a pair grouping is too socially constrained to be effective in modifying alternative constructions. The dyad grouping gives the reluctant or hesitant student no support or encouragement to explore new ideas, while the larger group size of four gives the students support to question themselves and others about their perspectives.

When questioned about the appropriate and desirable group size for science, the students unanimously selected groups of four. The pairs in the class expressed their overwhelming desire to be connected to a larger group. These two transcriptions indicate their frustration at the perceived injustice of working in pairs:

C: I like group work, but we need more people.

De: Yeah, two people is too small.

C: Both of us don't know what we are doing. We need more help. Why can't we be in a group of four like the rest of the class? It isn't fair.

De: Yeah. We need a bigger group.

As in previous transcriptions, student De was a reluctant member of a dyad group and needed the added support provided by the larger group. Her shyness, quietness, and non-confrontational stance did not help this group of two to function well. This group usually joined a neighboring group of four in order to be able to complete the assignments. There was not enough social interaction in their dyad to support intellectual growth; a stale learning environment was the result. In another dyad a similar pattern existed:

T: I don't like working in groups of two. It is too small. There are not enough people to help.

Ch: We need more people in our group. We shouldn't have to be the only group that works with one other person. It is not fair.

T: They are so lucky to have four people because they get to hear more ideas and get more right answers.

Ch: They are super lucky because if you don't like your partner, there is someone else to help in the group. Two just doesn't work.

T: I like group work so I can learn the right stuff but only if the group is the right size: four.

Ch: Yeah, group work helps, but we need a bigger group.

Students T and Ch did not enjoy working together because of their very diverse learning styles. Student T was a detail-oriented person whose goal was the end product, while student Ch was a global thinker who was always pondering the meaning of a topic. These two learning styles did not mesh well together. The students were cordial to each other but did not have the ease or comfort in negotiating disagreements about science concepts. It was easier for one to acquiesce than to express a disagreement or confusion about a response.

Both dyads sought out additional support from larger groups and were envious of them. The lack of social support in such a small group was detrimental to their concept development. The students wanted a larger group in which to explore new ideas and increase negotiation with additional parties involved in the process. In some instances, the styles of the learners were too diverse for them to be able to bridge the gap. In a group of four, there was more likelihood for compatible learners to support each other.

Perspectives of the quad groups on group size were found to correlate with those of the dyads: four was better than two or any other group size. The following transcription illustrates this point:

J: I think group work is better because four heads are better than one.

O: You have more of a chance to learn something because there are more people to explain the directions or the answers.

J: Two is too small. What if both of you don't get it? At least with four, somebody should be able to figure it out.

R: There are more people to share their ideas with you. You can get it not like when you are by yourself trying to do it (the class work).

O: It is boring to work by yourself. The class seems so long on the days we have to work alone.

J: Yeah, group work makes the class go fast.

R: I think four is the perfect size because you can share ideas and people can help you.

As in student J's apt descriptions of the benefits of a large group size, one member should be able to guide the group or moderate the group's progress. Since these transcriptions are from seventh graders, these students are primarily concerned with being able to complete the class work and complete it as quickly as possible. Group work was seen as beneficial in completing the required school work as there were people to assist in interpreting and re-explaining the directions. The group provided a means for the students to complete their assignments and to make connections from their personal frameworks to school science. The students received reinforcement from their peers that their conceptualizations were proceeding in the perceived correct direction. It is through these interactions that the students shared their constructions and could acquire quick feedback on their perspectives.

Another group of four had the following discussion:

Teacher researcher: Do you like to work in groups of two, four, or some other size?

J: Four

M: Four. Like now we are working in groups of four, and it is very fun to work together, and you get more ideas and stuff.

K: We put our ideas together.

D: And we get more answers right, and we finish quicker.

K: It is more fun.

J: I agree.

M: I think working in four. It helps you improve in your work, and if one person doesn't want to read something, another person can read it and help find the answers and tell you if they [the answers] are right, and they make everything work faster, and it's great.

J: You can work together during group work.

M: And you can get more of the answers to make one big idea.

D: It is good. We get more ideas in our head.

K: As individuals it takes longer, and it is boring.

D: Because you don't have any ideas.

K: You need help, and sometimes people won't help you.

M: Yeah, but in a group, you get help.

J: You don't have to call on the teacher for help. You have three other people who can explain it to you.

D: You don't have to ask the whole class, and they will think you're dumb or anything. You don't learn anything working by yourself.

M: You get more ideas from the group.

Student D, who struggled with her schoolwork and had an emerging conceptual level of science topics, addressed the notion of being able to seek support in a small group so as not to appear "dumb" to the entire class. It was evident in her comments to perceive the difficulties she encountered in reading and reasoning and her glad acceptance of being able to engage in the peer tutoring that occurred in her collaborative group. On the other hand, students M and K, who function at a higher conceptual level, focused on the concept of sharing ideas and building bridges from their individual concepts to the canonical science concepts. These students enjoyed the discussions that centered on their perspective of a topic. Student J was very pragmatic, and her comments about utilizing peers for assistance reflected her personality. Even though this group consisted of students with different learning styles and personalities, an equilibrium could be reached and the students could explore new ideas and negotiate misunderstandings with ease. The lower-level student felt accepted and could express her thoughts without reprisal, while the higher-level students had opportunities to be engaged in warm-up activities. The dynamics of the quad grouping provided more opportunity for student interaction to occur as opposed to monologues by one member in a dyad grouping.

Implications and Actions

After verifying the students' remarks and beliefs about group size, the two dyads were grouped together to form a quad. Physically, the group was separated because of the configuration of the laboratory tables, but the group gathered together around one area. There was little concern given by the students to the limited elbowroom. The benefits of being in a larger group outweighed the elbowroom concerns.

The dialogue by the students about the optimal group size being four rather than two was substantiated by the conceptual growth in the quad groups as opposed to that in the dyads. Limited social interactions, insecurity, and passivity of some of the students were more evident in the dyads than in the groups of four. Middle school students have preconceived ideas about their scholarly progress and acceptance by their peers, which hinder their ability to work in some small groups. A community of four students allows the passive or the perceived slow learner to be in a larger discourse community that can enhance their learning. Group discussions and negotiations proceed in a more scholarly direction in the larger groups of four than in the dyads. The dyads' discussion (or lack of discussion) were colored by the social identities of the partners; whereas, students in the quads were much more likely to engage in conceptual discussions.

The results of the students' discussions were shared with the other teachers on the team. This discussion by the teachers resulted in additional collaborative learning opportunities across the team. One teacher implemented a group project following our discourse, which was a change from her normal style of teaching. She reported that the students were highly receptive to this different style of learning. In addition, she (the team teacher) observed that the students had increased motivation and desire to accomplish the learning activities.

Further ideas that I would like to explore as a practicing science teacher are the students' ideas related to the gender composition of cooperative groups and their relationships with the ensuing discussion and learning. I would also like to explore the conceptual learning of middle school students and compare different stages of conceptual growth with alternative teaching strategies utilized in the classroom. Practicing middle school science teachers have disseminated very little research on the science learning of this age group of students. ◆

CHAPTER THREE

Does Teaching Science to Limited English Proficient Students through Cooperative Learning and Hands-On Activities Increase Language Proficiency?

Rose L. Bagley
Joella C. Good Elementary School

Rose L. Bagley has been a Dade County elementary school teacher since 1981. Previously she was an elementary school teacher with the Archdiocese of Miami from 1973-1981. She holds an A.A. degree in Bilingual-Bicultural Education from Miami Dade Community College, a Bachelor's degree in Elementary Education from St. Thomas University, and a Master's degree in Reading K-12 from Barry University. She is a member of several professional associations, as well as an active member of both her community and church.

Abstract

This research study was conducted with a group of limited English proficient (LEP) first grade students. For a period of four consecutive weeks, the target group was involved in cooperative learning strategies and hands-on activities using magnets. A non-target (control) group was given science instruction using a traditional method of lecture and recitation. The objective of the study was to demonstrate that after four weeks of science instruction incorporating cooperative learning strategies and hands-on activities, 80% of selected LEP students would increase their language proficiency by 10%, while 20% would increase their scores by 5%. The participants were also expected to increase their critical thinking skills by 20% while participating in weekly student hands-on activities. To measure the increase of each student's science language acquisition, the evaluation process involved administering a pre-test at the beginning of the four-week period and using this same evaluative instrument for the post-test. A checklist also was used to evaluate the development of the following science process skills: predicting, classifying, observing, communicating, experimenting, comparing, and inferring. Based on differences in pre-test and post-test scores, the findings of the study demonstrate an increase in science language proficiency of at least 10%. As a group, an increase of more than 50% from the first to the fourth week was demonstrated in student critical thinking skills.

Purpose of the Study

According to Chamot and O'Malley (1993), research and experience have demonstrated that the classroom organization strategy most effective for teaching science to students with LEP is cooperative learning. This pedagogical strategy fosters language development through inter-student communication both verbally and possibly in written form for all levels of language proficiency. Therefore, the purpose of this study was to explore whether the use of cooperative learning and hands-on experiences with one group of LEP students would foster an improvement in language proficiency and critical thinking skills when compared to another group of LEP students receiving instruction using the more traditional methods of teaching science (i.e., by lecture and recitation).

Background

This study was undertaken in the spring of 1997 in the setting of my first grade classroom. The K-5 school where I am presently employed serves a mainly middle class suburban neighborhood and also houses a Montessori magnet program and an in-house gifted program. A large number of parents belong to the PTA (Parent-Teachers Association) and have always been very supportive of the teachers and of school functions.

In 1996-1997, the student population of the school during the time in which this study was conducted was 1,580. Male students constituted 53% and female students constituted 47% of the student population, respectively. In terms of students' ethnic backgrounds, 52% were Black non-Hispanic, 18% were White non-Hispanic, 27% were Hispanic, and 3% were Asian/American Indian. Of this population, 178 students were receiving English for Speakers of Other Languages (ESOL) instruction, giving a total LEP population of approximately 11%. The school staff was composed of three administrators, 74 classroom teachers, two Exceptional/Special Education teachers, two counselors, two media specialists, and one speech pathologist.

According to 1995-96 data (Dade County Public Schools, 1997), the *Stanford Achievement Test* (SAT) results of our school in reading, writing, mathematics, and science showed that the median score in mathematics application skills at all grade levels (64.4%) was higher than the national average and also higher than medians reported for the district (52.4%) and region (51.6%). In reading comprehension, the school medians in all grades were higher than those for the district and region. School medians in grades 1 and 2 (52.8%) were higher than the national average (40.2%) and also higher than the median reported for the district (36.6%). In science, the school medians for grades 3 and 5 were also higher than those for the district and region. The median in grade 5 (50%) was higher than the national average, the district (36.5%), and the region (32.5%). Although the science scores were higher than those of the district and region, they still fell below the corresponding mathematics and reading scores.

The comparatively low scores in science achievement prompted the study. By utilizing a thematic approach, making the subject matter more relevant to the students, and providing many different types of science resources to enhance the students' knowledge with hands-on experiences and cooperative learning groups, I decided to find out if these strategies would help LEP students to understand and apply science facts, rather than just memorize them. LEP students were chosen to participate in this study because I teach this population of students at my school, and this population constitutes the majority of my students.

Advantages of Cooperative Learning

Our nation's schools are facing an ever-increasing enrollment of language minority students who enter schools without full proficiency in English. These demographic changes require that schools address the needs of a student population that daily grows more diverse (De La Rosa & Maw, 1990; Council of Chief State School Officers, 1990).

The challenge that these student groups present is often a new one for administrators and teachers, many of whom were trained and have gained their expertise in a world in which non-minority, English-proficient, middle-class students were the norm. Conversely, research conducted by Penfield (1987) indicates that more than 50% of all U.S. teachers interact with students who speak English as a second language. In addition, data from the 1990 census show that the number of foreign-born people as a percentage of individuals who typically speak a language other than English at home has increased significantly since 1980. A report by Minicucci and Olsen (1992) suggests that approximately one in seven students between the ages of five and seventeen speaks a home language other than English and that the number of these students is estimated to be growing.

In the Dade County Public Schools (DCPS) system, the K-12 student population reflects this increase in linguistic and demographic diversity. According to a recent Dade County Public Schools publication presenting a profile of the district and its schools (Dade County Public Schools, 1997), the total student enrollment for the 1995-96 school year was 333,444. This student population varied in ethnicity, language, prior educational background, and personal and family goals. The reported ethnic composition of this student population was White non-Hispanic 47,325 (14%), Black non-Hispanic 112,812 (34%), Hispanic 168,696 (51%), and Asian/Indian/multiracial 4,611 (1%). Sixteen percent of the total number of students was designated as being limited English proficient.

Studies by Collier (1987; 1989) have shown that language minority students acquire social English language in one to two years but need five to seven years to develop the academic English language proficiency required to participate fully in classes in which English is the medium of instruction. Educators untrained in administration of English as a Second Language (ESL) programs may be fooled by the verbal fluency of language minority children's English, such that they do not think failure in school could have a linguistic basis. However, previous research has indicated that minority students with fluent conversational skills in English may still lack the necessary cognitive academic language to participate fully in the academic dialogue that constitutes mainstream educational programs. The Council of Chief State School Officers (1990) has noted that the level of academic achievement by language minority students continues to lag significantly below that of their majority counterparts.

In traditional views of learning, the learner is viewed as a passive recipient of information. For example, in the area of language learning, the traditional use of drill and repetition is used to develop language habits. Similarly, in traditional instruction in academic areas, such as mathematics and science, classroom tasks that also place the learner in a passive role have frequently been used. Students may memorize and recite facts but too often develop little understanding of underlying concepts (Larkin & Sleeter, 1995; Tharp & Gallimore, 1988). Additionally, passive instruction is often teacher-centered, in which the teacher exclusively directs the students toward learning goals and provides the information to be learned. This type of instruction emphasizes lower-order thinking skills. The underlying premise in instruction that first emphasizes lower-order thinking skills is that basic skills must be mastered before a student can be challenged by more demanding, higher-order academic tasks (Secada, 1992).

In contrast, recent cognitive research on learning focuses on the active role of the learner. From this perspective, effective learning processes are those that involve the learner in a self-directed process of inquiry which is guided and facilitated by the teacher. In taking a more active role in defining questions, examining explanations, and reaching solutions, active learners develop higher order thinking skills. An active learning perspective such as this requires a substantial change in the roles and responsibilities of both the student and the teacher. The teacher no longer assumes a role as a mere dispenser of information; instead, he or she becomes a facilitator of the students' learning. The role of the student also changes. Students are encouraged to take more initiative in their own learning, which includes being given more responsibility for determining—with the guidance of the teacher—the questions to be asked and the information to be learned.

Although cooperative learning is believed to be the most effective among the three primary styles of teaching and learning (individualistic, competitive, and cooperative), it remains the least used in classroom settings (Johnson & Johnson, 1981).

A quality science education is essential to the future success of all students, as is proficiency in the English language. Since LEP students learn English skills most effectively when such skills are taught across the curriculum, it is especially productive to integrate science and English teaching. Effective simultaneous teaching of science and English language skills to LEP students rests on several important premises. For example, science content taught to LEP students should be the same as content that is presented to the other students. Cultural examples that are relevant to LEP students should be used to illustrate science content and concepts, pointing out the roles that such concepts play in their daily lives. This can be effectively accomplished by organizing the content to be taught around common themes, including hands-on experiences in a cooperative learning environment.

Cooperative learning currently is one of the most recommended teaching methods and in at least one state is mandated (California State Department of Education, 1987; Nath, Ross & Smith, 1996). When implemented correctly, cooperative learning results in many benefits to students: it prepares students for today's society and promotes active learning; students learn more when they talk and work together than when they listen passively; it motivates, leads to academic gains, fosters respect for diversity, and advances language skills (Johnson, Johnson & Holubec, 1990; Slavin, 1990); it breaks down stereotypes and leads to an increase in self-esteem (Johnson & Johnson, 1981); and it builds cooperative skills, such as communication, interaction, cooperative planning, sharing of ideas, decision making, listening, taking turns, and the exchange and synthesis of ideas (Sharan & Sharan, 1987). Surprisingly, although cooperative learning is believed to be the most effective among the three primary styles of teaching and learning (individualistic, competitive, and cooperative), it remains the least used in classroom settings (Johnson & Johnson, 1981). Roger Johnson and David Johnson, the primary developers and promoters of cooperative learning strategies, suggested that teachers who use cooperative learning in their classrooms will stop using it if they find it does not work the first or second time (Johnson, Johnson & Holubec, 1990). In support of cooperative learning, Chamot and O'Malley (1993) argue that research and experience have demonstrated that the organizational strategy most effective for teaching science to LEP students is cooperative learning because it fosters language development through inter-student communication for all levels of language proficiency. LEP students can demonstrate their use of higher-level cognitive processes that have been developed in another language up to this point in time. In this type of discovery environment, LEP students have the opportunity to find answers to the questions they themselves pose about a topic. They have ample opportunities to test their own ideas when they have access to materials. To further provide LEP students with opportunities to think about and apply science concepts and to formulate complete thoughts in English, the teacher should avoid the more traditional way of teaching science, that is, by lecture and recitation methods. Instead, lectures and recitations by teachers should be limited in use as summaries of what has been covered, while using complete sentences, appropriate diction, and correct grammar.

Methodology

The study was conducted over a four-week period. One hour was scheduled every day for science. The first step in the design of the study was to carefully select the target and non-target groups from among 12 LEP students (seven girls and five boys) out of the total class population of 25 students.

Students in the classroom were arranged in groups of five. Selection of the target and non-target groups was conducted in order to obtain a cross-section of varied academic ability in both math and reading, as well as to account for gender. Selected groups were composed of the following students: four high-academic students (two boys and two girls), two-average academic students (one boy and one girl), and one low-academic student (one girl).

The target group involved seven LEP students, chosen as stated above. During the course of the study two students withdrew, so only five students remained in the target group. The other five LEP students were part of the rest of the class not receiving the hands-on activities. They were doing science through lecture, recitation, and worksheets.

For the purposes of the study, a unit on magnets was prepared for the hands-on activities. The implementation of this thematic unit on magnets required lots of creative problem solving and was conceptually challenging because of the varying degrees of English proficiency and academic skills among the target group members. Before the unit on magnets actually began, I met with the target group to explain their participation in the study for the next four weeks. At this time, a number of preliminary cooperative group activities was provided to prepare them for the unit on magnets.

Written true-or-false pre- and post-tests were administered to the whole class before and after the unit was implemented. Ten teacher-generated statements from the unit on magnets were read to the students who wrote "yes" or "no" as responses to these statements. Pre- and post-tests using these items were used as measures of performance of students' science knowledge, language proficiency, and language acquisition. The pre- and post-test scores were graded, recorded, and then compared (see Table 1 in Findings section below). The ten teacher-generated statements from the unit on magnets were as follows:

- A magnet attracts any metal object.
- All magnets have a north and south pole.
- Like poles attract.
- Unlike poles repel.
- Magnets are only man made.
- Magnets can attract through glass and wood.
- The Earth is like a magnet.
- A magnet can have two north poles.
- Magnets can work under water.
- The weakest parts of a magnet are the poles.

Data were accessed from four primary sources throughout the study. One source was teacher observation and reflection, documented in the form of note taking. Some of the behaviors observed were those of students following directions for hands-on activities, students helping each other complete activities, and students asking questions of each other and of the teacher. The second source of data was that of student interviews. The students were asked how they thought they worked together as a group during the magnet science unit and what they liked or disliked. Some of the children expressed how much they enjoyed working with others. One student said, "Working together is fun because we get to talk and do fun things." Another student said, "I like working with others because if I don't know how to do it, they can help me." The third source of data came from the pre- and post-tests. Finally, the fourth source of data came from the *Hands-On Activities* checklist. This checklist was completed during individual interviews of the target group students. They had to rate each week's activity by giving it a number from 0-10, where 0 indicated the "least liked" and 10 the "most liked" activity. The activities that were rated were:

- What objects do magnets attract?
- What objects do magnets not attract?
- What are some different sizes and shapes of magnets?
- What are magnetic poles?
- What is magnetic attraction?
- What is magnetic repulsion?
- Can magnetic attraction occur through different materials such as plastic, water, or glass?
- Can objects be classified as magnetic or non-magnetic?
- How does a compass work?
- How is the Earth like a giant magnet?

At the beginning of the first week, the scientific process was introduced to the whole class at their level of understanding. A "science survival" vocabulary list was also started on the board. All science vocabulary used in the unit would be added to the list throughout the study. The target group was introduced to safety and handling of materials. Cooperative group roles were assigned for the target group: Recorder, Material Managers, Checker, and Safety Director. The objective for the first week was to find out why magnets attract some objects and not others. The following scientific skills were stressed: prediction, observation, deduction, and classification. This was accomplished by the students (both those in a cooperative group and as a whole class) as they engaged in the following: (a) reacting freely to a picture of magnets and objects, (b) sharing any experiences that they or their families may have had with magnets (for example, recounting places around their homes where they found magnets, such as on the refrigerator door, and also telling about playing with magnetic board games like checkers and chess as they traveled on family trips), (c) listening to children's "read-aloud" books about magnets, (d) handling magnets of different sizes and shapes, (e) observing the effect of magnets on different objects, (f) observing a demonstration of a magnetic field using an overhead projector and iron filings, (g) experimentation (by the target group) using magnets to pick up objects of assorted compositions, and then classifying them into two groups of magnetic and non-magnetic objects while the non-target group observed.

The focus of the second week of activities was on the different sizes, shapes, and poles of magnets. The following scientific skills were stressed: observation, identification, conclusion, communication, and comparison. The activities included (a) having the students learn the names of the magnets, (b) reviewing the history and uses of lodestone, (c) naming the poles and recognizing them as the "strong" part of the magnets, (d) comparing the strength of the magnetic pull of magnets on different objects. During this time, the non-target group completed and colored "fill-in-the-blank" activity sheets.

The third week of the study focused on the concept of attraction and repulsion. The following scientific skills were stressed: observation, comparison, and drawing a conclusion. The activities used to accomplish the above objectives were: (a) demonstration of how two like poles of magnets repel and how two unlike poles of magnets attract, (b) demonstrating how two magnets repel each other without touching, (c) oral description by the target group of what happened when like and unlike magnetic poles of bar magnets were brought together. During this time, the non-target group completed different activity sheets.

Week four objectives consisted of having the students gain an understanding of the concept that the Earth is a giant magnet, how to read a compass, and how to make temporary magnets. The following scientific skills were stressed: observation, experimentation, and communication. These objectives were achieved in the following manner: (a) by using a globe and board to demonstrate the invisible lines of force that come together at the poles, (b) guessing the answer to a riddle that named the Earth as the biggest magnet, (c) placing of a compass on different objects and magnets (target group), and (d) making temporary magnets to be used as compasses (target group). During this time, the non-target group worked on related work sheets.

Findings

At the elementary level, science with its potential for a multi-sensory approach to hands-on experiences, which allow students to see and feel the meanings of words and concepts instead of just hearing the definition, is an excellent vehicle for second language development. This study was designed to improve science language acquisition and higher-order critical thinking skills of selected first grade LEP students through hands-on activities and cooperative learning. The evaluation process involved administering a ten-statement, true/false, teacher-made test at the beginning of the four-week period and using this same evaluative instrument for the post-test.

Results for the pre- and post-test are presented in Table 1 below. The pre-test showed scores of 10-50%. The post-test showed an increase of 10 to 40 percentage points for students in the target group. This demonstrates that after four weeks of specialized science instruction, all selected LEP students increased their science language proficiency scores by at least 10%. Since all students improved their scores by at least 10%, the specific quantitative objectives of this study were met.

Student	Pre-test	Post-test	Difference
1	50	80	+30
2	50	80	+30
3	20	60	+40
4	20	40	+20
5	10	20	+10

Table 1. A comparison of students' scores on the pre-test and post-test (all pre-/post-test figures are%).

As part of my data collection, each target student was interviewed privately and confidentially to evaluate the critical thinking skills that had been developed during four weeks of activities. The interviews were also designed to find out what they liked or disliked during the unit. The rating scale used ranged from 0-10, with a rating of 10 being the top score. The scores were averaged as a group for each of the 10 activities from the unit on magnets. As a group, an increase of more than 50% between the beginning of the first week and the end of the last week of their evaluation indicated that this objective of the study was met.

The students in the target group clearly understood magnets better than the students in the rest of the class. By doing the hands-on activities, the students gained a more thorough understanding of the concept of magnets than the other students whose activities were guided by worksheets. During the study, the non-target students often were observed asking questions of the group doing the hands-on activities. I believe that these types of activities would benefit all students and give them greater understanding of the scientific concepts.

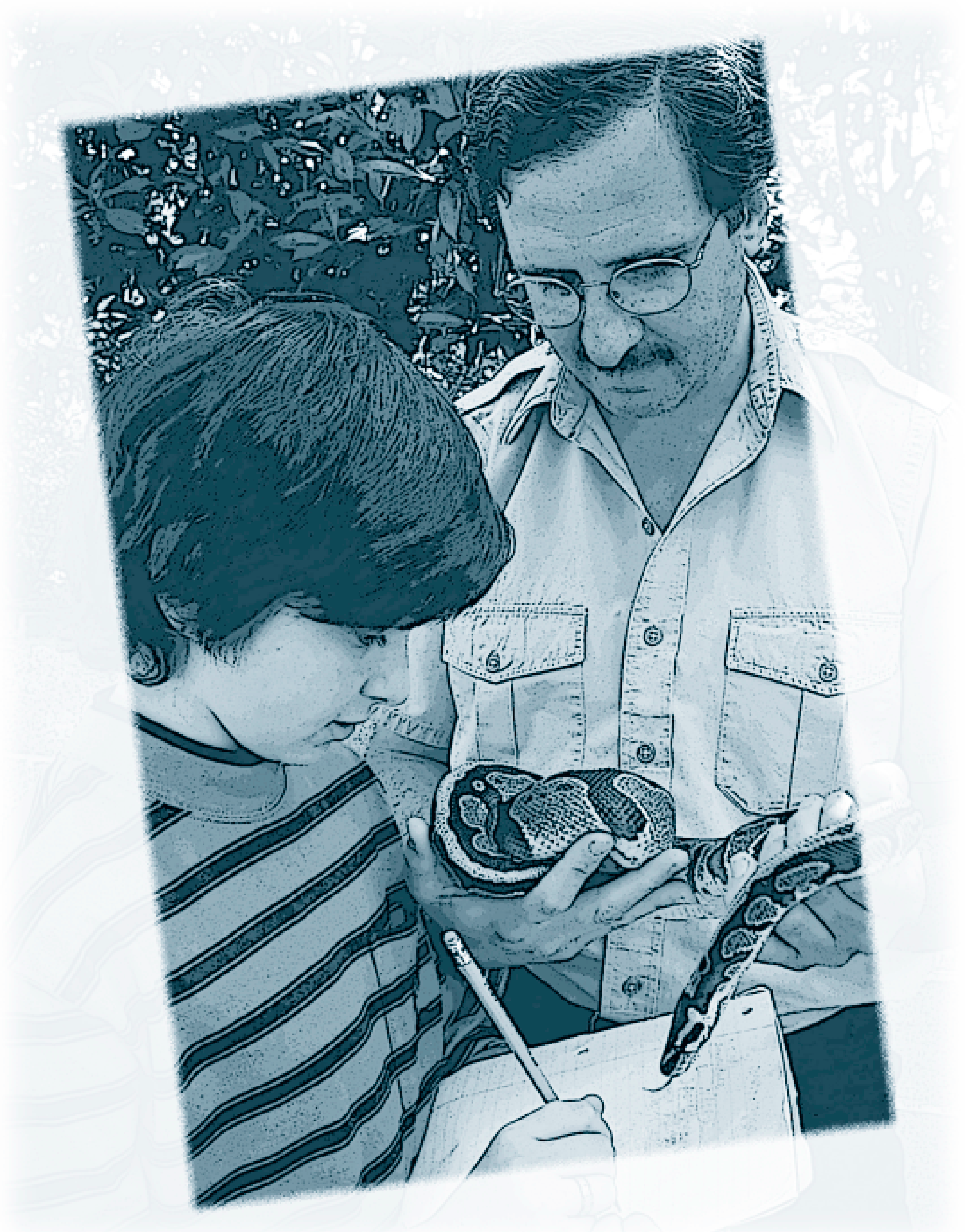
Conclusion

The study set out to demonstrate that after four weeks of specialized science instruction, at least 80% of selected students would increase their science language proficiency scores by 10%, while at least 20% of selected students would increase their scores by 5%. The results suggest that the objective of this study was met, since all students improved their scores by at least 10%. Analysis of the teacher observations also revealed that the students learned to work together to complete the activities. They began using the science vocabulary and were comfortable doing the activities and completing the worksheets. The five LEP students were far more adept at using scientific vocabulary to explain the way magnets acted than were the other LEP students not in the target group. The results of this study suggest that teaching science to LEP students through cooperative learning, and hands-on activities increases language proficiency and science conceptual development.

There were several important outcomes from this study. As a result of the instructional strategies used in the study, it was apparent that students were thinking extensively about how to complete the activities. They also showed thinking beyond the school situation. They wanted to experiment on their own with many different objects to see if they were magnetic. Some students asked parents to buy them magnets so that they could have them at home. Parents told me how interested their children were in finding out about magnets.

My experience with cooperative learning and hands-on activities will help me to enact this type of instruction more effectively in the future. I know that I will now try to teach in a cooperative learning style. I will try to provide my students opportunities to collaborate in small groups in all parts of the curriculum. Overall, I am developing an awareness of the importance of student-student interactions. I want to incorporate not only cooperative group learning, but to have all students carry on discussions about science in and out of the classroom using a language of science that builds on their own native language tools and their emergent English language. ◆

Language, Discourse and Learning in Science: Improving Professional Practice through Action Research



CHAPTER FOUR

How Urban Children Learn about Their Natural Environment

Carol M. Reiter
Flagami Elementary School, Miami, Florida

Carol Reiter, a native of New York, graduated from the University of Miami (Florida) in June 1959, with a Bachelor of Arts in Drama. After a career in theatre, she turned to education and the demands of family. Mrs. Reiter and her husband Jeff (an educational consultant) have raised three successful daughters. In 1995, Carol was voted Florida's *Region V Teacher of the Year*. In 1996, she was named *Elementary Social Studies Teacher of the Year.* In 1998, she became the *Science Teacher of the Year* at her school site. She received her Master's degree in Science Education from Florida State University in 1998. She believes in teaching thematically and enjoys, for example, pulling together such varied concepts as geometry, Native American folklore, history, and art. It is important for her to gain insight into her students' current knowledge about the subject at hand and what it is they want to learn. Her philosophy can be summed up simply in the following statement, "They are all at risk, but I teach them as though they are all gifted."

Abstract

In this study, I describe the ways in which my fifth grade urban students obtain information and learn about their natural environment. The study broadens the commonly accepted notion of discourse to provide descriptions of how these students utilized artwork, literature, music, and popular television programs in their development of a scientific discourse.

Introduction

The purpose of my research was to explore the ways in which my fifth grade urban students developed a science-like discourse and a sense of ownership about their natural environment. In so doing, I wanted to find out what they knew about their natural environment. As part of the research, the students compiled a list of literature, music, and program listings from television that had influenced their thinking about the environment. As they developed a science-like discourse, photographs and other visually oriented artifacts were used in order not to place my students at a disadvantage because of language difficulties.

In this study, I investigated how my 20 urban, at-risk students acquired the knowledge they had about their natural environment. As part of the study, I also wished to identify what other factors helped them to acquire scientific knowledge about the environment. I began the study with a certain amount of prejudice, assuming that my 10- and 11-year-old students probably didn't know a great deal about the environment of South Florida. Some of my perspectives were based on a trip into the Everglades that I took with my class to visit the Miccosukee Indians. I found my students not to be very knowledgeable about the flora and fauna of that specialized environment. This was disappointing to me, since I knew they had been exposed to the *Everglades and South Florida* curriculum in fourth grade. My other bias was based on my students' lack of vocabulary to express what they knew.

My Students

All but one of the students were of Hispanic background, and the home language of 19 of the students (out of 20) was Spanish. Their reading scores ranged from stanine three to stanine six, according to their fourth grade

> "They are all at-risk, but I teach them as though they are all gifted."

Stanford Achievement Test scores of March 1996. I teach the "Comet Lab" class, where admission usually is based upon poor attendance in the previous grade, low self-esteem as judged by the previous year's teacher, and reading scores no lower than stanine four. Students also can enter the Comet Lab class by teacher recommendation. However, it is not unusual for me to have four or five seemingly very bright students in my class.

Many of my students have one parent, no parent, a parent in prison, or are being raised by an adult who is not their biological parent. I had one student who slept one night in her father's house, and the next night she spent at her mother's house. She had never missed a day of school nor forgotten her books or homework. I don't know if I could be that responsible. It would not be surprising, then, if these students had poor attendance and low grades. They didn't. In fact, the Comet Lab had the second highest attendance in the school in the 1997-98 school year! Ten of my 20 students had perfect attendance all year. Although many of them achieved well, they were all in different stages of blooming. Indeed, 10 made the Honor Roll in all three grading periods during the school year. One of the possible ingredients for their successes in the 1997-98 school year—after so many years of failure—is my philosophy that: "They are all at-risk, but I teach them as though they are all gifted." I believe in them.

Drawings and Photographs as Learning Resources

Given the fact that the majority of these students did not speak English as a first language, I decided to use drawings and photographs as additional learning resources. My main verbal charge to my students concerning their drawings was that they pretend a visitor or alien being who had never seen South Florida would be able to use their drawing to learn as much as possible about the environmental features of the region. They were to show as much as they knew. As the students drew their pictures, I found myself moving from group to group, trying not to be intrusive. Sometimes I would simply sit, watch, and listen as the children spoke. At other times I might ask if they had actually seen a particular animal they were adding to their picture or where had they seen this or that item. Little by little—through our interactions, written answers to questions I had composed, and the drawings they had made—the students' conceptions emerged to provide me with insights into their knowledge of the environment.

I was able to alter my opinions about my students' knowledge of their environment. By using photographs and pictures, I was able to have them think more about specific questions concerning their environment. An example of this is a photo of a Westchester home with a concrete yard versus a home with a lawn. Most of my students were concrete learners and the more specific examples I could give them, the easier it was for them to go to the abstract. When I asked my students to discuss why we had such a flooding problem in the streets near our school, while other areas of Miami didn't have this problem, they began to provide answers which were based on their observations and life experiences: "Our yards are covered," "There is no place for the water to get to," and "It sticks on top." These were just a few of the responses I recorded in my log when my students spoke to each other in their groups.

Generating Questions

I asked students in their groups to develop questions that they had about their environment. Wishing to learn directly from them, their questions provided guideposts for what they might like to study and learn. My students collaborated in their groups which they subsequently identified with the following names: “The Microscopics” (two males, two females), “The Tree Frogs” (two males, two females), “The Nature World” (two males, two females), “The Bees” (four males), and “The Dolphins” (four females). Through their shared language and common understandings, I asked them to help me discern, using their questions, what they believe a fifth grade student should know about his or her immediate natural world. The respective student groups generated the following questions:

The “Microscopics”

- How do food chains work?
- How is it possible that we see the light from stars that no longer exist?
- What effect does the moon have on us?
- How do birds fly?
- How are rainbows made, and why do we see so many in Miami?
- Why does the moon change during the month?
- Why can’t we always see the moon?

The “Tree Frogs”

- Why is the ocean salty?
- Why doesn’t Florida have deserts?
- Why can’t we grow apples, peaches, and pears in South Florida?
- Why aren’t there volcanoes in Florida?
- How come South Florida seems to be a magnet for hurricanes?
- Why do alligators and crocodiles like water but lizards don’t?
- How do birds stay up in the sky?

The “Nature World”

- Why aren’t there mountains in Florida?
- Why is the ocean so salty?
- How were the Everglades made?
- Why are the Everglades so important to South Florida?
- What causes day and night?
- What is sand made from, and how come there is so much of it?
- Why do sharks have to keep swimming?
- Can sound travel underwater?

The “Bees”

- How was the Miami River created, and why is the river important to South Florida?
- What creates our shoreline, and why is it always changing?
- How is the moon important to us?
- Why are we at sea level? How does this influence our life?
- What are shooting stars, and where do they go when we see them shoot across the sky?

Allowing students to compose their ideas using artwork as legitimate inscription devices was one way to show what they knew and to interact with one another and myself.

- How does the moon change during the month?
- How do birds fly? What keeps them up?

The "Dolphins"

- How was the Miami River created?
- What is the importance of the moon to our area?
- What creates the shoreline, and why does it change?
- What does it mean to live at sea level?
- How do birds fly?
- Why do stars seem to go down?
- What happens to shooting stars?
- If water doesn't evaporate, where does it go?
- How do big rocks become small pieces of soil?
- How far does the Earth turn in one hour and in 24 hours?

As may be seen, there were some recurring questions across groups. Many students had a passion for thinking and learning about space. In particular, they wanted to know more about the moon and how it affected us, the tides, and the water at the shoreline. They also were interested in the stars. There was an interesting question about trees and why we do not grow apple, pear, or peach trees near Miami. This indicated an already present awareness of our very specialized climate.

Lists of Literature

Taking a cue from Erickson (1998), who suggested that science can be a rich environment for the acquisition of literary skills, I asked my students to identify which books, movies, television programs, and music enriched their thinking, attitudes, and knowledge about the environment. Their list is provided in Appendix A (p. 172).

Assessing Students' Knowledge of Science

I devised what I thought was a fair test of fifth grade knowledge of the natural environment. I cut out pictures of a butterfly's metamorphosis and a frog's development. Then I placed them on individual cards and had my students arrange them in the order which they believed represented the metamorphosis of each. Uncovering my students' conceptions involved not only having my students sequentially place picture cards of the metamorphosis of a butterfly (which would give me a "right" answer), but also having them explain as much as they could about what was happening at each stage of the insect's development. The additional information provided a window into the students' understandings about metamorphosis. I needed to rise above the pedestrian answer—a one-dimensional "right" answer. The pictures of metamorphosis were able to generate a meaningful discourse. Their explanations allowed me to discover more than just a "correct" answer (Brooks & Brooks, 1993, p. 65).

Another manipulative I developed was one that depicted our view of the phases of the moon. Students moved pictures of the phases of the moon as it appears in our night sky. I asked them to recall during which part of the month they would see a full moon. A third model I placed on moveable cards was the arrangement of the planets in our solar system relating to their distance from the sun. They added to this some information they learned about molecules and why some planets are called "gassy giants" while others are "rocky midgets."

Conclusions

When I began this study, I was new to constructivism, and I viewed my students' knowledge of their natural environment in a prejudicial manner. This was based largely on their lack of verbal skills in their native language and an underdeveloped knowledge of science. Finding an avenue for us to interact meaningfully was a priority. Allowing students to compose their ideas using artwork as legitimate inscription devices was one way to show what they knew and to interact with one another and myself. Creating manipulatives for them to explore and show what they knew also proved successful. Allowing students to draw, doodle, sketch out their thoughts, and use their native language enabled them to be part of a classroom community and encouraged co-participation. Eventually my students and I were able to negotiate a shared language and use it to learn science and show what had been learned (Tobin, 1998a). I am very conscious of the numerous resources for learning science. These include the minds of the learners as they consider what they have experienced and how it fits with what they already know, conversations within small groups, teacher and student interactions, and the students' inscriptions (for example, drawings). Arguments using a science-like discourse can occur in contexts involving all of these resources.

What I have been able to ascertain from observing them is that they are thrilled by a rainbow and will look up from a game of ball to follow a group of green parrots sitting on the wires overhead. They will follow the growth of tadpoles in a jar with a magnifying lens for over a week and share their concerns with me for the food needs of these creatures. They are, in short, at a point where they will become tomorrow's caretakers of the Earth.

Through their interactions with parents, family members, teachers, and peers, I discovered that over their 10 or 11 years of life on this planet, my students had indeed acquired some basic knowledge about their natural environment. What I have been able to ascertain from observing them is that they are thrilled by a rainbow and will look up from a game of ball to follow a group of green parrots sitting on the wires overhead. They will follow the growth of tadpoles in a jar with a magnifying lens for over a week and share their concerns with me for the food needs of these creatures. They are, in short, at a point where they will become tomorrow's caretakers of the Earth. Do they know the answers to all of their questions? Not exactly. But, as I became more observant and respectful of my students, they became more knowledgeable in my eyes. My students have brought an intuitive and natural understanding of their world that is not from books but from their experiences and a certain inner life of children that can see the wonder of the world in which they live their lives. ◆

CHAPTER FIVE

Semiotics and the Construction of Meaning in Science

Dana Kelly
Bel-Aire Elementary School, Miami, Florida

Dana Kelly began her teaching career as a substitute teacher in 1978. She graduated from Florida International University in 1982 and then worked as a permanent substitute in a sixth grade class at Cypress Elementary during the 1983-84 school year. After the birth of her son in June of 1984, Dana quit teaching for seven years, returning in 1991 to substitute for two years, mainly at Gloria Floyd Elementary where her three-year-old son was enrolled. She began her permanent teaching career in 1993 at Lakeview Elementary and has taught at Miami's Bel-Aire Elementary since 1994. Dana has been the second grade chairperson for two years, also assisting with her school's Science Fair each year.

Abstract

The purpose of this four-week study was to examine the ways in which students of diverse cultural backgrounds infer meaning from science experiments. Conducted with five second grade students, the study concluded that students of this age, regardless of cultural background, could not independently discover the underlying principles of the science activities. Meaning was constructed only with the guidance and facilitation of the teacher.

Introduction

The following perceptions are from five second grade students (Note: All names used are pseudonyms) about *The Collapsing Bottle* experiment, designed to demonstrate that air exerts pressure.

> Emilio: "The heat sucks it inside."
>
> Sue: "The air stayed in and vibrated and sucked in the bottle."
>
> Ed: "The bottle pulled it in."
>
> Marie: "Air came out, so the bottle fall in."
>
> John: "The air outside is pushing it in."

Only one child, John, had inferred the correct meaning behind the experiment. Why was the answer so elusive to the other children? Was their prior knowledge of the subject too limited? Was it the language of science that eluded them? Did their respective cultural backgrounds or limited English language skills have a bearing on their misinterpretations? As a basis for this study, I decided to focus on the students' cultural backgrounds and prior knowledge as possible explanations.

Educators in Dade County are in the unique position of teaching children who come from a wide variety of cultural backgrounds, since there are numerous cultures represented in this school system. The student population has changed dramatically in the past few years in support of Crandall's (1992) observation that the American classroom is increasingly multiethnic, multiracial, and multilingual at all levels. Given this diversity, many students must struggle with the dual task of constructing meaning from the language of science and grasping the underlying concepts behind scientific experiments. According to Cummins (1981), children acquire language proficiency in two different ways: via the development of basic interpersonal language skills and that of cognitive academic language proficiency. Cummins also points out that

…for purposes of social communication and interaction, appropriate language can be acquired in one to two years, but the level of proficiency needed to read texts or solve mathematical word problems can take five to seven years to develop.

for purposes of social communication and interaction, appropriate language can be acquired in one to two years, but the level of proficiency needed to read texts or solve mathematical word problems can take five to seven years to develop. Because of this, Krashen (1982) has suggested that language is most successfully acquired when the focus is on meaning rather than on form. As Kincheloe (1998) argues, communication is not a matter of extracting meaning, but of constituting meaning based on the cultural context, values, and social identities of those involved. This means that students must use their own personal experiences, their own cultural customs, and the language of science in their attempts to extract the inferential meaning of experiments. In short, they must use their personal constructions to make sense of the concepts.

I sought to discover whether students from different cultural backgrounds would derive similar or different meanings and concepts when performing science experiments. I chose a group of five students from diverse cultural and socioeconomic backgrounds to participate in this study. The cultures represented were Hispanic/Latino, White-American, African-American, and Multicultural. I felt that these children were representative of the cultures most often encountered in Dade County. Because of time, space, and material constraints, the sessions for this study were divided into one-hour periods twice a week for four weeks. Each student kept a journal, as did I. Individuals were interviewed, and responses were recorded.

Using the topic of air, I conducted several experiments with this group of students. Some sessions were conducted with the whole group. Some I did with two or three students and then let them teach it to the others while I watched and recorded them. I believe that children need this interaction in order to make sense of what they are doing, a belief congruent with Erickson's (1998) assertion that learning science is learning a new dialect and, as with the acquisition of other aspects of language, learning the dialect of science occurs in face-to-face conversation with others. After the students had discussed the experiment, and I was certain that they understood the underlying concepts behind the activity, I had the study group re-create the experiment for the entire class and explain it in their own words. I believe, as Tobin (1997) does, that "…in re-presenting knowledge to others, each learner has the potential also to be a teacher."

Background of the Study

The idea for this research study was sparked when a thin, blond boy with a shy smile was brought into my class one day. He had just arrived here from Cuba and spoke only Spanish. Every educator who speaks only English, as I do, can identify with the feeling of anxiety that comes with this situation. I am in agreement with the findings of Sweeney's (1997a) study which indicate that teachers seem to be inadequately prepared to teach students with limited English proficiency (LEP). Of course, this student would be an English for Speakers of Other Languages (ESOL) Level I student and receive instruction in Spanish for most of the day. Still, he would be spending a significant amount of time in my classroom, and both of us would have to try and work out some sort of communication system. We relied on student interpreters, an English/Spanish dictionary, and on signs and gestures. I was very aware that my job as his teacher was to help him understand and interpret the semiotics—the signs, codes, and conventions—of the classroom. It was apparent from the first day that this boy was intelligent and eager to learn. He excelled in mathematics and liked science.

…in re-presenting knowledge to others, each learner has the potential also to be a teacher.

At about this time, I read an early version of Kincheloe's (1998) article "Critical Research in Science Education." The section on semiotics caught my attention. Semiotics may be described as the study of codes and signs that help humans

…the cultural background of certain ethnic groups of minority students was regarded by teachers as being "inferior"—or "less advanced"—than that of mainstream U.S. culture (Sweeney, 1997a).

derive meanings from their surroundings. I began to wonder if this child, with no knowledge of the English language, would be able to understand the concepts behind science experiments if he were given just the materials and directions. How could he use the language of science to describe scientific concepts? Would he arrive at an understanding of the underlying principles if given the vocabulary? Would he describe phenomena and events in the same way as English speakers? What signs and symbols would he use to make sense of an experiment? What about children from other different cultures? If given the materials, instructions, and vocabulary, could they figure out the concepts?

Teachers in many school districts work with children from many different cultural backgrounds, all of whom are under-represented in the field of science. Sutman (1993) reports that schools with large Hispanic, LEP, and other minority populations have habitually clustered these students into low-ability tracks without consideration of their actual abilities or potential for academic success. The result of this discriminatory practice is the severe under-representation of minorities in advanced science and mathematics classes, and consequently, in careers requiring advanced-level science and math skills. The same study also reported that although the overall high school completion rate among all 25 to 29 year olds was nearly 80% during the period 1977-1990, for Hispanics it was only 60%. During the same period, the number of Hispanics who received college degrees in the sciences, compared with other racial and ethnic groups, dropped significantly and continuously. Furthermore, while African-Americans and Hispanics constituted 10% and 7% of the total professional workforce, respectively, the representation of each group in the scientific workforce was only 2%.

There appear to be many reasons behind this lack of interest in science by minority cultures. One reason may be the home situations of these students. In his study on teacher beliefs relating to minority students in the science classroom, Sweeney (1997a) asserted that the home situations and backgrounds of poor, cultural minority children (notably African-American children) are regarded to be such that successful science learning is nearly impossible (that is, use of non-standard English in the home; severe environmental poverty, crime, substance, and sexual abuse; and mentally/socially unstable parental/guardian figures).

Another reason for the apparent lack of interest in science by minorities could be that all students do not learn or make "cognitive connections" in the same way (learning styles) and that respective cultural backgrounds influence the ways in which students learn (Delpit, 1995). Because of this, Tobin (1998a) suggests that within each classroom, the power sharing needed to facilitate co-participation should be tailored to reflect the cultural histories of participants in the community.

For me as a teacher, the most disturbing reason of all was the realization that "…the cultural background of certain ethnic groups of minority students was regarded by teachers as being "inferior"—or "less advanced"—than that of mainstream U.S. culture" (Sweeney, 1997a). Perhaps because of inadequate teacher preparation, Sweeney also reported in his study that science teachers used student grouping methods so that LEP students could learn from others but not so that others could learn from LEP students. Teachers do not like to be standing in the spotlight of accusation. It would be much easier to point to the home situation of the student, a lack of parental support, or lack of student interest than to look at our own prejudices and practices as a possible reason for a student's failure. We would like to say that all teachers realize that we do students a disservice when we do not recognize that, "…belonging to a different culture is a source of disempowerment for minorities because the habitus associated with life in their home culture is no longer viable for them" (Tobin, l998a). The reasons behind the failure of minorities to succeed in science are complex and varied. It is imperative that teachers be aware of this and encourage minority students in this area.

Background of Students

The students in this study were chosen as representatives of the many different cultures in Dade County. For the purposes of this study, I have included some socioeconomic background information, as well.

My first student, Emilio, was an Hispanic male/Latino. His family arrived from Cuba with nothing but the clothes on their backs. During the time in which this study was performed, he was living with an aunt and uncle. He was a very quiet child and spoke only Spanish, performed well in mathematics, and liked science. He “spoke” to me by gesturing and pointing, and he and I enlisted the assistance of a bilingual student to interpret for us.

My second student, Marie, was an Hispanic female/Latina. She was also from Cuba, receiving free lunches at school. She lived with both parents and an older brother, speaking English at school but only Spanish at home since her parents spoke only Spanish. Her family was very poor. She fell one day in physical education and got a concussion. Her father picked her up from school, but he said he could not afford to take her to the clinic for an X-ray. Her poor academic progress in reading and math during the course of the academic year led to the possibility of her being retained in the following year, and yet she excelled in science. She was always the first to bring in objects relevant to the subject being covered: frogs, insects, flowers, shells, rabbits, planet books, etc. She did a wonderful science fair project at home, with which her father helped her. Unfortunately, neither she nor her father was fluent in English, nor familiar with the “scientific method.” My handout, I realized too late, was in English, so it was of little help to them! We had to redo and rewrite her experiment in standard English, and she subsequently won second place in the science fair. She was very curious and observant and would often come to me to talk about things she had seen or things that were happening in her world. She was an “ideal” student, always attentive and on-task.

My third student, Sue, was an only child who lived with her mother, received free lunches, and had a varied multicultural background. Her mother was French and her grandmother was Haitian. She was a compulsive talker and spoke English, French, Haitian Creole, and a little Spanish. She was very bright and on grade level in all subjects. Sue had witnessed the violence and horror of her father’s murder. A “mean man” came into the family home and shot him in the head as he sat in a chair. Sue was not very interested in science, but she was very social and wanted to be part of the group project.

My fourth student, Ed, was an African-American male. He had two older and three younger brothers. He lived with his mother and did not have a father figure in his life. He also received free lunch. He was soft spoken, curious about how things worked, and asked many questions. He was observant, kind, and thoughtful. His mother was poor, and it took her seven months to get the glasses he desperately needed. He often wore old, tattered clothes to school. Ed liked science experiments and was the first in the class to buy a science board. Instead of an experiment, he did a picture essay on Creation. It was very original, but, of course, the judges had to follow the strict guidelines of the scientific method, so he received only a participation ribbon. He spoke what is now called “Ebonics,” but tried hard to speak standard English and often corrected himself as he spoke.

My fifth student, John, was a white American male who spoke only English. He lived with both parents, twin older sisters, and a baby brother. They were a middle-class family and were insulted that I sent home a free lunch application. He was in the process of being tested for learning disabilities because of his difficulty in reading. He was a math whiz who loved science and experiments.

My Hispanic/Latino student who was the inspiration for this study completed only one experiment and then transferred out of the school. When he transferred, I was left with an English-speaking class again, albeit with different cultural backgrounds. The other four students were chosen because of their diversity from each other. The second criterion was that the students were chosen by their interest in science. In the interest of sample heterogeneity, two boys and two girls were invited to participate, each child representing an ethnicity found most often in a typical South Florida classroom.

At the request of my school administrators, in order to protect the privacy of the students, I did not videotape, tape record, or photograph any children from my study group. I complied with these administrative instructions, even though this seriously restricted my research.

Methodology

It is my philosophy that all children—no matter what their cultural heritage, race, or limitations—can succeed in science. All children, from all socioeconomic backgrounds and cultural heritages observe and interact with the natural world around them. Science, in my opinion, is the perfect vehicle for helping these children from various cultures derive and understand the meaning of language. As Sutman (1993) explains, at the elementary level, science—with its opportunities for hands-on experiences that allow students to see and feel the meanings of words instead of just hearing the definitions—is an excellent vehicle for second language development.

The topic of air was explored in six simple experiments about its properties. The experiments were

- A paper towel was placed inside a cup, which was then submerged upside down in water to show that air takes up space.
- A two-liter bottle was heated with hot water and then crushed by air pressure to show that air exerts pressure.
- Students tried to blow a piece of paper into an "empty" two-liter bottle to show that air takes up space inside of objects.
- Straws were placed in water and then the top hole was covered, leaving water "hanging" inside the straw to show that air pushes from all sides.
- A balloon was blown up and let go to show that air moves objects.
- Two blown-up balloons were balanced with string on either end of a yard stick. When one balloon popped, the other side was weighed down. This showed that air has mass.

The experiments were performed in a cooperative group setting. My classroom did not lend itself easily to this type of work. I am in a pod school and share a wide-open space with two other classes. Every word spoken by every other teacher or student can be heard in the room, so working in cooperative groups had to be limited to the two days a week when I had an aide in my class. This made group work difficult. However, I believe it is the best way for students to make sense of what they are experiencing. They need other students to help them bridge the gap between their prior knowledge and the concepts they derive from these activities. When the students understood the concepts inferred in the experiment, they recreated the experiment for the rest of the class.

Analysis

My original intent was to compare the language that these students used in their descriptions of the science experiments. This focus changed somewhat when my Spanish-only speaker transferred after the first experiment. Consequently, I would have only different dialects of English to compare. After the first experiment, it was obvious that the students needed more direction and teacher input. I realized that my focus had to shift from the use of spoken language *per se* to the understanding of concepts behind the experiments. I listened carefully to the language that they used, and it was very similar. The multicultural student, for example, when asked why the paper stayed dry in the cup, said, "When you turn the cup over in the water, the paper stays dry. This is because it stays on the top of the cup." The white American boy said, "The paper can't get wet because the paper is on top." The Hispanic/Latina girl did not even venture a guess, and the African-American boy thought that the paper was taped to the cup. Only with repeated, leading questions did they come to realize that air was in the "empty" space that prevented the water from wetting the paper. The students also used my exact words to recreate the experiment for the class, so a study of language was impractical.

I decided to address the pragmatic area of semiotics. Pragmatics, broadly speaking, deals with inferential meaning, not merely logical inference, but the subtler aspects of communication expressed indirectly and in specific social contexts. For example, an apparently innocuous statement of "It's drafty in here" can, in a particular social context be interpreted to mean "Close the door." In our experiments, I wanted to see if each child would arrive at the same inferential conclusion that "a piece of paper can't be blown into a bottle = air takes up space," or "holding a straw closed on top with liquid inside = air pushes from all directions."

The pattern that emerged after completing all six experiments was that all of the children had to be led to discover the concept. Not one concept was readily apparent to them. John, the white American male, and Sue, the multicultural female, understood the concepts after being asked leading questions. They were both more likely to look at a problem from a different angle and to try different methods of discovery. Ed, the African-American male, had to be led and coaxed into the answers and sometimes even just told. He was accepting of the answers given to him by other students and did not make any attempt to test their feasibility. The Hispanic/Latina girl, Marie, would keep repeating an experiment until she understood and accepted the explanation. She never offered an explanation of her own. I do not know if her limited vocabulary in English prevented her from venturing a guess or not. She kept repeating the experiment until it made sense to her. The following excerpts give examples of these findings:

Straw Experiment

Teacher: "What is happening here, John?"

John: "It stays because you are holding it."

T: "I'm holding it on the top, not the bottom."

J: "Oh yeah. Well, then the straw is holding it in."

T: "How?"

J: "Um. That space sucks the stuff up in the straw."

T: "What's in that space?"

J: "Nothing. Oh no, wait! Air?"

T: "Right. Can air hold something up?"

J: "No. Well, yes. Sometimes it holds balloons up."

T: "Well, if I close the top part of the straw, what is holding the liquid up?"

J: "AIR!!"

T: "Right!"

J: "So when you let go, the air pushes down the straw and makes the water go down!"

T: "Right. What did you learn about air?"

J: "It can hold stuff up, and it can push things, too."

I found that John was eager to share his knowledge with the others in the group. What was most interesting, though, was that he did not tell them the answers, but asked leading questions. For example, in this same experiment, John and Ed had the following conversation:

Ed: "Hey! Why do it stay?"

Teacher: "What do you think?"

E: "You be holding it?"

T: "No. I'm holding the top."

E: "Maybe the milk is stuck."

T: "What do you mean? It can't come out?"

E: "Yes."

T: "Why do you think it's stuck? What is making it stick?"

E: "I don't know."

John joins the group.

John: "What is all around us, but we can't see it?

Ed: "God."

J: "Well, right. But something that we breathe."

E: "Air?"

J: "Yes. See, air pushes on the milk. When you let go, air pushes the milk out."

E: "Okay. I get it."

In the following example, Sue, the multicultural student, offers a creative solution to try to help her find the answer to the question of why a piece of paper cannot be blown into a bottle.

"Air Blown into a Bottle" Experiment

Teacher:"Can you blow this piece of paper into the bottle?"

Sue: *(Tries several times).* "No."

T: "Why won't it go in?"

S: "Something is pushing it back out. It almost goes in, then pops back out."

T: "What is pushing it?"

S: "I think…um…it can't be the wind!"

T: "What is inside the bottle?"

S: *(Very excited)* "I KNOW! I KNOW! Air is in there! No air can go in because it is full of air!"

T: "Right! Can you think of a way that it can go in?"

S: "Um. Maybe I can shake some air out?" *(She tries it, but is unsuccessful.)*

S: "I know it can drop in."

T: "Did you try it?"

S: "No." *(She tries.)* "See? It can go down."

T: "Why?"

S: "Well." *(She thinks for a while.)* "Gravity pulls it!"

As teachers, we must be aware of our own prejudices and attitudes toward minority students if we are to be their link between life experiences and science. As Sweeney (1997a) notes, teachers often do not consider LEP students to "know" anything until they can express it in English.

In this same experiment, Marie asked to keep trying the experiment, and I told her she could. She sat and did this experiment for over half an hour before she came to me and said: "The air in the bottle can't let the paper in."

This sequence of events verified Shapiro's (1994) observation that, when we teach science, we in fact ask students to consider changing their beliefs about the world in which they live. Shapiro also explains that even after direct instruction designed to change learner ideas, students often hold on to their previously held conceptions. It was difficult for Marie to accept an idea that she could not verify with her senses. From a constructivist point of view, constructions come about through the interaction of a constructor with information, contexts, settings, situations, and other constructors using a process that is rooted in the previous experience, belief system, values, fears, prejudices, hopes, disappointments, and achievements of the constructor (Guba & Lincoln, 1989). Marie had already formed her own ideas through her own experiences, and she had a difficult time accepting that "science" was correct, which implied that her interpretations of her previous experiences, therefore, needed to be modified.

Conclusions

My original intent was to compare the language students used to describe scientific concepts. Noting that the students were not able to use their own words to describe an experiment, I began to focus instead on comparing the ways in which the students would use their cultural backgrounds and prior knowledge to arrive at the concepts behind the experiments. According to the emergent design described by Guba and Lincoln (1989), my focus changed from the language that would be used to the concepts that would be discovered. Indeed, as Tobin (1998b) argues, meanings are grounded in sociocultural processes; individuals do not exist as separate entities and can only come to "know" in terms of the cultures in which they have lived their lives.

Based on my observations and notes, I concluded that the white American male seemed to grasp concepts and ideas quickly, after only a few leading questions. This could be due to his prior experiences or his inquisitive nature. The multicultural female looked at problems from a different angle and was creative and original in her ideas. This could originate from her exposure to different cultures and languages at a young age or the fact that she was very social and outgoing. The African-American male did not seem to have much expertise or experiences from which to draw. He was the most accepting of answers and the least likely to question the findings of others. The Hispanic/Latina student would repeat an experiment until the findings made sense to her. She did not offer any explanations, but was not satisfied with blind acceptance of those offered either.

It is sad but true that many teachers have not been adequately prepared in working with LEP and ESOL students.

Overall, what I found is something I was not readily willing to accept. I thought that scientific concepts would be apparent if the students were given the "language" or terminology of science to use in these experiments. In fact, they could "talk the talk," but this did not reveal the meanings behind the words. It is one thing to know the terms "air pressure" and "force"; it is quite another to understand the ramifications of atmospheric pressure and to appreciate that air exerts a force on everything on Earth all the time, even if you can't "feel" or observe it. As Shapiro (1994) also observes, students find it hard to grasp a concept when they cannot verify it with their senses.

Verification via the senses, however, is not enough. As Tobin (1997) states, even though there might be extensive hands-on activity, communication, and problem solving, the development of scientific ideas does not necessarily follow. Scientific knowledge does not reside in the materials to be mysteriously released during hands-on activities. To facilitate the learning of science it is essential that the teacher infuses scientific discourse activities and provides a scaffold between the languages of the child and of science.

All of the children participating in this study needed that scaffold in order to conceptualize and understand the underlying principles. I must conclude, as does Tobin (1997) that "…students frequently constructed understandings that were not those of canonical science because they lacked the necessary language and physical actions and employed interpretive frameworks that produced understandings that were not scientific in character. Hence, it is improbable that students will construct scientific knowledge in laboratory activities unless they possess an appropriate interpretive framework and receive guidance from someone who already knows the science."

Science comprises the descriptions developed over time to explain how and why the environment operates as it does, and these understandings are universal, not more or less appropriate for members of certain races or cultures (Sutman, 1993).

As teachers, we must be aware of our own prejudices and attitudes toward minority students if we are to be their link between life experiences and science. As Sweeney (1997a), notes, teachers often do not consider LEP students to "know" anything until they can express it in English. It is sad but true that many teachers have not been adequately prepared in working with LEP and ESOL students. The questions we ask language minority students, as noted by Ballas (1995) tend to be too easy, and we don't really know how to challenge them in class. Adjustments in instruction, however, should not include a lowering of standards for these children.

All children can succeed in science, and as Sutman (1993) states,

> Science comprises the descriptions developed over time to explain how and why the environment operates as it does, and these understandings are universal, not more or less appropriate for members of certain races or cultures. ◆


Science

CHAPTER SIX

Writing as a Tool for Learning Science: Perspectives of a First and a Third Grade Teacher

Mayda Martin-Olazabal
Ben Sheppard Elementary School, Miami, Florida

Aurora Romero
South Miami Elementary School, Miami, Florida

Mayda Martin-Olazabal graduated from Florida International University in 1989 and was subsequently hired at Ben Sheppard Elementary. She has been working for Dade County Public Schools for the past eight years.

Aurora Romero is a third grade teacher at South Miami Elementary.

Abstract

The purpose of this research study was to show how elementary students' utilization of writing could be used to support their science learning, to examine how writing is related to achievement in science, and to evaluate the link between writing and scientific understanding. A major premise of the study is that writing is vital in the learning of science: by writing about science, students can better organize their thoughts and communicate scientific ideas. The study was conducted simultaneously in a first and a third grade classroom at different schools.

Perspectives of a First Grade Teacher: Ms. Martin-Olazabal

During my eight years of teaching, I have found that children are very attracted to science. I believe that regardless of their ability, it is a door that most children want to open. Science seems to be very exciting to them. Through the years, I have also seen the importance that is being given to writing and reading; there is an emphasis on the use of language across the curriculum. It is believed that students' goals for writing evolve as they develop cognitively over the school years and that this writing becomes epistemic (Glynn & Muth, 1994). For the purposes of this study, I concentrated on writing in science rather than on all content areas within the school curriculum.

Shortly after the beginning of the 1996-97 school year, I attended a workshop where the presenter demonstrated different ways of making books with elementary students. This event, in combination with my beliefs about the attraction that science holds for children, stimulated my interest in undertaking this research study.

Setting

The school in which this study was conducted is located in a predominantly Hispanic area in the north end of Dade county. The 40 students who participated were all members of our self-contained first grade TEAM (Teaching Enrichment Activities to Minorities) class. (TEAM is a program designed to instruct students in the implementation of higher order thinking skills.) I say "our" because the same classroom and class were shared with another teacher. We were each responsible for 20 students; however, each of us taught all 40 students. I taught mathematics and content areas to all 40 students, while the other teacher taught language arts to the same group. Of the 40 students, 37 were Hispanic, one was African American, one was Caucasian, and one was

Haitian. ESOL (English for Speakers of Other Languages) levels in the class ranged from I (least proficiency in the English language) to IV (independent). The school administration supported each teacher's approach to teaching and was very cooperative.

Purpose

Writing in science allows students to use their prior and basic knowledge to flesh out responses to more complex problems that require higher-order reasoning (Rivard, 1994).

With this study, I wanted to evaluate how the integration of writing—in an expressive form—would aid in the understanding of scientific concepts. Through this type of writing, the student is able to explain what he or she has learned or understood in regards to the material being taught or discussed. It has been suggested that writing is intimately related to thinking and that it may be used to enhance the learning of science content (Rivard, 1994). In other words, in order to fully communicate what they know in writing, students first have to have an understanding of it. Writing in science allows students to use their prior and basic knowledge to flesh out responses to more complex problems that require higher-order reasoning (Rivard, 1994). One of my main reasons for undertaking this study was my interest in seeing the students in our class create their own science books based on the knowledge or understanding which they may have acquired. I wanted them to have ownership of their learning. More importantly, I wanted to see how they made sense of their learning. Another reason for doing this was the idea that perhaps creation of their books would be more interesting or fun for the students to do rather than merely having a test at the completion of the unit. These books would also become a useful assessment tool for me.

Methodology

A narrative-based research methodology was used to conduct this study. After learning scientific concepts through experiments, activities, and readings, the students wrote about what they learned. They used science journals and notes and created their own books. Data were collected in several forms, including observations, teacher journal entries, student surveys and interviews, and student-created products.

Prior to beginning this study, informal interviews and discussions were held with the students in order to assess what their feelings were about tests. These responses included the following:

- I like taking a test because you tell us our grades, and if I make a mistake, I learn from it.
- I think that tests are good because you learn.
- Sometimes when I do a test, I get nervous.

In February 1997, upon the completion of a three-week unit on Space, the children were expecting a test. Although they were encouraged to study and be prepared, a conventional test was not what followed. Rather, they were going to be authors and illustrators of their very own books about Space. The following day, we began our science class with a brainstorming activity in order to review what we had learned about Space. Their answers were written on the board. At that point, they were given the materials that they would use to make their books. As I observed and listened, I could hear them discuss the sizes of the planets, the different characteristics of each, and even their relative distances away from the Sun. They were able to choose their own book titles and make their own illustrations for their covers, as well as illustrations inside their books.

By April 1997, as this study was coming to its conclusion, the students had written several books. Topics included endangered and/or extinct animals, matter, and pollution. One of the students, after having seen a television program where he learned about rainbows, brought in a report to share what he had learned with the rest of the class. At the time, it was evident to me that they seemed to enjoy making the books. Upon making their last book, data collection was concluded with a student questionnaire (see Appendix B, p.173).

Findings

> Science was a powerful source of motivation in the students' writing, and, in turn, through their writing and illustrations, I was able to assess their knowledge about the subject without the frustrations that involve a test.

It is my belief that when children enjoy their activities, learning becomes connected with their prior knowledge and can easily be accessed to apply to newly acquired knowledge. It is the kind of learning that stays with you throughout the years. Looking back to the beginning of the year, this idea of "bookmaking" had not occurred to me. However, I think that when we as teachers make a test, it is safe to say that there are a certain number of students with average grades or below average grades, and then there are those who do extremely well and who leave you wondering whether they perhaps know more about the subject yet were not asked to tell about it. I think that in making their own books, all students have a chance to succeed. The bright student is able to express all that he or she knows about the subject. At the same time, a student who may not be a good writer or who does not have mastery of the language could have the illustrations help him or her show the teacher what he or she knows. The students were very excited each time that we created a book. Through their sharing of information, I could almost "see" what they were thinking.

Reflecting on this study, I learned that while they made some very exciting books that were shared among each other, some of the students thought that the books were not shared enough. I believe it would have been very rewarding for them, as well as other students in the school, to have gone to other classes and other grade levels to read their books to other children.

Conclusion

It has been my experience that lower elementary students are fascinated by science. The school library books that they check out are mainly from the "easy" section. These include fairy tales, fiction, easy reading, etc. Since this study began, during our Space unit, the students in our first grade class only wanted to check out the science books dealing with what we were doing in science at the time.

Science was a powerful source of motivation in the students' writing, and, in turn, through their writing and illustrations, I was able to assess their knowledge about the subject without the frustrations that involve a test. I plan to include book making as part of the evaluations I will use next year with our students. It is very exciting and rewarding as a teacher to see students sharing their knowledge and having fun while they are learning.

Perspectives of a Third Grade Teacher: Ms. Romero

Over the course of at least the past two decades, there has been a growing trend in educational thought that writing in science—as well as in the other "non-language arts" areas of the curriculum—can be beneficial to students. Support for the concept of writing in the "non-language arts" content areas started in the United Kingdom and was based on the realization that writing was not implemented consistently across the academic disciplines (Britton, Burgess, Martin, McLead & Rosen, 1975).

Looking back to my experiences as a student in an elementary science class, I remember learning science solely using a science textbook. The assignments consisted of reading a chapter orally or sometimes silently, listening to the teacher highlighting the points that were important to her, and finally taking a chapter exam. The chapter exam tested my ability to memorize facts that I usually forgot immediately. I know that this method of learning science does not work for me. I wanted to teach science in a different way.

In past years, I have taught science using trade books, videotapes, laser disks, filmstrips, guest speakers, and hands-on laboratory activities. However, I still felt that I needed a method that would help my students to think critically about the content. This provided the focus of the research study in which I decided to explore how writing could help my third graders think critically in science.

Throughout my research study I gathered data so that I could analyze how writing might enhance students' achievement in science. I examined students' attitudes about the importance of writing and also examined students' writing for indications of critical thinking.

In summary, my purpose for writing this paper was to analyze the role that writing played in facilitating the learning of science in my classroom. My goal was to show how students' expression of themselves through writing encouraged science learning.

Setting

I teach third grade in an urban school with a population of approximately 550 students. Students in my class vary in backgrounds. During the course of this study, my class consisted of approximately one-third of each of the following backgrounds: Afro-American, Caucasian, and Hispanic. In addition, there were several Haitian students and one Indian student. A total of 27 students were in my classroom. Academically, students ranged in levels from above grade level to below grade level. Most students were performing at grade level. My school is also a magnet school for the performing arts. Typically, two-thirds of my students are from other schools, while the remaining one-third of my students live in the local area. These students audition for either art, dance, drama, or music. The administrators at my school are very supportive of teachers, and teachers are provided with an abundance of materials for use in their classrooms. To facilitate the teaching of science, teachers are provided with science-related trade books, a laser disk player, a science materials/equipment room, and reference materials. The school also provides teachers with in-service workshops in science and mathematics.

Methodology

The form of research methodology I used is narrative based. The data collected included student surveys and student-created products such as writings, books, and journals. During the initial phase of data collection, students were surveyed so that I could learn more about their attitudes concerning science and writing. The questionnaire was identical to the one used by my colleague, Mayda Martin-Olazabal, in her parallel study (see Appendix C, p.173).

Findings

During the study, the class participated in several laboratory activities. During a hands-on lab, students (using their senses of sight and touch only) were to predict what mystery substances occupied four cups. After feeling the dry substances, the students wet the substances and touched them again. Students recorded their observations and conclusions on a chart. I then asked them to reflect in their journals on what they had learned from this lesson. The following are examples of the students' responses:

- This was a fun project. I learned that there are many things you should not taste or smell. Not every type of powder is the same. We used senses. Only two. Touch and sight. There was flour, salt, sugar, and laundry detergent. It was very exciting. And that is what I learned.
- I feel good about doing this experiment. I really enjoyed it. It was fun. I learned that things aren't what they look like. That's what I learned.
- I enjoyed this experiment, and I learned that you can still tell what something is by seeing it and touching it.

Students using appropriate writing-to-learn strategies are more aware of language usage, demonstrate better understanding and better recall, and show more complex thinking about content.

These samples of students' reflections on what they learned indicate that they enjoyed the project. I believe students learn best when they are enjoying themselves. More important to my research, these samples show evidence of critical thinking. The first two samples show that these students learned that powders possess different qualities although they might look the same. The first and third student samples indicate that these students learned that they can investigate mystery substances using just two senses.

Students using appropriate writing-to-learn strategies are more aware of language usage, demonstrate better understanding and better recall, and show more complex thinking about content. Studies suggest that expository writing tasks—such as explaining, note taking, and summarizing—are effective strategies for enhancing learning (Rivard, 1994). The following writing samples illustrate how summarizing helped these students think critically about the project that they had just completed.

- When we made the book about doing science projects, I learned all the steps in making a science fair project. Now I know how I need to start and all the steps to the end.
- The big book about science projects showed me what I need to do to make a real good project for the science fair. I learned about picking a topic, guessing which means hypothesis and doing the experiment. I also know how I can share my results.

Using journals in the science classroom has been proposed as a possible method for improving the problem-solving skills of students, for monitoring student thinking and understanding, and for enhancing student learning (Fulwiler, 1987). The following samples of my students' journal entries allowed me to monitor what they learned from a lesson on magnets. The assignment was for students to predict the number of paper clips a bar magnet would hold. Next, students had to do the same for two magnets, then three, and finally four magnets. Students charted their predictions and recorded their results. The following are examples of the students' reflections on what they learned.

- We put two magnets together and picked up paper clips. We found out that two of the same poles picked up more paper clips than the opposite poles together.
- First we predicted how many paper clips each magnet will hold. Second, we took one magnet and put it in the pile of paper clips. Then we took it

out and counted how many it had, then recorded how many. We did the same for two, three, and four.

- I learned that if you put the north end to the north end, you pick up more paper clips. Same for the south end to south end.

I have learned through my research that writing is a powerful thinking activity.

Teaching this lesson on magnets revealed quite a bit of information. My objective for this lesson was to expose my students to bar magnets and allow them an opportunity to predict and test their predictions. However, had I assessed this lesson solely by conventional test taking, I never would have known of the discovery that some children had made about the magnet poles. I was able to assess the extent of student learning by reading what the children wrote in their science journals. These journals allowed me the opportunity to see exactly what knowledge students had constructed in this lesson.

Conclusion

When making big books or reflecting on what they have learned in a science lesson, children are exploring science concepts and having fun at the same time. Book making works well as an initial focus or culminating activity to any science unit. It integrates science with other subjects, helps children develop communication skills, and fosters a sense of pride and accomplishment that is difficult to achieve in other ways (Reif & Rauch, 1994).

I have learned through my research that writing is a powerful thinking activity. My research has shown me that I need to continue to implement writing in my science curriculum as a means to get students to understand concepts instead of merely memorizing for a test. Writing has proven to be a tool for learning. Writing leads to discovery. After all, field notes and journals have been an essential part of science for centuries. ◆

Language, Discourse, and Learning in Science: Improving Professional Practice through Action Research

CHAPTER SEVEN

Poetry as a Vehicle for Teaching Science

Eva Wich
North Carol City Elementary School, Opa Locka, Florida

For the past three years, Eva Wich has been a second grade teacher at North Carol City Elementary School, which consists of pre-kindergarten through fifth grades in the regular program. She previously taught first grade students for nine years at the same school.

Abstract

The purpose of this study was to investigate whether the teaching of science through poetry would better enable students to retain scientific concepts. Pre- and post-tests, surveys, student journals, student illustrations, and teacher observations were used as sources of data. Findings of the study indicate that poetry not only enabled students to retain scientific concepts, but also that the use of poetry can be a useful tool in the teaching of science.

Purpose and Background

During the time of the study, 593 students were enrolled at the school. Of that total, 519 (88%) children were African-American, 66 (11%) children were Hispanic and 8 (1%) children were Caucasian. Forty-eight percent (282) of the total number were Title I students. Two percent of the student population (12) qualified for Exceptional Student Education (ESE). Four percent of the students (24) were enrolled in ESOL (English Speakers of Other Languages) classes. Ten percent (59) of the student population was enrolled in the gifted magnet program. North Carol City Elementary is one of the most successful Title I schools in all of Florida, making the most significant gains on the *Stanford Achievement Test* in 1994-95.

During the course of this study, my class consisted of 27 second grade students. There were three second grade classes—two regular and one TEAM (Teaching Enrichment Activities to Minority Students) class. I taught a non-TEAM class that consisted of several students who were below grade level and some who had severe behavior problems that inhibited their learning. I had one ESE student, two Level I ESOL students who did not speak English, and four other ESOL students, including one who performed on a kindergarten level. My class consisted mostly of Title I students; therefore, the majority could not read on a second grade level. Since science involves reading, their scientific vocabulary was limited. Since they could not read proficiently, they also wrote poorly. Due to this fact, I wanted to see if there would be an easier and more entertaining way for my students to learn science. My personal interest in poetry sparked my idea for a research topic. The purpose of my study was to investigate whether the teaching of science through poetry would better enable my students to retain scientific concepts.

The Study

I knew that my students would not be up to the task of writing their own original poetry about concepts they didn't understand. I felt, however, that if I could somehow intertwine science and poetry, my students would benefit immensely. At the time when I began to think about undertaking this study, we had been studying life science. Textbooks were used, along with an overhead projector, transparencies, and worksheets. The students also went on a nature walk on the school premises and observed a butterfly garden. After about three weeks, I felt that the students had a good working knowledge of the topics covered: anatomy of a butterfly, camouflage, hibernation, parts of a tree, types of seeds, and habitats. However, when I gave them the chapter test, they tested poorly. Out of 25 students who took the test, not one student scored an A, one student scored a B, four students scored C's, seven students scored D's and 13 students scored F's. The test was read to them, and the concepts covered were certainly familiar; however, the scores did not reflect this. The next two chapters were also related to life science; hence, the students would need to understand the first chapter. I decided to cover the same topics but to use a cross-curricular approach. Intertwining science and poetry seemed like an innovative way to teach or reteach scientific concepts.

Methods

Before I used this new approach, I surveyed the children to gain insights into their perceptions of science and to determine if it was a part of their daily lives and a part of the literature that they read. Out of 20 students surveyed, 18 students revealed that they liked science and two did not. Five children enjoyed reading science books at home, while 15 did not enjoy this activity. Fourteen students enjoyed reading books about life science, but six did not read about this topic. Eight students enjoyed reading out of the science textbooks, but 12 did not like reading textbooks. Seventeen students revealed that they would choose a science book from the library, but three students would not. Nine students liked poetry, but 11 did not read books containing poetry. The majority of the students said they enjoyed science, but this survey revealed that they did not pursue this interest at home. Most students enjoyed life science because of the interesting concepts covered, yet they had trouble retaining the concepts.

Eight students enjoyed using the textbooks that we read together in class. The students were more fascinated with the pictures than the text. The majority of the students would choose a science book from the library, revealing that the children were willing to embrace science even if they didn't understand it. I was not surprised that the majority of the children responded that they did not like poetry. Poetry can only be appreciated if it is often heard.

To reintroduce the concepts, I wrote six original poems, one for each topic covered (see Appendix D, p.174). Each poem was written on a chart and children were given individual copies. The first poem was called *The Parts of the Tree*:

We are the roots.
Where can we be found?
You can't see us.
We're below the ground.

I am the trunk.
I am a thick stem,
that carries water,
from end to end.

We are the leaves.
We use sunlight,
to make food,
that's just right.

Upon my head,
is a crown,
like a wreath,
round and round.

Before the poem was introduced, the students had the opportunity to draw a tree and label its parts on a piece of construction paper. Out of 24 students, three could not identify any parts, four students could identify one part, eight students could identify two parts, six children could identify three parts, and three children could identify the four parts of the tree.

The students recited the poem daily and acted out the parts of the poem, using their own bodies. After a few days, most students learned the poem.

After learning it, each child was given a science journal in which he or she was asked to complete the same assignment. Two students could not identify any parts, four students could identify one part, four students identified two parts, nine children identified three parts, and five children identified all four parts. This indicated that the students were able to retain more when poetry was used as part of the instruction.

At this point, I randomly assigned each child a topic and gave her or him a piece of construction paper with a concept written at the top. The children were instructed to write or draw as much as they knew about their randomly assigned topic. The topics or concepts included were: anatomy of a butterfly, survival and hibernation, camouflage, habitats, and types of seeds. Each child worked individually on his or her topic.

Five students who were assigned the first topic were able to draw a butterfly and were able to label one or two body parts. One child did not label any body parts but wrote, “butterfly eat flower.” Out of five students who were assigned the second topic, only one depicted an animal hibernating. Another student wrote, “animals need food to saviv.” The remainder of the group drew pictures that did not depict survival or hibernation. The five students who were asked to depict camouflage did not accurately portray this concept. Six students were asked to depict habitats. One student drew a wolf’s home in the woods, another depicted a frog’s home in the pond, two depicted children in their homes, another drew a cat in the garden, and one student drew something totally unrelated. Six children were assigned the last topic. One student drew absolutely nothing, another drew seeds in isolation, and one wrote, “I put seeds in the grownd and wather it. The next day it grow little. Tand it grow big,” along with an illustration of a flower bed. Another depicted seeds floating around in the air and seeds in the ground, one drew seeds in the ground alongside some flowers, and another drew flowers and fruits and wrote, “food, flower, grass, wing, fruit, tree, crown.”

The next day each group was given a poem to learn. The students sat together, read their poems, and at the end of the period were allowed to draw or write anything in their journals that they had learned about their topic. For two more days, the students did the same activity. On the fourth day, groups of children came up to the front of the class and recited their poems. Some of the students learned more than one poem, and a few students could recite all five poems by heart.

The majority of the students drew pictures in their journals about their respective topics, while some students wrote in their journals. One student wrote, “I trea aount seeds! Some seeds fly. Some seeds can not fly.” Another wrote, “Today I learned a muskrat build him a home.” A third wrote, “Butterfly long antennas

The children were learning science and having fun at the same time. I was pleased to observe this taking place in my classroom.

help me smell and touch the flowers." Another wrote, "Some habitats are cold for a polar bear." Another entry stated, "Butterfly can smlell in see in touh." An ESE student wrote, "Seeds can fly Seeds have hooas Seeds can trave Seeds can stick to swetrs." "A squirrel buries its acorns" was another child's written response. And finally, one wrote, "I loan duck hiding thar egg. and I loan abuot a muskrat builds a home. and a woodchuck hibernates to stay alive. and abuot a squirrel buries its acorns to survive." The students did not have the poems in front of them when they wrote their responses.

The following week each group was given a large piece of poster board. On that poster board, each group created a large illustration that depicted their topic. After two days, each group finished their posters. The following day, the students presented their posters and recited the poems to the class, explaining what they had learned about their topic. Then, students were given time for a question-and-answer session. The students were very eager to present their posters and ask questions of their peers. At first, most of the questions were not directly related to the topic, so I found myself guiding the children and reminding them to ask about the topic.

Each poster showed a good understanding of the topic studied. The butterfly poster showed a butterfly correctly labeled with all its parts. The camouflage poster showed several animals hiding in trees and other surroundings. The next showed seeds with hooks stuck to the fur of a dog and seeds flying through the air. The habitat poster showed the homes of several animals including the frog, bear, and turtle. The last poster showed how the squirrel, muskrat, and duck survived.

The last week of the research coincided with the Earth Week celebration. A few years earlier, I had written a poem entitled *Enjoy Don't Destroy*. The children learned the poem and thoroughly enjoyed it. I handed out copies and observed the children reading it to themselves without being asked. The children were learning science and having fun at the same time. I was pleased to observe this taking place in my classroom.

I re-administered the test and the survey, which revealed that although there was a slight drop in the number of students who liked science, there was a significant increase in the number of students who enjoyed poetry. There was also an increase in the number of students who read science books at home and an increase in the number of students who read about life science. There was an increase in the number of students who liked to read the science textbooks, which were used primarily as a reference during the study. The majority of the students would still consider choosing a science book to read from the library.

The test scores revealed that five students scored an A, five students scored a B, seven students scored a C, three students scored a D, and five students scored an F. These scores show a significant improvement over the first test scores. The two ESOL Level I students did not take the tests.

Conclusions

This research was a good learning experience for me and for my students alike. The students were able to work in groups and participate in different activities. They enjoyed reading poetry, and I certainly enjoyed writing the poems. Their interest in science was broadened, and their appreciation of poetry was heightened.

The data reveal that poetry was able to help the children retain more. Some may argue that they simply memorized the poems, but I feel that they really understood what they were illustrating and writing about in their journals and what they were conversing about with their peers. I believe that if there were more time available, some of the students would have been capable of producing some of their own poetry about science.

Am I biased about poetry? Yes, because it's been a part of my life since I was 13. How easy would it be to incorporate poetry with science? Sometimes, it's hard to find stories that go along with the themes, let alone poetry! And, certainly not all teachers are poets. However, I feel that it is a worthy challenge! Poetry serves as a motivating tool in the learning of science, and it may be argued that the students would have performed better even if poetry had not been used and just traditional reteaching had been implemented. I can only say that more research would have to be done in order to answer these arguments.

Next year, I would like to do an extension of this study. I am interested in investigating how science misconceptions in poetry and literature affect a child's understanding of science.

I feel that this research study is just a skeleton of an idea. I hope that it might prove to be a springboard for other teachers to use in their own investigations of using poetry to teach science. ◆

CHAPTER EIGHT

Children's Literature: An Integrative Strategy for Teaching Elementary Science Concepts and Vocabulary

Rebeca M. Valverde
North Miami Elementary School, Miami, Florida

Rebeca Valverde has been teaching for eight years at North Miami Elementary in Dade County. She received her Bachelor's degree in Early Childhood Education from Florida International University and her Master's degree in Elementary Education from Nova Southeastern University. Her interest in Science led her to complete a Specialist's degree in Science Education from Florida State University, where she was involved in action research.

Abstract

This action research study attempted to improve third grade students' understanding of scientific vocabulary and concepts by integrating children's literature into the science curriculum. Student enthusiasm is a factor in gaining understanding of the material. The children were not excited about learning science vocabulary and concepts using the assigned science text; therefore, I decided to integrate children's literature with science. An extensive literature review revealed several strategies that were explored and applied. The students' enthusiasm was only one of the positive aspects of this study. I found many misconceptions and inaccuracies about science in children's literature. It is evident that the teacher needs to be careful when selecting the literature he or she will be using. Results of this study indicated that the role of children's literature in the development of children's vocabulary and concepts in science is an important one and should not be overlooked.

Introduction and Background

This study was an attempt to increase the acquisition of science concepts and vocabulary with third grade students through the use of children's literature. For the purpose of this study, I define a science concept as a mental construct or a group of ideas that explain a specific natural phenomenon. I felt that my students lacked enthusiasm when it came to learning science vocabulary. They were eager to participate in the hands-on activities, and I wanted to capture that same enthusiasm and motivation in all aspects of my science teaching. Since the students I taught were children who enjoyed reading, I felt that they would enjoy learning science by reading about it in books other than the formal science textbooks they could find in the library. I also encouraged them to read books that were scientific in nature to learn more about the world around them. Ross (1994) suggests that teachers who encourage students to use many kinds of trade books across the curriculum are likely to be rewarded with students who are excited about learning.

The setting for this action research study was a multi-ethnic school, located in a large city in the southeastern United States. A large proportion of this public elementary school's students came from lower to middle class socioeconomic backgrounds. The school had approximately 2,000 students of various origins. The majority of the students were African-American (74%), with Hispanic (20%), White

Unfortunately, parent support in the school was minimal. Each teacher averaged between five to ten parental visits at each scheduled Open House event.

(5%), and Asian (1%) students as minorities. The school qualified for Title I Basic Program because the majority of the students received free or reduced lunches.

Unfortunately, parent support in the school was minimal. The Parent-Teacher Association (PTA) received little support during "Open House." Each teacher averaged between five to ten parental visits at each scheduled Open House event. Many parents were hesitant to become involved because of the language barrier between themselves and the school's teachers. Often the students became the translators between the parents and the teachers. An increasing number of children attended the after school care program provided by the YMCA because their parents were not at home to watch them.

I have taught at this pre-kindergarten through the sixth grade level school for seven years. The majority of these students have an academic and behavioral performance that is below the expected range for their age. However, during the time in which this study was conducted, I was one of two third grade TEAM (Teaching Enrichment Activities to Minorities) teachers. In order for a child to be selected for the TEAM program, he or she must show motivation, creativity, and an eagerness to learn. These students are homogeneously grouped. Previous research has indicated that participating in heterogeneous groups can help students acquire and share knowledge, especially if the students have the necessary academic and social strategies to succeed in the group activities (Pardo & Raphael, 1991). For this reason, the children were classed according to their stanine scores and teacher recommendations. The main purpose of this program is to develop the children's critical thinking skills. Other goals are to develop students' general cognitive skills, to link critical thinking skills to all of the other subject areas, to prepare students for possible placement into advanced academic and talent programs, and to encourage more student/parent involvement in the school's learning community.

Given that one of the program's goals is to link thinking skills to all of the other subject areas, this study focused on linking science to these thinking skills. This was attempted by using children's literature to teach science concepts and vocabulary, as opposed to exclusive use of the science text provided by the county.

There has been an interest in the integration of literature into the content areas for quite some time. Several colleagues at my school shared this interest. In 1995, we connected to form a Literature-Based Committee simply to share ideas about books. However, we found that although the ideas were great, most of the time we had only one or two copies of the book. We used the books as read alouds, but we wanted children to be able to read the books themselves and have that personal experience of holding their own book so they could go back and read it at their leisure. As more teachers began to show a desire to share in the committee, we decided to go a step beyond just sharing ideas. We put a proposal together and a "wish list"' of several books we would like to have as a class set. We went to our principal, and after some negotiation, he agreed to purchase several class sets of books for different grade levels. The class set used for this study, *The Magic School Bus Inside the Earth* (Cole, 1987), was one of these acquisitions.

The Students

A need for this study came about when I noticed that the children in my class were not engaging in the science literature. They were very enthusiastic when conducting experiments and other hands-on activities but became bored and uninterested when they were asked to use the science text to read about a specific science concept or to build their vocabulary. This observation was made over a period of time and was discussed with several colleagues who had experienced a similar trend in their own classes. However, this class had some very active readers who especially enjoyed the *Magic School Bus* series.

The participants in this study were six students from a class of 33 third graders. The entire class participated in the program, but only these six students were part of the action research study. All students in the targeted group were identified because of their low achievement in science vocabulary. This was evident in their class work and teacher-made tests. They also showed lack of motivation or interest in science when formal lessons were presented and the science textbook was utilized. These six students chose not to participate at all or only during part of the lesson. An observation sheet was developed to tally the activity of these students during science time.

Literature Review and Theoretical Background

Reforming elementary school science has been a topic of discussion for quite some time now. Integrating science instruction and language arts curricula using children's literature is a strategy that has been highlighted (Nordstrom, 1992). Since the increased influence of the whole language approach at the elementary level and the increased emphasis on enriching instruction through reading across the curriculum, one alternative approach to teaching science that has received some attention from science and science education organizations is the use of children's literature (Rice & Rainsford, 1996).

Since children enter our classrooms with very different prior experiences, many of them have misconceptions about the ways in which the natural world works.

Several professional organizations, including NSTA (National Science Teachers Association), publish lists of recommended titles to assist educators in selecting appropriate resources for teaching science. The *Science and Children* journal also presents an annotated bibliography of outstanding children's science trade books intended primarily for kindergarten through eighth grade (Schön, 1996). Mayer (1995) states that "…because of the ease with which fictional trade books can be integrated into whole language and thematic curricula, these books are readily accepted by educators and heavily promoted by major book publishers" (p. 16).

By teaching with an integrative approach that includes children's literature, students may be assisted in their understanding of difficult science concepts (Miller, Steiner, & Larson, 1996). Since children enter our classrooms with very different prior experiences, many of them have misconceptions about the ways in which the natural world works. Misconceptions are perceptions children have about the world around them that are not supported by accepted canonical science. These misconceptions can be subject to change or modification when children are confronted with adequate evidence to change their minds. However, just as these children come with many different prior life experiences, they also come with many different misconceptions. These misconceptions often become alternative frameworks. Alternative frameworks are ideas or schemata children construct from trying to figure things out. They have given it much thought and have formed a theory about it. Alternative frameworks are more resilient and less likely to change easily. Even in the face of "hard evidence," children may cling to their alternative frameworks because they make sense for them. Accordingly, a student's existing knowledge base, or extant knowledge, may include inaccuracies or misconceptions. Spivey (1991) explains the constructivist characterization of the reading process as related to extant knowledge. She states that just as writers construct meaning when they compose texts, readers construct meaning when they understand and interpret texts. The students build meaning through organizing, selecting, and connecting material they read with knowledge they have previously acquired. They interweave the source material with content from their stored knowledge to develop new knowledge.

Cooperative learning groups may produce academic benefits, including higher individual achievement, as well as social benefits.

Johnson and Pearson (1985), among others, strongly advocate the development of instructional strategies to link the learner's prior knowledge to new knowledge. One strategy that produces an interaction between prior knowledge and new information is semantic mapping. Semantic mapping is a way to organize and cluster ideas in a graphic structured form that facilitates comprehension. For the purpose of vocabulary expansion, semantic mapping extends another avenue to linking information (Kinnison & Pickens, 1985). Vogt, as cited by Jacobs and Tunnell (1989), agrees that a semantic mapping technique is "…a desirable strategy to help students recall word meanings and should be used to develop vocabulary to improve reading comprehension" (p. 472). Jacobs and Tunnell (1989) conclude that good readers tend to define reading as being concerned with meaning while poor readers see it as a process of converting symbols to sound. Naturally, texts support reading as a meaning-related activity.

Fundamental to students' success is learning a common vocabulary. The question that is raised over and over again by elementary teachers is, "How do we improve vocabulary, spelling, and writing?" According to Trelease (1989), the answer is simple: "By reading, reading, reading. Vocabulary and spelling words are not learned best by looking them up in the dictionary" (p. 35). Trelease also states that "…the more a child meets words and sees how they are used in sentences and paragraphs, the better he will know, understand, and spell words. Conversely, the less you read, the fewer words you meet and the less certain you are of meaning" (p. 36).

Cooperative group work also was utilized as a means of supporting the goals of the study: the students in the TEAM class worked in such groupings and were expected to help each other achieve their learning goals. Pardo and Raphael (1991) suggest that students earn higher grades, develop more skill in critical thinking, and become better decision makers when they study in smaller cooperative learning groups. Cooperative learning groups may produce academic benefits, including higher individual achievement, as well as social benefits. Also, learning within collaborative groups more closely parallels activities found in the workplace.

Methodology

Although my methods were emergent, I tried to follow several suggestions and strategies previously suggested by researchers to connect science with children's literature. Many of the researchers made clear the importance of reading aloud to students. I read aloud daily to my students but found that while I usually selected books that were of different genres, they were usually not science-related books. I began to read aloud more stories with science concepts to model to children the importance of reading a variety of materials daily. This also helped to expose them to different scientific vocabulary that they might revisit at a later date.

Two other strategies utilized in the study were semantic mapping as described by Kinnison and Pickens (1985) and building vocabulary through background schema as advocated by Johnson and Pearson (1985). The students brainstormed on ideas they already knew and associated those with what they were learning. Students also shared what they already knew and what they wanted to know and then showed what they had learned. This is also known as the K-W-L method. Essentially, these strategies were used to provide insight concerning the students' extant knowledge. Their previous experiences helped to determine the direction of subsequent instruction.

Of direct relevance to this study, the strategies described were used to improve the students' understandings of science. First, in order to counteract children's misconceptions over certain topics, the misconceptions had to be identified. This was done by carefully analyzing the students' oral and written responses to open-ended questions, individual interviews, and large- and small-group discussions. When asked if they liked science, most of the students answered "yes," citing that it was fun and that they enjoyed the experiments. Four students, however, two of whom were part of the targeted group, responded that they did not like science. They described science as too hard or boring. They also wrote that the way to learn science is by reading the text. Another student replied that he learned science by watching TV. Most students indicated that they learned science at school.

I also found that the students had many misconceptions about Earth Science, specifically concerning what was inside the earth. The administered interviews and tests revealed that some of the students' thinking about earth science differed from canonical scientific thinking in a number of ways. Many of them believed the inside of the earth was a huge metal ball, not in layers that differ in composition. Others believed that the inside of the earth was made of water. I was curious about this response because quite a few had responded the same way to that question and the answer they described was interesting. They said that the reason they thought the earth had water under the outer crust was because when they dug a hole deep enough, water would come out of it. I found this to be very interesting because although they had a misconception, it had turned into an alternative framework because of their experiences with the earth. It was my task, then, to provide them with experiences to turn this alternative framework into one more closely resembling that of canonical science.

Once the area of concern was identified, a search of related children's literature, and real world connections and applications was conducted. Finding children's literature related to the subject turned out to be quite a challenge. Many things need to be taken into consideration. A checklist developed by Deborah Mayer (1995) was a helpful tool in choosing books for the science lesson.

Next, the misconception was brought to their attention through the demonstration of a discrepant event. A discrepant event has an outcome that is usually different from what children expect (Miller, Steiner, & Larson, 1996). The children were shown several stones from a rock collection. A clear basin was placed at the front of the room in which all rocks were displayed. Without touching the rocks, the students made predictions related to the weight of the stones and if they would sink or float when in water. At this time, science vocabulary was used to describe the issues under discussion. Words such as "mass," "density," and "buoyancy" were used. Many of their predictions were correct until pumice—a rock that forms from cooled volcanic lava—was introduced. As the rock cools it develops tiny air pockets, which results in a relatively low density and allows it to float in water. In fact, some children thought that it was a sponge or a piece of colored styrofoam. It was important for them to be able to touch it and experience for themselves that a rock could actually float. Children do not always take what the teacher says as being correct. They are inquisitive by nature, and it becomes our responsibility to encourage their inquisitiveness, which can contribute to their becoming lifelong learners. Since the idea of rocks floating in water contradicted their personal beliefs, the children had to accept that their beliefs were either incorrect or incomplete. This led them to want to justify and analyze their prior understandings about rocks and the earth.

I used the discrepant event as a lead into the next activity that involved making a K-W-L chart. The students became involved in a brainstorming activity of reconstructing their knowledge. They had time to remember and reflect on what they knew. The students then wrote what they knew about rocks and what was inside the earth, what they wanted to learn. At the end, they wrote down what they had learned as a result of their investigations. K-W-L was used as a form of assessment because it documented the students' initial perceptions along with what they learned though the course of the unit. The students were also assessed through their entries in their learning logs. These logs were taken out at the beginning of science time and were used as note-taking pads. They were encouraged to practice note-taking skills. I told the students that one way I remember ideas later is by writing down notes to help jog my memory. Several students said they have seen me do this on several occasions. I showed them the tablet I usually have handy to record my ideas or to make note of "to do" tasks. The students were able to write down concepts, ideas, drawings, or vocabulary words they did not understand. These logs were kept handy so that they could go back and review at a later date what they had learned or questioned (Pardo & Raphael, 1991).

At this time, the children's trade book by Joanna Cole (1987), *The Magic School Bus Inside the Earth*, was introduced. This book was chosen as the primary source of information because of the concepts introduced and the appropriateness of the vocabulary for third graders. The children could relate to the characters depicted since they were already familiar with them through other books and the popular television series. Since the children were already familiar with the author's work, they were immediately enthusiastic. A primary reason for choosing this book was that many of the misconceptions or inaccuracies in the book are explained at the end of the book. This provides the children with a resource that addresses erroneous beliefs they might have. It is important to check the scientific accuracy in a nonfiction science book because it can very well lead to misconceptions or the perpetuation of such fallacies (McMillan, 1993). I then modeled note-taking skills with the children by stopping after every other page of *The Magic School Bus* to think about and discuss the main topics and the most important ideas or vocabulary words that were new for them.

The third strategy used was the presentation of a number of experiences that challenged the children's erroneous beliefs. This is where vocabulary development took place along with hands-on experiences. Research cited by Miller, Steiner, and Larson (1996) suggests that students rarely give up their misconceptions, but rather, persist in clinging to them, even as they successfully pass teacher-made or end-of-chapter tests. Since real world connections are also important in dispelling misconceptions, the students were shown videotape on volcanoes and watched dramatic footage of eruptions. When a discussion about the video took place, some were familiar with the eruption of Mount Saint Helens in 1980. One student said that he had read about a volcano in Hawaii. We then discussed the black beaches in Hawaii caused by the volcano Kilauea. We also were able to integrate geography into our unit as the children identified new places that had volcanoes.

The students were also interested in knowing what caused volcanoes to erupt. For a demonstration of this, we went outside. I took a two-liter bottle of club soda (two-thirds full), placed a thumb over the top, and shook the bottle. Then, making sure to point the opening away from the children, I uncovered the bottle top. The startled children jumped back as the club soda squirted out. When we went inside, the students eagerly shared their explanations as to why the club soda had shot out of the bottle. Some suggested that "the pressure inside the bottle made the soda squirt out," while others were sure that "the pressure outside the bottle squeezes the sides of the bottle and made the soda squirt out." Others even said I squeezed the bottle and made it come out. I spoke about the ingredients in club soda and how the carbon dioxide added to the bottles just before being sealed makes them and other sodas fizz. A few of the students were concerned and asked if this could kill a person. I explained the difference between carbon dioxide and carbon monoxide, the poisonous gas. I was surprised by the amount of vocabulary that was emerging from this demonstration. I explained that the shaking of the bottle agitates the molecules, increasing the pressure in the bottle. When the top was uncovered, the extra pressure forces the soda out of the bottle. Then one student explained that the same thing had happened to her when she dropped a bottle of soda and then opened it. "It foamed up and squirted all over the place," she said. After making a list of other phenomena that are influenced by differences in gaseous pressure, I went back to the concept that the most powerful demonstration of gaseous pressure is a volcanic eruption.

According to Miller, Steiner, and Larson (1996), in order to facilitate conceptual change in children, one should encourage the exploration of a wide variety of sensory experiences. Children learn through different modalities, and this is why I used hands-on experiments, videos, books, class discussion, journal writing, charts, and any other resources the children wanted to bring in. All of these materials and experiences helped support the fourth strategy used in the study, (that is, that of confronting the child with evidence that indicates the validity of a "new" concept). As suggested by Ross (1994), sensory experiences and the confrontation of inappropriate prior knowledge can take place through the use of children's books. Literature can supply an excellent medium to provide concept validity and, therefore, to challenge existing, erroneous beliefs.

Having said this, it is instructive to note the results of a study conducted by Mayer (1995). The researcher used the book *Dear Mr. Blueberry* and read it to children in grades K-3. In this book, a teacher corrects a young girl's misconceptions about whales. Mayer interviewed the students before and after reading the book. She found that the students had not acquired a significant amount of new information from reading the story. In fact, she states that some responses to her questions supported the idea that some children's literature may actually *interfere* with science learning and that misrepresentations in the text and illustrations can confuse children.

Fortunately, this did not occur with my class. The students had been exposed to enough of *The Magic School Bus* books to know the author's style. They knew that the illustrations are many times purposefully inaccurate. The illustrator presents some information in a humorous way. I also pointed out the misconceptions. I made sure that the children had the opportunity to identify and explain the fallacies in the story so that any misconceptions they had would be addressed and dispelled. Several other books also were introduced to the children. There was an array of books related to volcanoes, rocks, minerals, earthquakes, and the earth around the room. The children were free to read them, and many of them even came back from the library with books of their own on these topics (see Appendix E, p.175).

As a culminating activity, the students were to make a volcano using the facts they had learned about their shape, form, texture, etc. They had to present their knowledge through the use of graphs, tables, diagrams, and words along with their manufacture of a "volcano." They constructed their volcano with clay as a group and had to describe it, reviewing what causes it to erupt. I helped the groups make "eruptions" and asked them what caused the "lava" in their volcano to flow out of the top. They recorded their observations and shared with the members of their group.

Findings

As I reflected on the progress of the study, I discovered some encouraging results. When students compared and contrasted their previously recorded predictions with what they had learned through classroom teaching/learning, reading books, keeping learning logs, observing discrepant events, and doing hands-on activities, it seemed that they began to understand new concepts and were able to use the vocabulary in their conversations. The children then began to construct a more appropriate understanding of the scientific principles related to geology and earth science.

> Children make sense of the world in a very concrete way, and literature and storytelling unaccompanied by scientific explanations can lead to misconceptions (Miller et al., 1996).

It was also interesting to note that several students began to consult their science textbook for answers to questions they had. They used the text as a source for information, but it was no longer their primary source. It was exciting to watch these children engage in a scientific conversations and understand what they were saying to each other. Five of the six targeted children also were demonstrably involved in the activities. The sixth child was more involved than he had been before this research was conducted, and although he was still not involved to the degree that I had hoped for, I considered this also to be a success. I believe all the children benefited from this experience. The new knowledge was added to the students' extant knowledge; therefore, the children were able to assimilate it and change their prior understandings. They were given experiences to help them make sense of the new knowledge.

"Children make sense of the world in a very concrete way, and literature and storytelling unaccompanied by scientific explanations can lead to misconceptions" (Miller, Steiner, & Larson, 1996, p. 27). Teachers can help students overcome their misconceptions by integrating science and children's books in the proper context, using literature to support good science teaching. I found that through the use of children's literature, a teacher could offer students the chance to work through a needed conceptual change to achieve a deeper understanding of scientific concepts and create interests in further learning.

Conclusions

During this unit, students not only learned about what is inside the earth and about the nature of volcanoes, but also about weight, density, buoyancy, pressure, physical changes, erosion, and chemical reactions. Several words (that I did not plan on covering) emerged during the course of the study, and the children understood them because it was part of what they were doing. It became part of their experiences and, thus, part of their extant knowledge. I was very impressed with the progress of the students. The students were all actively engaged in all of the activities and reading of the literature. They were able to identify and explain meanings of words and concepts using real life terms, not just by memorizing what the book said.

Afterword

I believe a teacher's ability to communicate enthusiasm with students is a necessary ingredient for building a community of learning. If the teacher is excited about the material being presented, the children seem to pick up on his or her excitement in a contagiously productive way. This action research study gave me added enthusiasm for teaching and learning. I was able to see concrete evidence of the difference I was making daily in my students' lives.

As a result of my action research, I have learned many different things mostly about my students and myself. This has been a long, hard road, but I feel that it has been a worthwhile journey. I like to structure activities, and I feel that I need to set boundaries. However, I did find myself taking an emergent approach to the research as I saw what was working for my students and kept adding to their tasks. I also found out that children may complain at first, but they also love a good challenge. When the motivation is there, they are willing to work hard because they know the rewards will mean so much more to them if they achieve something they thought impossible. This is the same lesson I learned from this research. The action research was a terrific experience for me, and I believe the children benefited from the experience as well. ◆

CHAPTER NINE

Using Conversation to Improve the Learning of Science

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Laura Vogl began her career teaching in the Dade County Public School System in 1990. Eight of those years were spent teaching Middle School Comprehensive Sciences I, II, and III. Presently, she teaches Honors Physical Science and Honors Biology at Coral Reef Senior High in Miami, Florida. Laura received her Bachelor of Science degree in Biology from the State University of New York at Albany and a Masters of Science in Science Education from Florida State University in Tallahassee, Florida. She is a member of several organizations including Miami-Dade County Science Teachers Association, United Teachers of Dade, and the National Association for Research in Science Teaching. Laura is currently pursuing National Board Certification in adolescent and young adult science, and during her free time, she enjoys scuba diving in the Florida Keys.

Abstract

The purpose of this research study was to evaluate the use of certain discussion strategies as a means of enhancing the learning of science taking place within my classroom. Two strategies identified for the purpose of increasing reading comprehension and developing independent thinking were modeled and implemented over a period of six weeks. Findings of the study suggest that the amount of prior knowledge a student possesses is an important factor in the level of success or failure associated with improving the quality of scientific discourse.

Conversation and Learning

Children cannot be expected to learn when they are not actively involved in the process. Each one of us comes to a learning situation with prior knowledge, which can be either correct or incorrect, according to conventionally accepted meanings and definitions. No one individual, though, has the total picture. We live in a social world and come to know it by interacting with others. It is believed that by pooling our understanding and talking about what we think and know, we emerge from instructional conversation with a deeper understanding and a clearer focus for more learning.

Traditionally, classroom discussion has been focused around teacher-centered dialogue. This commonly takes the shape of individual teachers asking many questions of their students. Cazden (1988) calls this model of discourse “IRE.” It is exemplified by a teacher initiated (I) question followed by a student response (R) and then teacher evaluation (E). This model often results in nothing more than an exercise in recitation and seldom leads to knowledge that students can internalize and use to create their own inferences. This type of teacher-student dialogue becomes more a convenient means of assessing rather than teaching. While teacher directed questions do serve a purpose in the classroom, I wanted to look for ways to improve upon the type of dialogue that was taking place within my classroom. I wanted my students to be less dependent on me as the “giver” of knowledge and more responsible for their own learning. I was looking for the means to better my classroom community through the use of discussion, to allow students to construct their own meanings, and then to test their ideas and consider the ideas of others.

Setting

> Most parental contact occurred as a result of inappropriate behavior on the part of the child, and at times, such contact by the school largely was perceived by the parent as being antagonistic.

During the time in which this study was conducted, the student population at my school was 1,461. This number was expected to increase since several nearby apartment complexes were nearing completion at the time. The research site is in the center of a small agricultural town outside of a large metropolitan area. Built in 1978, the school was retrofitted in 1996 to incorporate modern technology such as networked and Internet-ready computers. Of the total student population, 88% qualified for free or reduced lunches, 51% of students were classified as Hispanic, 36% were African American, 11% were Caucasian, and less than 2% were Asian and/or American Indian. The history of parental involvement at the school was poor despite recruitment efforts by the Parent-Teacher-Student Association (PTSA). Unfortunately, the parents were not actively involved with the school in order to support their children's education. Most parental communication or feedback occurred as a result of teacher correspondence and teacher conferences or after administrative contact with the parent. Most parental contact occurred as a result of inappropriate behavior on the part of the child, and at times, such contact by the school largely was perceived by the parent as being antagonistic. Some of the surrounding businesses participate in school activities, and with their help the school is trying to promote and encourage additional parental involvement.

Methodology

The students participating in the research study were in my seventh grade Comprehensive Science II advanced course, and their stanine scores ranged from two to four. These students' reading comprehension scores on the 1995-96 *Stanford Achievement Test* were below the national average. The group consisted of 15 males and 19 females who generally were from a middle to lower class socioeconomic background.

Before implementing any reading/discussion strategies with my focus group of 22 students, I felt it important to survey my students on their views of the subject. A survey consisting of eight "yes" and "no" questions followed by nine free response questions was administered. The following table with the results of this preliminary survey provides some general information of this group's experiences with reading.

Table 1: Student Survey Prior to Implementation of Strategies

	Yes	No	Undecided
Reading is important to them	17	4	1
Reading is important to their parents	20	2	
Enjoys reading on their own time	12	10	
Feel that they read on grade level	17	3	2
Enjoys reading school materials	5	17	
Thinks becoming a good reader is easy	11	11	
Thinks the more you read the better you get	19	3	
Does not mind SSR* in school	12	10	

* *Sustained Silent Reading is a program in which the school population silently reads for 30 minutes on Tuesday mornings.*

One of the joys I derive from teaching is when I get a student response that I had not anticipated or that had not occurred to me.

I was surprised by some of the results of my preliminary survey. I would never have predicted that some students would feel that reading was unimportant to them or to their parents. These results could suggest a diminished perception of the value of education that is being filtered down through familial lines. Another outcome to be noted is the fact that the majority of the children saw themselves as reading on a seventh grade level even though the stanine scores for this target group ranged from two to four. Many of these students seemed to be unaware of the basic skills they were lacking. The students were evenly divided in their opinions as to the ease of becoming a good reader. No great surprise was the high percentage of students (77%) who felt that the reading of school materials such as textbooks was not an enjoyable experience. A possible explanation has been offered which demonstrates that the number of words presented in most science texts far exceeds the number of words in a foreign language text (Holliday, 1991). When so much of the text is centered on vocabulary in the form of excess jargon, is it any wonder that students do not derive enjoyment from it? In analyzing the open-ended questions, a series of patterns began to emerge. The majority of the students associated the speed with which a passage is read with the ability of being a "good reader." Comprehension never entered into the discussion. One of the open-ended questions asked the students if they felt that reading involved talking and communicating and also asked them to explain why or why not. From the group of participants, 14 out of the 22 students surveyed (64%) responded "yes." Their rationale to support this reasoning had to do with being able to communicate with others about what they had read. Were their questions left unanswered? Did others agree with the author's point of view or information presented? One of the joys I derive from teaching is when I get a student response that I had not anticipated or that had not occurred to me. It puts a smile on my face to know that the student constructed it on his or her own. This was my experience when evaluating the question regarding the involvement of reading and communication. One student responded:

> "Yes. Reading involves talking and communicating because some people are far away or can't talk so they need to write letters and other person reads it."

Setting the Ground Rules

Before beginning any discussion strategies, I felt it important that basic ground rules be established. The rules were developed collaboratively by the class and posted in a visible location in the room. I led the discussion by suggesting some rules that might be used as a guide, then allowed the class to brainstorm ideas. The brainstorming activity lasted approximately 18-20 minutes, long past my time estimate. Many redundant rules had been written out on the board, and so the next step was to have students condense them and select the handful that were most important to the class. This final decision would be the basis for the ground rules throughout the upcoming planned activities. After reaching a consensus, the rules selected were as follows:

1. Respect others.
2. One person talks at a time.
3. Be mature.
4. Be honest.
5. Listen. Pay attention.

The class was made aware that these rules would be posted in a prominent place in the classroom and referred to as necessary during discussion sessions. In addition, they could be amended or refined if the class felt that the need arose.

Implementation

Most students do not think about the mechanics involved in learning. This is an important process that should be understood. One of the most effective strategies for having students become more aware of their own thinking is for the teacher to model the desired behavior. It is suggested that the teacher must show, tell, model, demonstrate, and explain not only the content but the process involved in active reading (Bauman, 1987). When teachers share their own cognitive processes with the class, students become more aware of how learning and comprehension take place. The teacher must set the stage for modeling activities. I began modeling the first strategy to be implemented by explaining what the strategy was and how it would benefit the students to use it to improve their learning. If students are unaware of why they are performing a particular activity, they seldom, if ever, repeat the behavior on their own. The second step involved demonstrating the actual strategy and discussing the procedures for implementation. Once the behavior was modeled, the students were charged with carrying out the activity on their own. Feedback and guidance were provided throughout the discussion sessions.

Strategy #1: *Think-Pair-Share*

Having students just listen or read is not enough. Learning is not a mechanical translation. Students need to be active participants in their own learning. Classroom communities where students write, talk, and teach one another are sites for increased comprehension. Students understand and remember ideas better when they have to transform them from one form to another. Transformation takes work, both on the part of the student to become engaged and on the part of the teacher to motivate. I selected *Think-Pair-Share* as an initial strategy to incorporate in my classroom, based on its ease of implementation. *Think-Pair-Share* is a discussion strategy, which can be utilized with any curriculum (Kagan, 1989). It is regarded as a powerful tool based on the premise that every student becomes an active participant. It is suggested for use anywhere in a lesson, such as as an opening activity, mid-lesson, or as a conclusion and wrap up. The procedure is as follows:

1. The teacher begins by suggesting a topic or asking a question.
2. Students are then given time to think about what they know or have learned on the particular topic. These thoughts are jotted down.
3. Students are then paired to share their ideas.
4. The activity concludes with a class discussion.

> When teachers share their own cognitive processes with the class, students become more aware of how learning and comprehension take place. The teacher must set the stage for modeling activities.

Sounds easy, right? Now it was my turn to implement this strategy. I was beginning a new lesson on the circulatory system, and due to time constraints with my research, I used the initial *Think-Pair-Share* activity to activate prior knowledge on the subject. After explaining and modeling the procedure the following question was posed to my students: "How is the blood in the arteries similar or different to the blood in the veins?" My initial planning allotted about five minutes for individual student thought and response writing, after which eight-to-ten minutes would be given for "pair sharing," followed by 15 minutes of class discussion. One student videotaped the session as she walked freely around the class. Not wanting to be committed to the lone view from a tripod's fixed position, I made sure that the camcorder's battery was fully charged for all videotaping of sessions. I did not interfere with students working independently nor while they were in their groups. I acted more as a casual observer and spoke up primarily when students were off task. As I perused the class during the initial activity, I observed that approximately half a dozen students had nothing written down on their papers. When questioned about this, responses varied from blank stares to the all too familiar "I don't know." My students have taken this kind of response to a new level, as it is not uncommon to see responses to written assignments answered as "DK", with the translation of this being "Don't Know." Immediately following the paired session, we broke for our scheduled half-hour lunch. I took the opportunity to record my thoughts in my journal:

> **Think-Pair-Share Activity Trial #1:** Overall things went O.K., I guess? My time estimates were way off—individual and paired activities concluded faster than expected. Did my students get to the task at hand expeditiously, or was there no knowledge on the subject for them to pull their thoughts from?

Resuming after lunch, we continued with the group presentations to the class. My worst fear was being realized—the content knowledge was not surfacing. The following were some of the views presented to the class:

- "The blood helps us breath."
- "The veins are like lines, and the arteries are not."

What did this mean? Did my students possess an understanding but an inability to verbalize it in correct scientific detail, or were they grasping at straws? Had the students taken this to be a 20-minute exercise in free time with one or two minutes devoted to science? After collecting data from the videotape of the session, it appeared to me that much of the class time was spent on social extraneous activities. I kept in mind that associated with any new activity is a learning curve and that my students and I were starting at the beginning. Teachers who utilize cooperative learning group strategies know the difficulty of keeping students on task when the room is divided up into 15 or more groups with only one teacher to monitor progress. The subsequent viewing of the video recording assisted me greatly in picking up on what was happening in places where I was not present. My camera person seemed to excel in zooming in on students off task. She was usurping the power and authority bestowed on her via the camera. Through the taping, valuable data sources were being revealed to me. While there was more off-task behavior than I would have cared for, there also was much evidence of on-task behaviors. My students were constructing their knowledge of the topic, even if it did not fit with my preconceived notions of what their knowledge should be. Students were caught on tape holding out their arms tracing the veins exposed at the surface of their skin and discussing the "arteries" they saw. They discussed how blood and air were related to each other. They just could not verbalize the correct scientific terminology and concepts that corresponded to their observations.

Science talk was being generated in my classroom. I observed one student telling her partner that "when arteries get clogged, the body can't function properly." Confused by this, her partner questioned her on it. The young lady responded, "The blood slows down and you might not get enough oxygen to your brain." Both girls then tried to figure out what could cause the arteries to clog. When their prior knowledge and textbook resource did not satisfy their curiosity, they called me over and asked for my assistance. I was also contented after review of the video to hear additional on-task conversations taking place. One such recorded instance came from a boy and girl who talked about the fact that the blood is blue or red depending on the amount of oxygen present. I did not observe this discussion during class time nor did it come up in the group discussion. Could it be that this *Think-Pair-Share* strategy had merit after all?

The students I teach lack confidence in themselves to present their ideas for fear of being incorrect and embarrassed in front of their peers.

I have since utilized *Think-Pair-Share* activities on six occasions within my classroom. With each successive occasion, I find that less time is spent modeling and more time is spent with students on task. There is still a struggle to keep my students conscious of the ground rules as multiple talkers are seen and heard quite often. I can frequently be heard on the videotape saying, "Rule number two, rule number two." My students have amended rule number three from "Be mature" to "Follow the rules" since different definitions of "mature" existed in the classroom. I have not yet developed full confidence in the power of this discussion strategy. I have seen in my particular classroom that it works best when utilized midway through a lesson or at the conclusion. The students I teach lack confidence in themselves to present their ideas for fear of being incorrect and embarrassed in front of their peers. Demonstration of increased *Think-Pair-Share* participation is observed after the students are more confident in themselves and feel that they are familiar with the subject matter. To activate prior knowledge at the commencement of a unit, I feel my students respond better to brainstorming aloud. Every comment is written on the board without judgment, then sifted through for what is kept and what is erased via discussion afterward. This activity has the tendency to elicit more responses from my students. Students are not dependent on themselves or their partner since they can "feed off" and get ideas from the whole learning community from the onset. Some of the weaker students might just mimic what has already been said, but it is my opinion that some participation is certainly better than none at all.

Strategy Number Two: *Read-and-Say-Something*

After feeling confident that the class understood the premise of the *Think-Pair-Share* strategy, I decided to implement strategy number two of my research plan. Since reading comprehension was a weakness with the majority of my students, I again decided to focus on activities that would increase comprehension through the use of discussion. I selected a strategy called *Read-and-Say-Something*. Again, I based my decision on several factors: time constraints, ease of implementation, and the difficulty presented to my students in reading the science text. The *Read-and-Say-Something* strategy is designed to work effectively with difficult material. The idea behind this is that instead of having children struggle alone with meaning, they could help each other to discuss the ideas. As with the *Think-Pair-Share* strategy, I began with an introduction and modeling for the class. The procedure was as follows:

1. Students were asked to read a passage silently. It was suggested that more difficult passages be broken down paragraph by paragraph.
2. After the individual silent reading, students, were paired as partners and said something. They were free to say anything related to the passage.

What attracted me to the *Read-and-Say-Something* strategy was the ease of implementation and that it afforded the opportunity for student-centered discussion. My students caught on to this activity much faster than the one previously selected. I noticed immediately that the discussions were much more science centered than with the *Think-Pair-Share* activities. My journal reflected more of a feeling of confidence that "learning took place today!"

By meandering through the student groups as well as observing what was recorded on the videotape, much more on-task behavior was present. I was immediately struck with the question, “What would account for this?” Both strategies employed were quite similar in nature. What made one so much better suited for my class environment over the other? After viewing the first two tapes of the *Read-and-Say-Something* activities, patterns began to emerge. It became evident to me that much of the student discourse was taking place because there was a lack of pressure. The students did not have to come up with something that they already knew about the topic, as in the *Think-Pair-Share* activities. Students were allowed to express whatever ideas or thoughts they wanted to when involved in *Read-and-Say-Something* activities. They were free to react to ideas and descriptions, as well as to pictures presented in the text.

More often than not, what I found being discussed were questions that the students had on their minds. The discussions tended to center on areas of student confusion. There was evidence of peer tutoring taking place within the confines of the group work. Students appeared more eager to open up when they were afforded the opportunity to ask questions of their peers and did not have to rely solely on what they already knew. Again, this brings me back to the self-confidence issue. Students who characteristically are underachievers lack self-confidence and are more likely to be unwilling to put themselves on the line and take risks. It is only in non-threatening situations that these students will make any attempt to take a risk. The utilization of the *Read-and-Say-Something* strategy did not present a danger to my students. After eliciting my students' thoughts on the *Read-and-Say-Something* strategy, it became apparent to me that they looked upon it as a “win-win” situation. When I questioned them further on this I was told that:

> “Even if you didn't know anything about the topic, the worst case scenario was to just repeat something taken from the book. Or if you really wanted to live dangerously, you could ask a question and put the burden of ‘thought’ on your partner.”

> I wanted them to understand that we might come away from our reading assignments with more questions than when we started and that having questions is not a sign of comprehension weakness but a sign of a good reader….

After observing a handful of groups reciting from the text during the initial and subsequent *Read-and-Say-Something* activities, I began to modify the focus during subsequent sessions. On one occasion, I utilized the activity as a means of reviewing class notes. Students who were confident in their understanding of the material could be observed tutoring partners who were not so clear. Here were “surrogate teachers” in the making right before my eyes.

Since this activity was carried out during the conclusion of our unit on the circulatory system, the discussion tended to focus more on extension-type questions than review. One group was observed asking each other:

> “How do doctors fix the problem if a mother and baby have different type Rh factors in the blood?”

These examples of authentic questions allowed me to segue into an important point that I wanted to get across to my students. Individual readers have their own questions and their own ideas. I wanted my students to understand that these questions that come to mind are genuine and valid. Additionally, I wanted them to understand that we might come away from our reading assignments with more questions than when we started and that having questions is not a sign of comprehension weakness but a sign of a good reader who monitors his or her own comprehension.

Conclusions

Participation and discussion from my students was far more positive and task directed as my students gained confidence in their understanding of the subject matter.

At the onset of my research project, I was wrapped up in the literature review as excitement built for the task I was about to undertake. There is certainly no lack of written resources available for teachers to utilize, only the problem of having the time to avail oneself of those resources. A lot of time and preparation was put into locating and utilizing research focusing on teaching students how to learn through the use of reading, writing, talking, and listening. In the back if my mind, as I began the process of sifting through the various strategies researched, I kept asking myself "How do I know if I am selecting the best ones?" Since time was of the essence during my research period, I had to rely on my emic knowledge—or my "insider knowledge"—as a professional teacher. I selected two strategies, which were employed as a means of increasing my students' learning of science. I focused on activities that were designed to increase comprehension through the use of discussion and talk-centered activities. Both strategies were selected based on their ease of implementation, which accommodated the narrow time frame available, in addition to being flexible for use at any point in the curriculum. The strategies are founded on constructivist principles where students construct their own meanings. As student discussions evolve, students then test their ideas and consider the ideas of others.

The first strategy implemented—*Think-Pair-Share*—is designed to get every student involved as an active participant. I found this not to be the case in my class. In general, I found that it was difficult to engage my students in rich scientific discourse through the use of *Think-Pair-Share* activities. It was used as a means to activate prior knowledge at the beginning of a new unit of study. My initial attempts utilizing this activity in the classroom proved to be less than fruitful from my perspective as a teacher. For example, conversation broke down when discussions lacked prior knowledge elicitation, and the groups struggled for a focus. This often led to off-task behaviors. In general, my students felt unsure of whether their conceptions were correct and, therefore, were less willing to come forward with the information. Their lack of self-confidence inhibited them from fully partaking in the design of the activity. I have had much better experience eliciting prior knowledge from this group of students through the use of journal writing and brainstorming. Both of these activities are looked upon as non-threatening by my students who derive greater participation from them. I do not wish to leave readers with the impression that I could find no value in the *Think-Pair-Share* activities. On the contrary, I found it to be a useful tool as a break from lecture or as a means of review or follow-up activity. Participation and discussion from my students was far more positive and task directed as my students gained confidence in their understanding of the subject matter.

The second strategy employed was a strategy designed to assist students when reading difficult material. This activity caught my attention after reflecting on the fact that more than 75% of my students surveyed responded that they did not enjoy or look forward to reading material from our text. The *Read-and-Say-Something*, if effective, could help alleviate some difficulties my students had in this area. Both the students and myself found this activity to be the most beneficial of the two for their science learning. Students were not as fearful of looking "dumb" since they were not obliged to reveal their knowledge. It was O.K. for them to ask questions of their peers. Peer tutoring seemed to follow a natural progression when implementing this strategy. I observed some of my brighter students pairing together and trying their hand at a friendly competition of "stump your pal." The conversation was certainly much more scientific in nature, even through the content knowledge was not always constructed in a technically "correct" manner. I also found evidence of more authentic questions being generated through the use of *Read-and-Say-Something* strategies. An increase in discussions derived from authentic questions generated by my students can only benefit the learning of science which takes place in my classroom. Once my students realized that their questions were taken seriously and that asking questions was "safe," authentic questions tended to emerge. As a result of implementing both strategies, class and small-group discussions have taken a step toward becoming more scientifically enriched in addition to being more student centered. Time and continued classroom research will take my students and me even further.

Currently I am researching strategies that focus on helping students develop their own questions generated from higher levels of thinking and which assist students with their own critical inquiries. ◆

CHAPTER TEN

How Do LEP Students Acquire and Develop the Language of Science?

Lizette Aladro
Jack D. Gordon Elementary School, Miami, Florida

Years Teaching: 9
Present Position: Second Grade

Teaching is more than a job for me. I am given the challenge to educate many young minds from different backgrounds and experiences. I feel very lucky to be a teacher. Each day is a wonderful experience.

This action research study has given me many opportunities to reflect upon my teaching and the students' learning. I believe that the experience has assisted me to reach for newer heights and to grow from each experience.

Olga Suarez
Kinloch Park Elementary School, Miami, Florida

Years Teaching: 8
Present Position: K-5 Spanish and CCHL (Curriculum Content in the Home Language) teacher.

Teaching science to fifth graders in their native language is a challenge. My goal is to make science meaningful to the students. I provide them with as many experiences as possible through hands-on activities, videos, computers, and field trips. By being exposed to science through many media, students become aware that science is all around them.

Abstract

Our action research study investigated the acquisition and development of the language of science by students with limited English proficiency (LEP). In addition, the research was designed to improve the quality of instruction associated with these students. Over a five-week period, the study took place in a second grade classroom with 13 LEP students who were either at ESOL (English for Speakers of Other Languages) levels III or IV. Each student was interviewed, and brief descriptions of the interviews are included below. The research was organized in the following manner: data collection, findings, and implications. The data were collected from student and parent surveys, teacher field notes, students' writing, and observations of a student teacher. All data were carefully examined and reviewed in order to identify prevalent patterns in the classroom. These patterns led to the formulation of certain assertions that helped us to focus on the correlation between them. The data were repeatedly reviewed, and assertions were revised as necessary.

Review of Limited English Proficiency

After reading an early version of an article by Erickson (1998) on qualitative research, we decided to undertake our own interpretive, qualitative research study. According to Erickson, qualitative research is extremely beneficial when one seeks detailed information about everyday occurrences. It also becomes an ideal method to identify the constructions that have developed from these occurrences, especially when the researcher is concerned primarily with the qualitative nature of what is being studied. A qualitative study is an excellent avenue to observe, interpret, and comprehend the changes that occur after certain implementations, for example, in classroom instruction or educational policy. The purpose of our study was to identify the acquisition and development of the language of science by LEP students. An additional goal of the study was to improve the quality of science instruction according to the implementations developed.

A student is designated as LEP when the individual was not born in the United States, his or her native language is not English, or he or she comes from a home environment where a language other than English is spoken. The student has difficulty listening, speaking, reading, or writing in English for the above mentioned reasons, to the degree that he or she is unable to learn successfully in classrooms where English is the language of instruction (Florida Department of Education, July 1995).

In August 1990, a judge of the United States District Court, Southern District of Florida, signed the *League of United Latin American Citizens (LULAC) et al. vs. State Board of Education Consent Decree*, giving the court power to enforce an agreement between the Florida State Board of Education and a coalition of eight groups represented by Multicultural Education, Training and Advocacy, Inc. (META). The Consent Decree settlement terms centered on the following six issues: identification and assessment, equal access to appropriate programming, equal access to appropriate categorical and other programming for LEP students, personnel, monitoring, and outcome measures. Under Section IV of the agreement, the personnel component of the Consent Decree requires teachers to take classes in order to comply. Teachers with no prior experience in teaching LEP students and whose major responsibilities include English language teaching are legally obligated to obtain an ESOL endorsement. The requirements for the ESOL endorsements are as follows: methods of teaching ESOL, ESOL curriculum and materials development, cross-cultural communication and understanding, applied linguistics, and testing and evaluation of ESOL (see also Sweeney, 1997a; Florida Department of Education, March 1995; Florida Education Association/United, 1994). A few years ago, one of the authors of this study (Aladro) completed the requirements to obtain the ESOL endorsement.

Background and Purpose of the Study

During the 1996-1997 school year, the first author of this study (Aladro) was a second grade teacher at Jack D. Gordon Elementary School. The second author (Suarez) was a Spanish teacher at Kinloch Park Elementary School. The study took place in Aladro's second grade classroom. Aladro conducted the primary research reported in this study, and, with the assistance of Suarez, the data were analyzed and assertions were constructed.

There is a large population of LEP students in Dade County, Florida. According to Dade County Public Schools' District and Schools Profile publication (1997), the total percentage of LEP students was 16% for the 1995-96 school year. As teachers, we should be aware of, and knowledgeable about the different cultures in our classroom. We thought it would be interesting to investigate how LEP students acquire and develop their use of the language of science. The LEP students we wished to study received their science instruction in English. We wanted answers to some of our questions: How much were they understanding? How much knowledge were they able to obtain and process? Were they able to transfer this knowledge? All of these questions and associated issues aroused our interest. In addition to seeking answers to our questions, we wanted to reach these students and meet their needs. We believed that these students needed to be empowered in the area of science in order to open doors to their future.

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Statistically, minorities are hardly involved in the science community. Science careers typically are perceived to be the purview of middle class, white males. According to Moll (1992), most of the LEP students in the United States come from working class homes. Moll believes this is a major concern for the goals of science in our country. Typically, the instruction of LEP students consists of rote memorization, drill and practice, and other intellectually limited forms of instruction. In our diverse world, the time has come for a change. Minorities should take a more active part in our science community. Consequently, another goal of our research was to reach students who may not have had the opportunity to experience success in science. We hoped to be able to make a change and to empower our students. We wanted them to feel as if they were a part of the science community.

Aladro's Reflections of Her Teaching

Some time prior to conducting this study, I videotaped myself demonstrating a science experiment to a first grade class. Since I had been their kindergarten teacher, I had taught these particular students for two years. I felt very comfortable around the students and believed that the classroom exemplified a positive learning environment. There were three LEP students in the class. The videotape was an eye-opening experience, to say the least. Since this was my first time videotaping myself teaching a lesson, I was a bit nervous. Afterward, I observed myself stumbling through an experiment in which all the students wanted to be involved; however, only a few were allowed to participate. The kind of science learning that I knew needed to occur in a classroom was not taking place in my room—and I had previously thought that I was reaching all of my students! It was obvious that I was not helping these students reach their potential. They were not a part of the science community in the classroom. I was the one "doing" and not the students. I felt awful!

> The videotape forced me to ponder my beliefs and practices. They were not connecting. My practices were not representing my beliefs.

After reading *How NOT to be a teacher: Opening doors to student self-expression by making sense instead of judgments* by Dykes (1995), I found myself thinking about the teacher I desired to become. The teacher within me wanted to allow for exploration and discussion, introduce activities that would promote interest in learning, be kind and thoughtful, and foster the development of an environment where all students would become risk takers and involved in their learning. I also wanted my students to become active rather than passive learners. The videotape forced me to ponder my beliefs and practices. They were not connecting. My practices were not representing my beliefs. I was disappointed after viewing the tape of my science lesson. Later in the year when I found out that I would be teaching second grade in the subsequent semester to a group almost half of whom were LEP students, I knew that I had to change my way of teaching science. However, I did not know where to begin. After Suarez and I had discussed this problem at some length, Suarez began to assist me with my decision to develop a research plan to look at the way LEP students learned the language of science in my classroom. We were both aware that our developing understandings would need to be revised as necessary in order to incorporate our emergent and most current constructions and assertions (Guba & Lincoln, 1989).

Study Background

The research described in this study was conducted at Jack D. Gordon Elementary School, one of approximately 200 public elementary schools in Dade County, Florida. The school is located in a middle-class neighborhood in the southwest part of the county and was built for approximately 900 students. When the school opened in 1995, it was overcrowded. During the time in which this study was conducted, the school had a student population of 1,442, of which the majority was Hispanic/Latino.

Data sources were accessed from my second grade class consisting of 30 Hispanic/Latino students. Thirteen of the 30 students (43%) were classified at ESOL levels III or IV. The district plan for LEP students at ESOL levels III and IV provides 60 minutes daily of ESOL and 150 minutes weekly of Spanish, which is referred to as Home Language Arts. The rest of the 150 minutes of class time is taught in English using ESOL strategies to teach science, social studies, and mathematics. The students were from low to upper middle income families. All of the 13 LEP students had parents not born in the United States. Nine of the 13 students also were born in foreign countries. Five students had taken four semesters or less of English and were, therefore, exempted from taking the *Stanford Achievement Test*. These 13 students were "pulled out" from the classroom four times a week by another teacher for additional instruction in English. The teacher utilized techniques required by the state for instruction in ESOL. The data for this study were accessed during science instruction when the entire class (including the LEP students) was present. The science class was held several times a week to adhere to the Dade County Public Schools guideline, which recommends 150 minutes per week of science instruction. All science lessons and activities were developed in accordance with the Dade County Public Schools *Competency Based Curriculum* (CBC) in science, which is aligned to the state of Florida's *Sunshine State Standards* and the *National Science Education Standards*.

I believe that students need time in the day to have enjoyable learning experiences and to interact with each other.

The learning environment is very important to the learning process. I believe that the room should be student centered. The students generated almost all of the materials displayed in the classroom, since I wanted the classroom to exemplify their work. The arrangement of the furniture was conducive for promoting student interactions. I believe that children learn not only from their teacher but from each other. There were no desks. Instead, the classroom had eight large, rectangular tables. Each table was color coordinated with a cabinet that held the students' materials. The arrangement of the tables allowed for the frequent use of group work. According to Garcia (1988), children with Hispanic/Latino backgrounds who are learning English show gains in oral English development when the classroom environment enlists many opportunities to interact with English speaking peers. I believe that the seating arrangement in my classroom helped these students to do just that.

Four times a week, the students attended the different stations in the classroom. The stations were designated as science, language arts, mathematics, and reading, respectively. Half an hour was allotted for a visit to a station. One station was assigned to two tables. There were approximately eight students per station at any given time. Various materials were supplied for the students at each area. The students were given the freedom, most of the time, to do an activity of their choice. Occasionally, I designed and suggested a specific activity.

I believe that students need time in the day to have enjoyable learning experiences and to interact with each other. Station time was rarely taken away from them. I believe that the role of the teacher is to encourage and assist the students in their learning endeavors. I think that students are more eager to learn if the environment is relaxed; therefore, I encourage all students to take risks. I also offer a great deal of verbal praise and foster the celebration of all achievement. In an organized and strict manner, I try to create an environment where my second graders can learn successfully. The role of the teacher plays a significant part in the gains of LEP students' development of English (Garcia, 1988); therefore, I wanted a classroom rich with language from all students.

Methodology and Data Access

Data for the study were of various types. We composed surveys for both the LEP students and their parents and also utilized teacher field notes, students' writing, and student-teacher observations.

A student and parent survey was written by both of us. I designed and wrote the survey in a manner that was developmentally appropriate for second graders. Suarez, being a Spanish teacher, designed and wrote a survey in Spanish for the parents. Twelve of the 13 parent surveys were returned. Eleven parents responded to the survey in their native language, Spanish, and one parent responded in English. All 13 of the students responded to the survey in their ESOL class, which, as mentioned above, was taught by another teacher. It was felt that this would allow the students to answer with more freedom. In addition, all survey responses were anonymous.

Field notes were kept in a small spiral notebook close to my desk so that observations and reactions about what was occurring during the science lessons and during the science stations could be documented as they happened.

In the area of students' writing, a great deal of information was obtained. The students were asked to write on a "Science Talk" board attached to the wall in the science station. The "Science Talk" board was modeled after the graffiti board discussed in the authors' Florida State science methods class, and we thought that it would be an innovative way to collect data. It was also felt that the students would be indirectly required to talk about science. During the course of the study, I was able to collect data from three different boards. All students were asked to include their names with their responses and/or questions. Almost all students wrote their names. Many personalized their talk by blocking their space or circling their territory, which was interesting.

Data also were collected from students' worksheets and notebooks. I had the students watch various filmstrips either as a whole group or in smaller groups at the science station. After viewing the filmstrip, the students applied what was taught in the film. Most of the time it was an experiment that was self-explanatory. The students responded on a worksheet or in their notebooks. It was fascinating to observe these little second graders engrossed in watching a filmstrip and then providing engaging responses to what they had seen. The task of watching a filmstrip or a video related to science is an activity widely used in the elementary schools. At Gordon Elementary, the library is a great resource for visual materials. LEP students need numerous visuals to help them acquire an understanding of the subject. However, when there is no follow-up to the filmstrip or video, the teacher cannot accurately identify what the students have learned from their experience. As part of the study, we wanted to seek information in order to find out if the students had learned from this and other similar activities.

The last method of collecting data was for a student teacher to record observations of me and my students in the classroom. The student teacher was very eager to assist in the classroom. I asked her if she would like to help me collect data. I had her observe me teaching science either in a small group setting or with the whole class. At first, she did not know what to write down. I also did not know what kind of information I wanted her to note. I told her to just

"…write, write, and keep on writing." One day at lunchtime, after a science lesson, she told me about an incident with an LEP student, which had occurred during the lesson. I had responded too quickly and incorrectly to the little boy. I was not aware of my reaction until this was pointed out to me. I was excited! This was exactly the kind of thing I wanted her to record. I wanted an "outsider" to observe me with the LEP students. This particular student had poor language skills, and he was trying to explain something related to our science lesson. I did not understand what he was trying to say, and I had cut him off. The student teacher knew exactly what he was trying to say, and he was correct. This was a surprise to me. I was not aware that I had interrupted the student, but, after some reflection, I realized that I had. The student teacher wrote for several weeks until she had to teach science in order to fulfill her student teacher requirements.

In order to complete the study, I met with Suarez to analyze all of the data. All the data were systematically examined and reviewed, and patterns were identified. The patterns developed into a sample of ethnographic writing. According to Maanen (1988), ethnographic writing is complex. It presents problems as they occur. It is an evolving way to write about one's constructions over time. Our attempt at ethnographic writing is a description of what occurred in my classroom. The data were transcribed into a narrative of the happenings in this science classroom environment during a five-week period. Subsequent constructions were refined from our understanding of these patterns.

Findings

The student and parent surveys were written in order to access additional data. We had no idea what we would receive. I had the 13 LEP students and their parents complete a survey at the onset of the study. On the student surveys, mathematics was listed as the favorite subject by eight out of the 13 students. One of the students listed science as his or her favorite subject. Physical education and reading each received two votes.

From my experience, LEP students understand and perform better in math because there is no language barrier.

The next question I asked the students was why they chose the particular subject as their favorite. Seven of the students believed they learned a lot in the subject they had identified as being their favorite. I interpreted this to mean that it was relevant to their lives. They saw the importance of learning the subject; it was a part of their world. From my experience, LEP students understand and perform better in math because there is no language barrier. The LEP student who responded that science was his or her favorite subject probably had a better grasp of English and of the language of science.

In the science station, I posted a large piece of paper on the wall. It was placed at a level that allowed easy access for the students. I did this three times throughout the five weeks. Each time the paper was full of writing, I replaced it with another one.

I wrote the question, "What Is Science?" on the first "Science Talk" paper. I wanted the students to write on this topic. Therefore, on Monday morning, I took the time and explained to the whole class about the "Science Talk" board. I encouraged the students to write what they wanted as long as it was related to science. I only received four responses from the LEP students. Another LEP student began writing her name and the date but did not expand. The four who did respond answered positively about science. They wrote comments such as "Science is fun," "It is interesting," "Science is important," and "Science is about volcanoes and animals." The four LEP students were comprised of one boy and three girls. I found this to be an interesting situation. I may have received more from the females because these particular girls were strong writers. I was disappointed with the results from the first "Science Talk"; however, I decided to forge ahead and try another one but without a title. I believe the question I placed at the top of the paper may have inhibited the LEP students.

This time, I explained to the students that they were to write about whatever they wanted to say about science. I would check on the paper every few days. This time, I found that the students were writing up a storm. I could not have been more pleased. I had more than half of the 13 LEP students writing comments.

However, a problem developed. After the paper was completely full of students' writing (with more LEP student responses), I took the paper down to make my notes. Some of the students had copied from the various written materials I have at the science station such as "The Zoo Books" and other magazines or books related to science. Once again, I did not say anything to the students, but I was disappointed. Did I want the students to copy from a book instead of writing their own thoughts? After much thought and discussions with Suarez, I came to the conclusion that it was a start at least for them to become knowledgeable about written science material. Most likely if they were copying the material, they had read the material. Next, I looked at what they had written to see if it made sense. The material copied by the students consisted of interesting facts. I felt a bit better about the situation that had developed.

Only after having read some of the published research in the field did I feel satisfied with the above results. According to Bernhardt, Destino, Kamil, and Rodriquez-Munoz (1995), LEP students can read scientific information even though they do not have complete mastery of the language. LEP students should be given the opportunity to read science information in addition to completing hands-on activities. The LEP students' ability to read scientific information should be taped, reinforced, and enhanced (p. 8). We came to the conclusion that reading scientific information and what occurred during the second "Science Talk" could only be of assistance in developing the science language of these students.

The third "Science Talk" paper received very few responses from the LEP students. I again did not place a question at the top. However, this time I removed the books and magazines. I only had three responses from the LEP students. Again, there were more girls who wrote a comment. The two girls wrote in all three "Science Talk" papers. It was the first time for the boy, who wrote:

> Science is about leves and dinosaur water and anfibian and trees science is very important science is to learn.

I wish there had been more responses, but I was not able to reach a happy medium. Either the students copied and wrote a lot, or only the few who enjoyed expressing themselves wrote. This may have been more successful if I had used another method such as audiotaping their spoken comments.

Another activity at the science station was the science filmstrips. I organized two separate opportunities to view a filmstrip related to Earth Science during station time. First, the students watched the filmstrips in their groups. Next, I asked them to write a personal response about the filmstrip. The students were allowed to discuss the filmstrip with each other. Finally, if time permitted, the students were asked to share their responses with each other.

After a great deal of reviewing their written work in addition to my fieldnotes, I could identify the students who had a greater ability to express themselves in written form. The students who had longer and more detailed written responses felt comfortable and were capable of writing about their experiences. There were a few students who slipped by and did not write at all. I am not certain whether they chose not to participate or if there simply was not sufficient time for them to collect their thoughts and write. Another explanation for their lack of participation may lie with the teacher. I may have been too busy and simply forgotten to collect them.

On the third occasion, I decided to show a filmstrip to the whole class. Afterwards, I required all the students to write a response to the material on the filmstrip. I collected 12 responses from the 13 LEP students. One of the students was absent on that particular day and did not make up the assignment. Two of the written responses were incomplete. Later, during a brief interview, the two students explained that they had difficulty responding in written form. They did not write as well as the other LEP students. Orally, the two students were able to respond to the filmstrip.

In a 25-to-30 minute period, I believe my expectations were unattainable by most of the LEP students.

Finally, during the five-week period, several experiments were planned and undertaken. I had the students perform some of the experiments on their own in groups of seven or eight at their science station. The 13 students were mixed heterogeneously into four groups. Each group had the opportunity to visit one station per day; therefore, each student attended the science station once a week. I received eight responses from the 13 LEP students throughout the week. This led me to believe that I may not have organized my time adequately in order to ask for and collect a written response. After some reflection, I decided that the experiments were an exciting activity to perform during station time; however, they would require more teacher involvement in order to produce the kind of responses which I believe to be more productive.

The next time I wanted a written response from a science experiment, I planned the activity with the whole class and received a much greater level of participation. I was able to initiate interaction. The written responses were detailed and lengthy. The students probably had more information. Also, during the interaction, most of the students were able to express their constructions. The activity generated language, which, in turn, helped the LEP students with their own constructions. Most of the students drew illustrations to correspond with their thoughts. These illustrations were not included in the experiments during science station time probably because of the time limit; although station time was allocated approximately 30 minutes, it was usually closer to 25 minutes. The whole class experiments had a higher success rate in my opinion. I was able to reach more of the LEP students, even though the whole class was involved with the experiment at once.

When I initially began having science stations, I thought it would be a great place to provide an opportunity for experiments. Also, I expected that the language of science would develop within the task of completing an experiment. After looking at the responses, I had mixed feelings: the science station was a place where students could explore the different materials, but was I actually promoting the kind of learning that I wanted? In a 25-to-30 minute period, I believe my expectations were unattainable by most of the LEP students. I had asked them to do and to write about an experiment. This was not enough time for the students who were still learning English and acquiring the language of science. Although I had their best interests at heart, I may not have been allowing sufficient time for a scientific discourse to develop.

Methodological Reflections on the Study

From my data collection and analysis of the findings, I now believe LEP students acquire and develop the language of science through a strong emphasis on oral language in formal instruction. The results from this study revealed my over-reliance upon written language. According to Gallas (1995), talking should be a starting point for all new information to be learned. This study showed me the shortcomings of too great an emphasis on written language when LEP students are learning science.

Talking should have been an important part of the weekly science environment. I had considered tape recording students talking about their understandings and constructions. The class schedule should have been altered to allow for "buddying," talking, and whole-class discussions. Also, the pairing of a student who spoke English well with a student who was still acquiring the English language would have been beneficial to the LEP students.

LEP students learn best by engaging in experiences and assignments that allow them to feel successful.

LEP students learn best by engaging in experiences and assignments that allow them to feel successful. Also, their best learning might have taken place if I had modified my expectations after considering their level of language development. Since I relied a great deal upon written language, I should have made a word bank with some of the science words that the students compiled. In addition to having the students write, having them draw would have been beneficial. Many children can express their thoughts in pictures. It would have helped to shed light on the students' understandings along with those indicated by their written words. Records such as these would have interested me and enabled me to construct a better understanding of their acquired science language.

Instead of writing solo on the "Science Talk" page or writing after a video or an experiment, perhaps the students could have worked in cooperative groups or with a partner to map/cluster about the science topic. Another written activity the students could have accomplished with a friend or with a group might have incorporated the "cloze technique," which provides most of the words in a sentence and requires the students to fill in a word or words that complete the sentence. This technique works if there is time for the students to put their thoughts together.

LEP students may not have felt comfortable writing on the "Science Talk" page where all could see and read. The use of a private journal may have been a better tool. The journal would have allowed the students to make grammatical and spelling mistakes without their being on public display. The opportunity to make mistakes is a part of the process of learning a second language. Reliance on written language may not have assisted the students to acquire and develop the language of science.

Limitations and Suggestions for Further Study

After considerable analysis, assertions were constructed from the different types of data accessed as part of the study. I began the task with much apprehension. The concept of validating and forming constructions was new to Suarez and myself. In our years of teaching, are we ever asked to form constructions about what goes on in our classroom and why? Occasionally at a child study team meeting, we are asked to explain or verify our assessment of a particular student. We remained uncertain about how to construct assertions with only five weeks worth of data, and the assertions and constructions presented below reflect our beginning attempts to make some sense of what was encountered in that situation.

Currently, I think I have more girls who are risk takers. This is encouraging, since Malcom (1996) has suggested that females practically did not exist in the science world until recently.

The student-parent survey was a useful tool. I believe that it was an avenue to empower the students and their parents. They knew I would read and analyze their thoughts and comments. The survey was a great way to generate interest in the topic of science in school and also provided us with several insights into conducting future classroom-based research. Next time, I would make some changes. I would like to add a post-survey as part of a similar study. Also, after looking at the surveys from the LEP students, next time I would like to tape record their responses. Overall, the survey provided a great deal of information as described above which will be used in the future.

The "Science Talk" board appeared to be a functional resource, but I am still not certain that I was able to collect much from the students' responses. I believe that I probably was expecting too much from the LEP students. The time frame was a major factor. The area of concern was my reliance on their writing. I would need to make adjustments for further use, which might include, for example, encouraging the use of spoken language and also modifying data access techniques to include audio and videotaping in addition to the use of personal science journals. At this time I cannot say whether the "Science Talk" was a success or not, although more girls than boys participated in the writing.

Currently, I think I have more girls who are risk takers. The girls may feel more positive about presenting their thoughts about science in writing. This is encouraging, since Malcom (1996) has suggested that females practically did not exist in the science world until recently. If they were present, they were relegated to stereotypical roles with very little chance to move upward in the science field. Travis (1993) described a number of programs which encouraged females to get involved in science. One of these is directed by Wahl who explains:

> We thought about the qualities of a scientist, such as the ability to generate questions, to wrestle with uncertainty, and tolerate creative chaos, to have the courage to experiment and learn from failure. Furthermore, we posited that girls' socialization in this culture inhibits the development of these very qualities. Our answer to this problem was scientific inquiry, an approach that encourages questioning, exploration, discovery, and risk-taking (Travis, 1993, p. 413).

At the time of our study, Wahl was the director of programs at Girls Incorporated, which was previously known as Girls' Club of America. One of her programs, Operation SMART (Science, Math, and Relevant Technology), aims to help girls develop scientific inquiry and apply it to the world around them. I believe the results from my observations supported Wahl's point. Females need to become risk takers. From the "Science Talks," I observed patterns that have led me to an assertion that most of the females in my classroom are risk takers and have become science learners.

As I have previously mentioned, the science filmstrips are a great resource. However, next time, I would need a better tracking system. The students knew I was not successfully keeping track of who was responding to the film. The LEP students who completed the task may not only have been better writers, but they were probably more responsible learners. They understood the task and completed the requirements. I can say that for the most part, there was not enough time allotted for a rich discourse or rich engagement of the science language. I also did not incorporate sharing time, which, as suggested by Garcia (1988), is needed for gains in the development of English. Although it was not my intention to restrict their development, my reflections on the study suggest that I did limit their development. In the future, I think a collaborative written response with a heterogeneous group would be profitable for all. Although the group was heterogeneous, I still need to consider the writing abilities of the students. Some students' abilities to write may be low even if they are not LEP students. All of these factors need to be considered in order to design and enact a more useful study.

The science experiments also required a tracking system that I will have to implement for further use. The students needed to know that I would follow-up on their experiments during station time. A teacher or maybe even a teaching assistant could have been involved. The students would have understood more and might have obtained greater insights with the guidance of an adult who could have helped to develop a science-like discourse. Also, I should have encouraged illustrations. Some of the students did illustrate their ideas about the experiment, but next time I would ask them to begin with an illustration before attempting to write their responses. The illustrations could have been a useful source for the LEP students to develop the language of science.

The whole-class experiments were more successful because I was able to initiate a science discourse prior to the experiment. Also, a great deal of language was going on through my accessing of their prior knowledge and their constructions. The majority of the students were engaged in the class project, even though the experiment was done in groups of three or four. It is important to note (as my student teacher did) that I may not have understood all of their constructions. I still believe the whole-class experiments provided me an avenue to develop the language of science with my LEP students.

According to Bernhardt, Destino, Kamil, and Rodriquez-Munoz (1995), there are many paths by which LEP students may gain and express their science knowledge. It is the responsibility of the educator to bring these paths and experiences into the classroom.

Overall, this study of the learning of science provided me with great insights. It was definitely a challenge. I wanted to have a positive influence in the lives of my LEP students. According to Bernhardt, Destino, Kamil, and Rodriquez-Munoz (1995), there are many paths by which LEP students may gain and express their science knowledge. It is the responsibility of the educator to bring these paths and experiences into the classroom. This was my attempt to influence these students by showing them these paths and providing for these experiences. However, many times throughout the five-week period, I became discouraged. I recognize that I have high expectations for my students and myself. It was my first attempt at researching and working with LEP students. I cannot honestly say I was successful, but I can say I tried my best. I would change many things in subsequent studies. However, from what I have learned, I can say that I wanted to give more experiences, but I was restricted by the available time. I will have to address this issue. At last, I am attempting to bring closure to this rigorous but worthy process. I have learned a great deal from my students. I only hope to grow from this experience, as I hope they have learned from their experiences with science in my second grade classroom. ◆


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Number Chart

CHAPTER ELEVEN

Does Small-Group Discussion Contribute to the Understanding of Scientific Concepts?

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Dolores M. Rodriguez has been teaching for the past 15 years at Skyway Elementary School in Miami-Dade County, Florida. She received her Bachelor's degree from Biscayne College in Miami, Florida; a Master's degree from Nova Southeastern University in Fort Lauderdale, Florida; and her Specialist's degree in science education from Florida State University, in Tallahassee, Florida. This action research project took place in her third grade class. She currently teaches first grade.

Abstract

Hands-on science activities are an excellent way for students to actually experience science. However, in order to gain scientific understanding of the many concepts, there must be some discourse that goes along with it. This study suggests that small-group discussion is a highly useful instructional vehicle leading to scientific understanding. The study targeted two groups of six third grade students. They were given time to discuss any findings or questions as they went along in their journey through the third grade science curriculum. After the exploration activities and ample time for discussion, each group then presented their findings to the whole class. The research methodology consisted of teacher observations, interviews, and surveys. When students in the targeted groups made connections of science concepts to other areas of science as well as other subjects, it was noted in a journal. By interviewing the students before and throughout this study, the value of small-group discussion in leading to an understanding of scientific concepts became apparent.

Background and Purpose of the Study

In recent years, there has been a trend in science education toward reform. Research has indicated that students in the United States score lower in standard assessments of science knowledge in comparison to other students around the world. Many researchers and educators believe that there needs to be a systemic change in science education (Brooks & Brooks, 1993). In the past five years, my school has been involved with the Statewide Systemic Initiative (SSI) and an Urban Systemic Initiative (USI). These are federally funded initiatives trying to achieve improvements in science education. Personally, I have always been interested in the field of science. A few years ago when my school became involved in the SSI, I was one of the teachers chosen to participate in this program, which dealt with having science become an integral part of the elementary curriculum and teaching science concepts through a hands-on approach.

I personally traveled to the University of Iowa in 1994 to learn more about constructivism and science through the Chautauqua Program (Blunck & Yager, 1990). Here I saw a constructivist classroom at work. The Chautauqua Program was intentionally thematic, and science concepts were taught across the curriculum according to a constructivist philosophy. Constructivism is not a set program or a way of teaching, but rather is an epistemological position that proposes that the individual constructs knowledge through interaction with the surrounding environment and with other people (Tobin, 1998a). This program emphasized hands-on applications and was being implemented in many Iowa public schools. The students were constructing knowledge of scientific concepts and were involved in all aspects of their learning. This total involvement of students in the curriculum went beyond science to other subjects as well. The students in the program also scored from "average" to "above average" on the annual Iowa Basic Skills test battery. Seeing the success in Iowa convinced me even more of the need for systemic change.

The whole week while at the University of Iowa, I read much about constructivism. My involvement in the SSI had exposed me to this term, but I really did not quite understand it. In Iowa, I learned a little bit more. I learned that constructivism is not a theory about teaching strategies; it is a theory about knowledge and learning (Brooks & Brooks, 1993). Everything pointed to the realization that science needed to be taught in a manner that would allow students the opportunity to construct their own knowledge. Upon returning to my school, it was evident that the hands-on approach worked well with my students. They were enthusiastic about science, and we became involved in building two science laboratories at the school—a primary laboratory and an intermediate laboratory. Students enjoyed science so much that they looked forward to science and the time in the laboratory. However, in spite of these occurring changes, I always felt that something was missing. I noticed that students did not view science as part of their everyday lives, and they often did not make connections between one concept and another. At the end of the school year, I felt as if a whole lot of activities had been performed that were not connected and that the students saw them as completely unrelated activities. It seemed as if the students were not truly learning the scientific concepts behind the laboratory experiments.

I noticed that students did not view science as part of their everyday lives, and they often did not make connections between one concept and another.

As the 1996-97 school year started, the school became departmentalized, and I was given the task of teaching the content areas of science and social studies. Throughout the summer, everything I read as part of my graduate coursework suggested that hands-on activities alone were not sufficient for students to acquire scientific concepts. Children needed to be allowed to discuss findings so that a scientific discourse could evolve. Dr. Tobin spoke about letting students discuss their findings in small groups, since science "…is a form of argument" (Tobin, 1998a). I subsequently decided not only to have hands-on activities in my classroom, but to also have the students work in small-groups and discuss their findings. I wanted the students to have a chance to share their ideas and opinions among their small-groups and then present their findings to the whole class. By doing this, I intended to determine if, indeed, my students would be able to make their own constructions and acquire a deeper understanding of scientific concepts by giving them an opportunity for discussion and to hear others' interpretations and constructions.

Theoretical Framework

Current research in science education suggests that hands-on activities are a way for students to gain understanding of scientific concepts (Sivertsen, Riley, Robinson, & Conaty, 1993). Students are given first-hand experience and the opportunity to develop science process skills. The emphasis on the hands-on aspect of science has truly helped in making science a part of the everyday curriculum in most schools. It has allowed students to get a better grip on the subject of science in the elementary school and be better prepared to learn from science instruction in the middle and high school. By using a wide variety

If students are to understand scientific concepts, they must have more than hands-on activities. Students must be allowed to discuss their findings and make conceptual connections.

of materials, the students learn by doing. They get to experience first hand the practical applications of many scientific concepts; however, there must be some connections between the activities. They cannot be presented in isolation. If this happens, then the students will only be acquiring bits of knowledge and not the whole concept (Sivertsen, Riley, Robinson, & Conaty, 1993).

Hands-on activities in science are not enough by themselves. If students are to understand scientific concepts, they must have more than hands-on activities. Students must be allowed to discuss their findings and make conceptual connections. The discussions must be much like an hermeneutic circle (Guba & Lincoln, 1989), where they express their opinions and share them to construct their own personal understandings. There must be a give-and-take attitude among the members of the group, a "bouncing off" each other by asking questions and clearing up misconceptions. For students to construct and acquire science concepts, the experiences must be concrete, relevant, and varied (Sivertsen, Riley, Robinson, & Conaty, 1993). The construction of knowledge happens when there is discussion among peers and the teacher. It is in these interactions that students can clear up misunderstandings and where conceptual learning can take place (Tobin, 1998a). When students are allowed to discuss and bounce ideas off each other, then the construction of scientific concepts can begin to occur.

Richmond and Striley (1996) found in their research that when students are allowed to explore and discuss in a small-group format, they begin to make conceptual connections and acquire scientific concepts. Their study was performed by posing a series of scientific problems that challenged their tenth grade students. The students in their groups did not initially have the ability to engage in a useful scientific discourse, but as the study progressed, it was found that "…the students' arguments became more sophisticated and better situated in an intellectual context" (p. 847). The students were developing the ability to formulate appropriate scientific arguments.

Students have often considered science—as part of the formal school curriculum—as being hard to master. This is especially so in the United States, where studies have indicated that there have been many deficiencies in the learning of science. Students often are ill prepared to tackle the sciences at the high school and college levels. One major contributing factor to this state of affairs is that science cannot be learned in isolation. Scientific theories and explanations cannot be discovered simply by a personal interaction with an experiment. This means that there must be talk and discussion with peers and teachers in order for conceptual understanding to occur (Alexopoulou & Driver, 1996). Studies in this area have shown that peer discussion gives students opportunities to "…construct new ways of understanding through a collaborative negotiation of their meaning" (p. 1100).

Science is more than exploration. Kuhn (1993) argues that there also must be scientific thinking. This scientific thinking does not come naturally. A child's curiosity, on the other hand, is a natural occurrence. We must take advantage of the natural curiosity of children. In elementary schools, children are enthusiastic about science, but as they grow, they seem to lose this enthusiasm. According to Kuhn (1993), the development of scientific thinking is crucial if students are subsequently to engage in a lifetime of science learning. As she states, "…I argue that we look at scientific thinking more deeply. It does not come naturally, but then once you get it, you do not lose it. Viewed this way, scientific thinking is an endpoint, not a starting point, of a complex process of intellectual development" (p. 321). From this perspective, science is thought of as a type of "rational argument," in which the abilities to engage in debate and discussion of theories should be developed among students just as the scientific community holds debates and discussions on their theories. Kuhn (1993) goes on to add that "science as exploration" and "science as argument" do not exclude or contradict one another. "Scientific thinking" is the way in which we would like all students to think, not only in the content areas of science but in all other content areas as well.

To achieve the goals of "science as argument and exploration," it is essential that students work in small collaborative groups.

To achieve the goals of "science as argument and exploration," it is essential that students work in small collaborative groups. Having students work in small groups can be extremely difficult, and it is important to have a well-balanced group. The group members must be able to work together. DuBois (1995) in his study was very meticulous about how to construct his cooperative groups. He went so far as to give them activities in which they first learned to work as a team. Once the students learned to work in the cooperative group style, they accomplished a great deal. One study found that students who were taught science through cooperative group discussion had higher retention rates and could better apply their knowledge to problem solving exercises (Woodward, 1994). When students are able to talk, ask questions, and share ideas and opinions, then they are able to gain deeper understandings of scientific concepts. Another study, performed to investigate the relationships between cooperative groups and problem solving strategies, showed that students who were involved in cooperative groups demonstrated a greater long-term memory of problem-solving strategies (Duren & Cherrington, 1992). Cooperative groups and discussion—along with hands-on activities—seem to allow students to construct their knowledge and have a better understanding of the scientific concepts taught.

Group discussion is very helpful in getting students to make sense of what they are learning. Students who are given an opportunity to first discuss a concept in a small-group setting are better able to then verbalize or explain individually than if they are just asked to explain first. The research in this area indicates that when collaborative groups are used along with group discussion in performance assessment, students verbalize their understanding better than if they are just given a written test (Webb, 1995). Small-group discussion is at the heart of science learning. It is essential that students be given the opportunity and the challenge to learn science with understanding. Students should be able to construct their knowledge and understand their world.

Setting

This action research took place at an elementary school in North Dade County, Florida. The students come from either single parent homes or two parent homes where both parents work. There is a small number of mothers who do not work and who volunteer at the school. Most of the students live in the surrounding community, although there is a small-scale busing program. The school consists of pre-kindergarten through fifth grade. There is a Headstart program housed at the school and operated through the local community center. There also is an after-school care program for the convenience of the working parents. The ethnic make-up of the school has changed over the years but remains primarily composed of Hispanics and African-Americans with very few Caucasians or other minorities. During the time in which this research was conducted, the student ethnic make-up of the school was recorded as 56% Hispanic, 38% African-American, 5% Caucasian, and 1% other minorities. In my 15 years at the school, I have taught all grades from kindergarten through fifth grade, and I taught third grade during the course of this study. As mentioned above, the school was recently departmentalized, and I taught two periods of science and social studies and one period of reading and language arts. My homeroom class consisted of 32 students (18 boys and 14 girls), and I was responsible for teaching science, social studies, reading, and language arts to them. My second class consisted of 30 students (14 boys and 16 girls) to whom I only taught science and social studies.

The two-story pod school was built in the early 1970s. There are no windows or walls to divide each class. Each grade level has an area (or "pod") to share. It can be difficult and very loud at times since there are as many as five classes going on at the same time in one area. Things can become very loud, especially when doing the science laboratory activities. Students also can become easily distracted by what is going on in another class since there are no walls. The class is arranged in tables of six students, and there are no individual desks. Every class in third grade is equipped with four computers and a printer. The school is very fortunate in that it has a wide variety of computer software to fit many parts of the curriculum, including science. Since I teach science, my area has a wall of cabinets and two sinks that are very helpful when preparing the exploration activities. There is also a separate laboratory housed in the fifth grade pod on the second floor where students go once a week with an aide to do teacher-prepared explorations. This is in addition to the weekly laboratory activities done in the class itself.

Methodology

The methodology used in this study was a combination of teacher observation, interviews, science journals (or learning logs), and student surveys. At the beginning of the school year, I placed the students in both science classes in groups of five or six. Each group was composed of students with differences in academic ability as well as differences in ethnicity, race, and gender. After some days of observation and modifications of some groups due to personality conflicts, I chose one group in each class for the study. Although all students had previously been placed in groups of five or six, only one group in each class was observed closely and interviewed individually for the purposes of the study. These students completed a survey of their views on science and the world around them in September 1996. The survey questions were derived from the Constructivist Learning Environment Survey (CLES; see Taylor, Dawson & Fraser, 1995). Five questions from the CLES were selected and modified to fit the understandings of the third grade students (see Appendix F, p.176). The same survey instrument and questions were administered in March 1997 that included the free response question, "Name something that you have learned in science this year that can affect your life outside school." The survey answers were most helpful in providing insight into the students' views on science and the role that science played in their lives. Along with the survey, I interviewed the students of each group. The interviewed students were allowed to express their views on science and the world around them. This allowed the students to thoughtfully verbalize and not just give a quick answer.

Throughout the year, each student kept a science journal. They wrote their experiments as well as what they had learned in each activity. This was an eye-opening experience. The journals became more detailed and thoughtful as the year progressed. I also kept a teacher journal where I placed any comments or observations of the two targeted groups. This too was a rich source of data because it allowed me to remember small details that may have been overlooked.

The classes were held in the following manner. Each week the students were engaged in a laboratory experience. The students completed the laboratory activities as a group and discussed their findings. Findings were then presented to the whole class. After all the groups had presented their findings, we went back to compare and compile the results. The class, as a whole, came to agreement as to why things happened in each experiment. The students then wrote their laboratory reports and findings in their journals. They also wrote what they had learned in each activity.

When we went on to subsequent parts of the science curriculum, the students made connections to the parts we had just finished.

As each group discussed its findings before group presentations, I observed and listened closely to what was being said and wrote it down. In these group discussions, I started to notice that the students took their discussion seriously and that they were thinking and learning science. Furthermore, the students were taking their scientific knowledge and trying to apply it to other subjects as well. When we went on to subsequent parts of the science curriculum, the students made connections to the parts we had just finished. For example we did a unit on sound, and later, when we studied plants and their need for light energy, many students went back to mention sound as another type of energy. This kind of connection had not happened before. In past years, once a particular science topic was finished, it was finished, never to be brought up again. It surprised me to hear students go back to previous concepts taught. Students often asked for the directions to an experiment so that they could do it at home. Parents told me how excited their children were to show what they had done in science class. It is also important to note here that parents took an active interest in their children's science projects, and their interest made a further significant contribution to the students' motivation and learning.

Report of Findings

The findings provided a useful and enlightening insight into the students' views of science. The initial interviews revealed that the students viewed science as just a subject to be studied in school. All but one student said that science was not a part of the everyday world. One student stated that science was hard and that he just wanted to get a good grade to please his parents and his teacher. Most of the other students expressed similar sentiments (i.e., that "…science is a subject that one studies only in school"). One student said that maybe you could use it outside school, but he didn't know how. The students' attitudes at the beginning of the school year were that science was a comparatively unimportant subject. In the interviews, a student said that science was not important but that reading and math were "really important." Some of the science "stuff" he had done in second grade was fun, but he couldn't remember what any of the activities were. A girl stated that she got good grades in science in second grade but could not remember anything she had learned. It was a good subject, and it was a lot of fun, but that was all. These interviews showed that very little scientific knowledge had been constructed in the previous year's science program.

Following these initial interviews, the CLES survey was administered (see Appendix F, p.176). The results of the survey (administered to both groups in September 1996 and again in March 1997) showing a percentage breakdown of how students answered each statement are found in Appendix G (p.176). A review of the survey results indicates marked differences between the responses of the two groups. While I had the first group of students with me for only one hour each day, the second group of students was my homeroom class, and they were with me for most of the day. I believe that since I tried to integrate science as fully as possible into my curriculum, my homeroom students were, therefore, more enthusiastic about science. For the homeroom students, science was incorporated into their language arts and reading classes, and this may account for the differences in the survey responses between groups. Overall, a comparison between the first and second surveys shows that the second group of students demonstrated a more positive view of science as a whole, although the first group also showed differences in their attitude toward science as assessed by the first and second surveys.

The results clearly indicate that at the beginning of the school year, more than half the students viewed science as just a school subject and not as part of their everyday world. They also did not feel comfortable expressing their ideas and opinions to others or having others explain something to them. The results of the latter survey, on the other hand, indicate that more than half the students had started to view science as part of the world around them. They were also more willing to share their opinions and ideas. Most of the students had a real change in attitude toward science. In the second survey, students were asked to list one thing that they had learned in science over the course of the year that could affect their lives outside school. The answers varied. Some said it was that sound is made through vibrations. Another said it was that sound was also energy. One child said that science was everywhere. Another response was that habitats are places where things live. Each response embodied a concept that we had covered over the course of the school year.

The interviews occurring at the end of the school year revealed that science was now being viewed in a whole new way.

The interviews occurring at the end of the school year revealed that science was now being viewed in a whole new way. One of the interviewed students told me that science was everything. He said that everything in the world had to do with science: "Even when you breathe it's science!" The students were more enthusiastic when talking about science, and when projects were assigned, nearly all students participated and were willing to share what they had learned with the rest of the class.

The year started with a unit on sound. I wanted the students to explore how sound is made and how it travels. As the unit progressed, I observed that the students enjoyed their discussions and became quite adept at gathering information and coming to conclusions. They were able to discuss vibrations and tell how sound is made and how it travels. They were always eager to report the group's findings to the whole class. Their journal writings showed that they were acquiring concepts and constructing scientific understanding.

When discussing sound waves, one student said that she couldn't see the waves because she did not live near the ocean; several students immediately said, "Not water waves, but sound waves." One student even drew what waves looked like as far as low and high pitch were concerned. I also found that the students used the associated scientific vocabulary comfortably, not just in the science class but in other classes also. It was an eye-opening experience for me as well as my students.

The science journals also revealed that the students were constructing deeper understandings of the science concepts that were being studied. Their drawings were more precise, and they were better able to verbalize their findings. During the latter part of this research, my students and I began to study plants and the meaning of photosynthesis. I was surprised at the intricate drawings and the written explanations in the science journals after a series of explorations and discussions. The students drew pictures that showed the roots taking water from the ground through the stem to the leaves. The sun was shining, and the rays were being absorbed by the leaves to come together with water and carbon dioxide to make the sugars needed by the plant. This was something that in years past had been very difficult to teach and for students to comprehend.

At the beginning of the school year, the students had a hard time adjusting to working as a team. There were numerous arguments, and I had to adopt the role of a referee. As time went on, there were fewer arguments and more cooperation among the groups. I believe that the students learned to work with each other as they gained experience working in cooperative groups. Once they understood that they had to work with one another to achieve a common goal and that I would accept no excuses, they left the bickering behind and started to work together. True discussions started to take place. There were real-life problems to solve, and the students approached their tasks in a thoughtful manner.

One problem involved deciding what to take on a desert hike. We were studying the desert habitat, and the students were asked to decide what supplies to take. The groups got together and discussed what were the best things to take. One of the students wanted to take sandwiches. Another student said "no," because the meat would spoil and the bread would get soggy with the heat. Another student then said that water was the one important thing that was needed. There was a suggestion from a student to take a knife to cut into the cacti to get water in case they ran out of water. Canned food was suggested, but others said "no" because it was too heavy to carry across the hot desert. Then a student suggested dry fruits and food packs similar to army rations. They also put matches and light-colored clothing on their lists. The last items were a hat and comfortable shoes. Both groups were very thoughtful in choosing their supplies and gave reasons for choosing the items on their lists.

This same problem was given to the students if they were to hike in a forest habitat. Again, the students made a list then compared their list to the one for the desert habitat. In their journals they wrote the reasons for the different items on their lists. One big difference was water. The students said they didn't need as much water in the forest habitat because the forest has rivers, brooks, streams, lakes, and ponds where they could get water on their hike.

…when students are given the opportunity to discuss and debate findings, then learning is enhanced.

When we studied space, the students asked about the space shuttle. One student knew that it travels above the speed of sound. There was a discussion on sound and how fast it can travel. One of the students in the targeted groups said that before the space shuttle lands, you could hear a very loud sound. He told the class that a reporter on TV had stated that these were "sonic booms." He wanted to know what they were. He subsequently went to the library to find out and then reported it back to the class. Over the course of the school year, students had many more questions on the topics we were studying. It was an opportunity for the group to go and find out and then report to the class. The other teachers on the grade level would comment that students made connections from the science being studied to topics being covered in reading or even in mathematics.

Interpretation

I believe that the student interviews and survey have shown that when students are given the opportunity to discuss and debate findings, then learning is enhanced. Because of the small-group discussion, there is an element of critical thinking involved, and students can begin to construct scientific understanding. The students had a better understanding of what was covered in the science curriculum over the course of this particular school year in comparison with the previous year. This is only by virtue of the time they spent on discussion of findings. All the findings of this study have suggested that the students are on their way to making connections among the science concepts studied. The science concepts were revisited many times throughout the year and were not taught in isolation. The small-group discussions allowed students to gain a deeper understanding of the science concepts and to see connections between the concepts.

> Students often went to their parents to investigate how science is used in their own homes.

Students often went to their parents to investigate how science is used in their own homes. One such example of this was illustrated through an investigation of heat and solar energy. The exploration consisted of water placed in two cups with a thermometer in each. One cup was covered around the sides with black construction paper, and the other cup was left alone. The starting temperatures were recorded, and both cups were placed outside in a sunny part of the schoolyard. The temperatures of the water in the cups were then checked every 10 minutes. At the end of 40 minutes, the water in the cup covered with black construction paper was much warmer than that in the uncovered cup. A discussion ensued as to why this change in temperature happened. It was theorized that the dark paper absorbed more of the heat, and this was the reason the water became warmer. Students then said this was the reason to wear light colors in the desert because they absorb less heat from the sun. The students had discovered that dark colors absorb more heat than light colors. One of the students mentioned that we needed to keep our homes cool in the summer, as well as warm in the winter. This student went home and asked her uncle who worked in construction about this. She then reported to the class that homes need insulation to keep cool in the summer and warm in the winter. She said that insulation looks like cotton, but you have to wear special clothing to place it in homes. This was because it could hurt your skin and your lungs if you breathed it in. By doing these activities on their own, the students were applying the science concepts to their own lives. It made what we were studying relevant and useful, and no longer was it a matter of "Why do we have to know this?" Through it all, it became even more readily apparent to me as a teacher that science needs to be taught in a different way. There need to be more hands-on activities, but children also must be allowed to discuss findings so that a scientific discourse can come about. As aptly stated by Brooks and Brooks (1993), "…the students' point of view are windows into their reasoning. Awareness of the students' point of view helps the teacher challenge students, making school experiences both contextual and meaningful" (p. 60).

Conclusion

I have always had many hands-on experiences for my students, but it has only been as a result of undertaking this study that I have incorporated the element of scientific discourse. As a part of the design of the study, I made a conscious effort to allow for small-group discussion in my science classes. This has worked very well. The students seemed to be more interested in science and were able to perceive science as part of their everyday life. As a consequence of engaging in this research, I have tried to foster a constructivist classroom. Constructivism is a way to know one's world. The responsibility of learning belongs to students and teachers. A teacher needs to create an educational environment that allows students to take responsibility for their learning (Brooks & Brooks, 1993).

There have been many examples to illustrate that students felt more comfortable with science learning over the course of this past school year. One such example was the science subtest of the *Stanford Achievement Test*. As the students took the science subtest, I noticed that they were more confident in answering the questions. It seemed that these students were answering a greater number of questions correctly. I am curious to know what the results were and whether the scores were better than the previous year. More important than test scores, however, is the fact that the students seemed to understand the scientific concepts that were presented over the course of the year. In order to understand, students must search for meaning. For this meaning to occur, students must have opportunities to form and ask questions (Brooks & Brooks, 1993). I believe that through the use of the small-group discussion format, the students were better able to construct scientific understanding. I will share my results with the fourth grade science teacher in the hope that she will want to continue using small-group discussion with this group. If this happens, then the students will be well on their way to acquiring and developing the habits of scientific thinking that Kuhn (1993) advocates to get students to become lifelong science learners.

My science classroom is noisier, but I maintain that the students are learning and understanding more science.

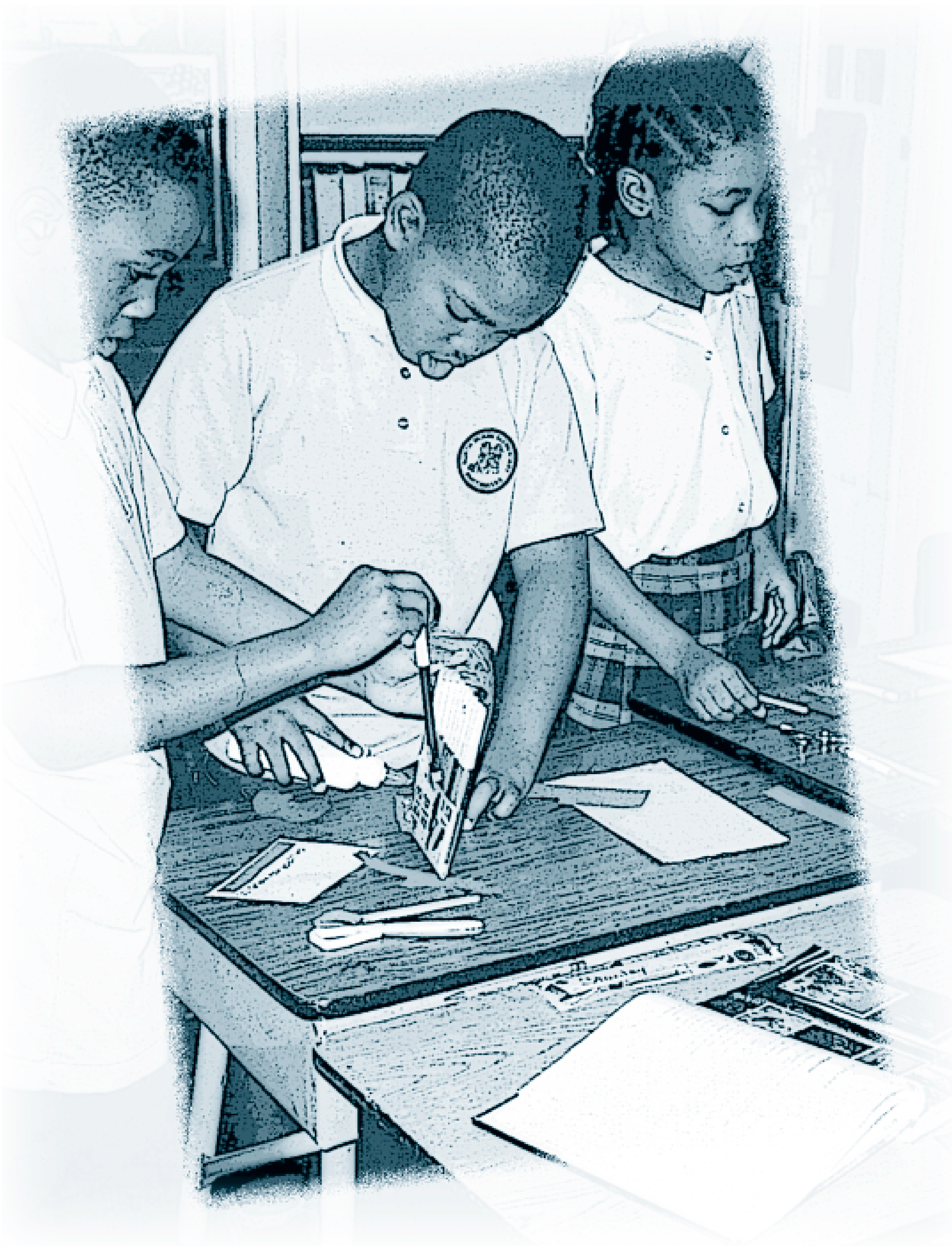
I would like to continue with this study in the next school year when a whole new group of students come to third grade. Will small-group discussion prove to be as successful with another group of students as with the groups in this study? As I observed the groups on which this study is based, I noticed that positive peer interaction was taking place. Students were helping and teaching one another. Even though I have only reported the results of two groups in this study, all students in my science classes participated in the small-group discussions. They all benefited from this type of learning. I believe that my science classroom has become a better place for learning because of the opportunities for small-group discourse and my implementation of constructivist learning principles. It has allowed my students to better appreciate the nature of science and be able to construct scientific knowledge. My science classroom is noisier, but I maintain that the students are learning and understanding more science. It has been somewhat hard to let go of the control in my classroom and allow the students to be part of the learning process. More than letting go of the control was a matter of sharing it with the students and allowing them to be active participants in their learning. As I have stated before, I would like to continue with this type of learning. Applying a constructivist philosophy and having students engage in discussion and develop a scientific vocabulary has been a learning experience for my students, as well as myself.

The notion of discourse is also spreading to other parts of the curriculum in my school. Regardless of what subject is being covered, the students are now very willing to discuss and make connections to topics we have already covered. The students are learning science that is meaningful to them. ◆

Language, Discourse, and Learning in Science: Improving Professional Practice through Action Research

Throughout my life, science has been a source of wonderment and joy. It has always been my goal to share these feelings and attitudes with my students. I want my young students to acquire a lifelong love of science exploration and learning. To this end, I have tried to incorporate science in all that we do in the classroom. The action research I did with my students has been a true learning experience. I was in awe of the way the students handled the discussions and the thoughtful theories and ideas they proposed. These students were enthusiastic and would go out of their way to find more information on the topics that we were studying. I would recommend action research to all science teachers who wish to improve teaching and learning in their classrooms.

—Dolores M. Rodriguez



CHAPTER TWELVE

Constructivism and the Teaching of Science to Limited English Proficient Students

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Abstract

The following is an excerpt from a class discussion, translated from Spanish to English.

Teacher: Where does the sun go at night?

Student #1: It goes to another place. Maybe to another country. I don't know.

Student #2: I think it goes to sleep.

Student #3: It goes into the ocean.

Teacher: Where does it go to sleep? Does it stay in the sky, or does it go some place else?

Student #2: When I was little, I saw it go behind the mountain. Then it got dark.

Teacher: What do you think happens when it goes behind the mountain?

Student #2: I don't know.

Student #3: I think it goes in the ocean because when I was at the beach, I saw it go under the water.

This study was initiated to enhance simultaneous learning of science and language acquisition while utilizing a constructivist approach. Findings of the study suggest that when limited English proficient (LEP) students engage in science conversations and activities, they are developing communicative skills that will extend their abilities to convey meaning.

Background and Theoretical Rationale

Classrooms in South Florida are composed of a cultural mix of students, unlike most school districts nationwide. The children in these classrooms are arriving from countries throughout the world, consequently impacting our schools.

Although the negative impact that immigration has had in our classrooms has been widely discussed, there also is a positive side. These children bring with them a variety of rich experiences and background knowledge that can be used as resources to enrich the classroom learning environment.

The term "Language Enriched Pupil" (as opposed to "Limited English Proficient") has been seen on several Dade County Public School memoranda.

Previous research suggests that the scientific community might not be fully cognizant of the impact LEP students are making in the science classroom. Several researchers have found that members of the science education community possess some sense of minority awareness; however, little information or understanding exists about the learning of science through a non-dominant second language (Sweeney, 1997a). Fortunately, the trend is changing to reflect a more positive attitude toward bilingualism. To this end, the term "Language Enriched Pupil" (as opposed to "Limited English Proficient") has been seen on several Dade County Public School memoranda.

In order to accommodate such a diverse group of students, teachers must meet their educational as well as their emotional and social needs by adjusting their teaching techniques and styles. Meeting the needs of such a diverse population is one of the many tasks given to South Florida's teachers, and teaching children classified as LEP or ESOL (English Speakers of Other Languages) continues to be a major educational concern (Ballas, 1995). Throughout South Florida, students who are classified as ESOL Levels I or II are placed in self-contained classrooms, depending on the school's population, or are serviced on a pull-out basis for two hours of basic ESOL classes and 45 minutes per day of Curriculum Content in the Home Language (CCHL). Students who test at ESOL Levels III or IV are placed in regular classrooms along with other children in their grade level who have either exited the ESOL program or who were never enrolled in it. These students are serviced on a pullout basis for one hour per day of basic ESOL classes.

Although science activities in the ESOL classroom and in a science classroom can effectively provide conditions for acquisition of both language and science concepts for students acquiring English language proficiency, they also pose complex problems for students learning a second language (Fathman, Quinn, & Kessler, 1992). The process of integrating previously acquired knowledge with newly acquired knowledge presents a challenge that may be accomplished only superficially, even after formal science teaching. This challenge is further compounded for learners who come from cultural backgrounds with world-views that are inconsistent with those reflected in the classroom (Kessler & Quinn, 1987).

The American Association for the Advancement of Science (AAAS, 1989) has adopted five recommendations on science literacy, including mathematics and technology—which are surprisingly similar to the principles for promoting second language acquisition:

- Prior knowledge influences learning.
- Learning moves from the concrete to the abstract.
- Learning requires practice in new situations.
- Effective learning requires feedback.
- Learning is not necessarily an outcome of teaching.

Fathman, Quinn, and Kessler (1992) have suggested that science teachers can help their LEP students acquire an understanding of basic science concepts and improve their English skills by using specific strategies that include

- Promoting collaboration between teachers and students
- Modifying language
- Linking science lessons to students' everyday lives
- Adapting science materials
- Using language teaching techniques when presenting science concepts

They further suggest that successful science teaching involving LEP students requires simultaneous attention to the language used, as well as to the science concepts presented.

Since much of the terminology and many of the concepts associated with science are new to both ESOL and non-ESOL students, they can serve as a connection between the students. Students can discuss, model, and experiment with the new concepts and form links to their previous experiences. The information being introduced may be related to concepts the student already is able to describe in his/her native language and subsequently, the student can begin to make connections in the second language. Students should be allowed time to reflect on their life experiences so they can make sense of science and weave new ideas into their knowledge base (Ballas, 1995). Additionally, learners should be involved in hands-on activities that make the curriculum content meaningful to them. As educators, we should take part in this active process of research and discovery. In order to incorporate both science and language as suggested by Fathman, Quinn, and Kessler (1992), we suggest using techniques such as repetition, hands-on activities, visuals, technology, and manipulatives to facilitate the development of students' verbal abilities, as well as the learning of science concepts. The manner in which science ideas are presented to LEP students can either foster the learning of the concept with the simultaneous acquisition of the language or can become a source of frustration and confusion to both teacher and student. It is for this reason that we believe a constructivist approach to teaching science serves the unique needs of LEP students more so than other approaches. This epistemological position proposes that learners construct their own understandings of new ideas based upon their previous experiences. By using constructivist approaches to teaching, teachers can encourage students to experience learning in ways that actively stimulate them to construct and acquire knowledge in personally meaningful contexts.

As educators, we play a major role in setting the atmosphere of the constructivist classroom. Teachers can structure activities in which students engage in a way such that students can use their existing knowledge to make sense of what is happening and build new understandings on a foundation of extant knowledge (Tobin, 1998b). It is our responsibility to bring students' current understandings and experiences to the forefront. Our main role is to seek out and communicate all such constructions and to explicate the ways in which such constructions—and their underlying value systems—are in conflict (Guba & Lincoln, 1989).

Site and Student Information

This child had little schooling in her own country, yet she was placed in a second grade classroom upon arrival and could not function academically at the capacity of her peers.

Our research was conducted at Ethel Koger Beckham Elementary School in Miami, Florida, during the Fall of 1996 and the Spring of 1997. During the time in which this study was performed, the school student population consisted of 683 students (83% Hispanic, 14% White, 2% "Other," and 1% African American). One hundred of the 683 students (approximately 15%) were classified as LEP.

Of a class consisting of 12 second grade students, four were involved in this research. The students selected were all ESOL Level I and were two girls from Venezuela and one girl and one boy each from the Dominican Republic. All of the students were eight years of age and had been in the United States for approximately six months. The students' verbal skills in English were very limited. The girls from Venezuela and the boy from the Dominican Republic were able to read in Spanish and were in the process of decoding words in English. However, the girl from the Dominican Republic was a non-reader in her native Spanish and had difficulty expressing herself in Spanish. This child had little schooling in her own country, yet she was placed in a second grade classroom upon arrival and could not function academically at the capacity of her peers.

Methodology

In order to conduct the study, we utilized an interpretive research methodology. Five sources of data were accessed as part of the study: researcher observations, researcher journal entries, peer teacher evaluations, student interviews, and peer debriefing. As described in Guba and Lincoln's (1989) Fourth Generation Evaluation, student interviews were conducted utilizing a hermeneutic dialectic approach that includes a member's checking process as an integral part of interpretive inquiry.

Both researchers used observations and journal entries in order to obtain their own accounts of students' perspectives, document their insights into their developing understandings of what the students were actually learning, and cross-reference and discuss each other's notations. As one researcher conducted the lesson, the other observed and conducted the student interviews. These evaluations were conducted in lieu of videotape and were used in order to obtain another professional's perspective of the classroom activities, students, and the classroom environment.

At the conclusion of the study, peer debriefing sessions were conducted with four additional teachers in order to obtain their views and opinions of the research. Their suggestions were incorporated into the final version of this paper.

As part of the research methodology, the four-step lesson cycle (Atwater, Baptiste, Daniel, Hackett, Moyer, Takemoto, & Wilson, 1993) for implementing a constructivist approach within the classroom was used. The steps in this cycle are

- Engaging—assessing prior knowledge and making a connection between past and present learning experiences
- Exploring—providing the opportunity for direct involvement with phenomena and materials
- Developing—communicating abstract experiences, analysis, and further explaining
- Extending and Applying—expanding on concepts, making connections, and applying understanding to the world around the students

Before the introduction of the unit lesson *A System in the Sky* (Atwater et al., 1993), students were asked to think about the meaning of the word "system," and give examples of things they thought made up a system. They were encouraged to recall "systems" of which they might have had previous knowledge in their native countries. Our goal was to provide an environment in which the students felt at ease discussing their feelings and opinions. When this happens, Eisner (1993) refers to it as "re-presentation," that is, the process of transforming the contents of consciousness into a public form so that they can be stabilized, inspected, edited, and shared with others. In contrast to many immersion classrooms, the use of the students' home language was encouraged and not restricted.

After this discussion, a definition of the word was introduced. The students were then asked to think of the Earth, moon, and sun as objects working together to form a "system." Later, in order to assess prior knowledge for planned future lunar observations, we presented them with the following eight questions to respond to as part of our student interviews:

- Where does the sun go at night?
- Where does the moon go during the day?
- Does the moon change the way it looks?
- Where does the moon get its light?
- Does the Earth move?
- Does the moon move?
- Does the sun move?
- Do the sun, Earth, and moon "work" together?

A list of vocabulary words necessary to the development of the unit was compiled for the purposes of discussion and understanding. Students were shown pictures of the Earth, moon, and sun and were introduced to the theories of Ptolemy and Copernicus. The students explored both astronomers' theories by using styrofoam balls to make models of the Earth, moon, and sun. They also role-played, taking turns being the spheres, rotating and revolving around each other accordingly.

Several "hands-on, minds-on" activities were developed in order for the students to construct better understandings of lunar phases with an emphasis on expressing and articulating their observations. These activities included, but were not limited to, the following:

- Project Moon Watch (ongoing for a four-week period)
- Building models of the moon's rotation around the Earth and the Earth's rotation and revolution around the sun
- Illustrations to show the developing phases of the moon

Upon completion of all activities, the students read from the book, *A System in the Sky* (written in Spanish), whereby they were able to relate concepts and apply their understanding to "real world" physical phenomena. During this part of the lesson, the students were presented with all of the questions, discussions, theories, models, concepts, and vocabulary in Spanish (their dominant language) in order for us to gain a better perspective relating to the development of their thinking. The students engaged in lively discussions (in their dominant language) of their perceptions, describing their prior knowledge and previous experiences. Once the students were comfortable with discussing and understanding the concepts in their home language, we felt it was appropriate to introduce spoken English into the lesson.

An audiotape of the book's English version was provided to all the students in an effort to have them begin the process of transferring the information gleaned from previous discussions, readings, and activities into the English language. The students listened to the tape, following along in their books, and were later given an opportunity to read the text out loud themselves. The same vocabulary words were also introduced in English, enabling the students to make connections while they read the English version. Many students found words that were similar in structure to the Spanish language word, thus making their connections that much more significant.

On a daily basis, the students recorded the location of the moon through illustrations or writing. They were also encouraged to discuss their moon observations, using teacher-prepared, controlled English vocabulary at the beginning of each class period. The questions included, but were not limited to the following:

- Did you see the moon last night? (Possible answers were provided for students' selection.)
- Where was it? (Use of directional phrases such as in front of, behind, above, below, left, right)
- What did it look like? (Use of adjectives, including words denoting shape and color)

We believe that this "hands-on, minds-on" approach, in conjunction with the reading, enabled the students to make sense of the concepts presented, thus opening the door to further inquiry and new understandings.

By using multiple strategies, we were better able to target the varying abilities of the students. Among the strategies that were most effective with our second language learners were use of visual stimuli, demonstration of techniques, restating and re-explaining, and using concrete hands-on activities to aid in understanding abstract concepts.

Findings

We learned many exciting things as a result of implementing this unit lesson:

- We noticed that the students were applying the vocabulary learned to new situations, thus improving their oral language skills.
- The students' decoding skills improved dramatically as a result of the readings and listening to the audiotapes.
- The students' fear of using their acquired English skills in the presence of others also decreased.
- The students were able to orally express an understanding of the relationship between the Earth, moon, and sun to our satisfaction.
- The students demonstrated an understanding of lunar phases through illustrations and explanations of the illustrations.

- The students distinguished between the terms "rotation" and "revolution" through role-playing activities.

The girls from Venezuela improved their communication skills and also developed an understanding of the Earth's relation to the moon and the sun. Their improvement was evident in many ways. For example, they began decoding previously unknown words in English and were able to gain understanding from the reading by relating the Spanish version of the text to the English version. They keyed in on words such as rotation/rotacion and revolution/revolucion and noticed the similarities. They were among the first to notice that many English words were structurally similar to their Spanish counterparts. These girls expanded their vocabulary in both languages and felt comfortable using the words when applicable. When asked to describe the movement of the system being studied, the following transpired between one of the girls and the teacher (written phonetically):

Girl #1: *La luna le da la vuelta a la tierra. La tierra y la luna le dan la vuelta al sol.*

Di moon rivolve di ert. Di ert and di moon rivolve arund di sun.
(The moon revolves around the Earth. The Earth and the moon revolve around the sun.)

Teacher: *Se mueve la tierra alrededor del sol?*

Does the Earth move around the sun?

Girl #1: *Si, la tierra rota alrededor del sol.*

Jes, di ert rotate arund di sun.
(Yes, the Earth rotates around the sun.)

Both girls showed noticeable improvement in their knowledge of science concepts and their English language acquisition. In our professional opinion, the fact that these girls had a solid academic base in their home language with which to begin, helped them to acquire and transfer information from one language to the other more readily.

This student began to feel more at ease with English due to his increased understanding and exposure to the language itself.

The boy from the Dominican Republic started coming out of what is often referred to as "the silent period." His oral skills increased, which was made evident by the confident manner in which he used the English phrases in the presence of others. For example, in the beginning, he would always ask for things in Spanish since he knew he was allowed to use his native language. However, as the lesson progressed and more English was introduced, he began using simple English phrases to ask for things he previously would have requested in Spanish. One documented incident transpired as follows:

Student: Wat page do we in?
(What page are we on?)

Teacher: We are on page 39.

Student: Tenk you.
(Thank you.)

This student began to feel more at ease with English due to his increased understanding and exposure to the language itself. He was also able to read and comprehend the English version of the text due to his ability to find structural similarities to the Spanish terms in many of the vocabulary words. He also used the book's illustrations to help him gain understanding and pointed out the similarity in terms to the other students.

We felt that the girl from the Dominican Republic started off with the greatest disadvantage as compared to the three other students. Since she was a non-reader and had limited schooling in her native country, she was unable to progress in reading at the pace set by the other students. However, her oral abilities turned out to be the highest of the group. We believe that this student compensated for her disability much like a blind person, for example, might develop a sharper sense of hearing. She developed her auditory skills to a point where she was using the words she had heard in the class and applying them to other situations. Other teachers commented on this student's verbal progress and her enthusiasm. She asked and answered questions in English, thereby relating the vocabulary she had learned during our lesson into other learning situations. She did manage to acquire several sight words and was able to identify them in other texts. She recognized most primer words. She also expressed an understanding of the relation between the Earth, moon, and sun during the final student interview session. She was the spokesperson for her cooperative group's illustration. She insisted on explaining their illustration in English, which is transcribed as follows:

Girl #3: Dis is di Earth. It revolve around da sun. Dis is di moon. It revolve around di Earth. Day revolve around di sun. (This is the Earth. It revolves around the sun. This is the moon. It revolves around the Earth. They revolve around the sun.)

Teacher: Very good! Now, can you show me the difference between "rotate" and "revolve?"

Girl #3: Okay. Like this. (*She began to rotate and revolve around one of her classmates.*)

It is interesting to note that these students were also heard using the English phrases learned in the science lessons during other times of their school day.

It is interesting to note that these students were also heard using the English phrases learned in the science lessons during other times of their school day. In one particular incident, the boy from the Dominican Republic was heard asking another student, "Did you see my pencil?" We believe this dialogue came about as a result of daily conversations in the science classroom using controlled vocabulary to determine the lunar observations made the previous night. One question that the students were required to ask each other and answer was, "Did you see the moon last night?" In a separate incident, one of the target students was looking for her jacket as she was getting ready to leave the classroom. When she was unable to find it, she asked, "Have you seen my jacket?" The reply from another target student was, "What did it look like?" This was another question that the students were required to ask and answer on a daily basis. This exchange is significant because the students were able to use the vocabulary learned in the science classroom and transfer it, in its correct context, to another situation.

Conclusion

According to the findings of our study, it makes sense to use the constructivist approach when teaching science to LEP students. There are many misconceptions regarding the knowledge that LEP students bring to the science classroom. Many of these students have experienced situations that many American children may never experience. However, if teachers can tap into these experiences, they will find that they can help students make sense of their learning and begin the process of constructing a solid knowledge base.

It is in everyone's (teachers and students) best interest to find a common communicative ground in the classroom, in this case spoken language. In the process of negotiating a shared language, it is essential that students use all of their language resources to develop understandings of science (Tobin, 1998a). An increased awareness of the sensitive nature of the learner's feelings, self-image, and individual circumstances must be taken into account when teaching all children, especially those classified as LEP. The success or failure that LEP students encounter in the curriculum content—including science—will depend to a great extent on their teachers' awareness of the unique challenges these students bring to the classroom and the particular teaching techniques most beneficial to these students. ◆

CHAPTER THIRTEEN

Ciencia en Español: Effects of Bilingual Education in Kindergarten Science Construction

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Mary began teaching in Dade County Public Schools in 1970 and presently teaches kindergarten at North Twin Lakes Elementary in Hialeah. She received her Bachelor's degree in Elementary Education from Florida State University, her Master's degree in Elementary Curriculum and Instruction from Florida Atlantic University, and her Specialist's degree in Science Education from Florida State University. She is a member of several special organizations including United Teachers of Dade, Pi Lambda Theta International Honor Society and Professional Association in Education, and Florida Alpha Delta Kappa educational honorary sorority. Mary is a native Floridian and enjoys reading, needlecrafts, and watching nature.

Abstract

As part of a study utilizing a constructivist theoretical framework, two children participated in a kindergarten extended foreign language program in Spanish and English. The children co-participated in both languages in *Science Talks* to build constructions on what they observed in science lessons. This interpretive study demonstrated a design emergent in nature. The two case studies compared and contrasted the children's science constructions in both languages as determined by parent and student interviews. Scientific observations made by the children reflected their home language development and showed some transfer of concepts from the second language.

Introduction

The Miami-Dade County Schools Extended Language Bilingual Program commenced in kindergarten at North Twin Lakes Elementary in the 1997-98 school year. Yadira Cano was assigned to teach the Spanish portion of the bilingual classes, while Mary Wagner was assigned to teach the English portion. In this model of the program, children were taught in English for half of the school day, with the rest of the day's instruction being given in Spanish. The program was voluntary in that the parents opted to have their children taught in both languages. Each subsequent year another grade is added to the program with the same group of children moving up together each year. This prototype operated with a two-teacher team and two groups of children. One teacher was responsible for teaching two-and-one-half hours in Spanish to both groups of children. The other teacher was responsible for two-and-one-half hours of instruction with each group in English. The children switched classrooms at midday.

This bilingual program has been designed to meet the increasing demand for a literate, bilingual workforce in Miami-Dade County, Florida (Manzo, 1996). The

Greater Miami Chamber of Commerce has found that local businesses have a difficult time finding qualified personnel to handle international business. The hope is that the extended, intense work in both languages will produce biliterate students (Manzo, 1996).

At the present time, students usually choose not to take Spanish as an elective in middle school. Because of changes in graduation requirements, many also decide not to take Spanish or another foreign language in high school. The students who graduate may be bilingual in that they speak English and a form of "street Spanish." However, they are not able to read and write in Spanish and, therefore, are not biliterate. The businesses in the international market demand well-spoken, biliterate professionals to handle their office routines.

The school system's bilingual department held workshops for the teachers involved in implementing this program. The directors strongly urged teachers to use a thematic approach. Thematic units that included activities in both English and Spanish enhanced the implementation of the program. Interdisciplinary/cross-curricular teaching provided a meaningful way in which students used knowledge learned in one context as a knowledge base in other areas. This teaching supported and promoted a transfer relationship between literature, science, and social studies. Interrelating the activities enabled children to make stronger science constructions and increased the students' motivation for learning, as well as their level of engagement. Students' abilities in many areas improved as lessons intertwined around an expanded theme and incorporated several science disciplines. Rather than addressing science topics individually, themes allow students to consider topics that are relational, interactive, and interconnected as in "real life" (Barba & Reynolds, 1998).

Purpose

The purpose of this study was to determine the effects of the bilingual program concerning student science constructions.

Setting

The settings for this study were two kindergarten classes in Miami-Dade County, Florida. The Miami-Dade County Public School District is the nation's fourth largest school district with a student population of approximately 345,000. The school was comprised of a low socioeconomic student population that had a high rate of transience. The school enrollment was made up of 93% Hispanic, 4% African American, and 3% Caucasian children. The selection of students for these interpretive case studies spoke only English when they entered school at the beginning of the school year. One student was chosen from each of the two class groups. Both students were average achievers.

Theoretical Backgrounds and Perspectives

In the last two decades, South Florida and the rest of the nation have undergone a tremendous metamorphosis. Political and economic refugees from Central and South America and the Caribbean islands have immigrated by the thousands. School systems have had the monumental task of educating the children who have arrived. All of these children bring with them their native culture, and some bring a language other than English. Because of the demands of American society, children are faced with the job of learning English in order to achieve and be successful in school. The different worldviews of language minority students can clash with those of the dominant culture (Cruz, Bonissone, & Baff, 1995). In some locations where large numbers of immigrants have settled, discontentment has been great.

Our world is changing constantly. Have our schools changed to meet the resulting needs? Many schools have done little to address new conditions. In some parts of the world, speaking more than one language is not only acceptable but a necessity. A large number of people in the United States feel that only the use of spoken and written English is permissible. Linguistic and cultural abilities are at the forefront of our ever-shrinking world. Yet we continue to shy away from addressing these very real global necessities (Cruz, Bonissone, & Baff, 1995). The United States has faced political and economic setbacks because so many embrace English monolingualism as being superior. Persuasion rather than armed coercion has become the way to do things politically, and effective persuasion requires that one know the other party's values and manner of establishing rapport (Cruz, Bonissone, & Baff, 1995).

Many teachers have been unaware of how cultural differences affect learning and have unconsciously forced their values on diverse students. American education, for the most part, has attempted to assimilate or acculturate these children into our society and, perhaps, has not valued the knowledge these students bring with them. Children and their families constitute "funds of knowledge" that represent essential cultural practices and bodies of knowledge and information that households use to survive (Gonzalez & Maez, 1995). Therefore, a classroom of 30 students represents 30 households and their networks with their respective funds of knowledge. Classroom teachers across the country are underusing a valuable resource: the community and its members. Educators must provide a greater role for parents in order for them to become active partners with the schools in the learning process of their children.

To ensure cognitive and academic success in a second language, a student's first language system—both oral and written—must be developed to a high cognitive level, at least through the elementary school years

(Collier, 1995)

Language development includes the acquisition of the oral and written systems across all language domains. To ensure cognitive and academic success in a second language, a student's first language system—both oral and written—must be developed to a high cognitive level, at least through the elementary school years (Collier, 1995). Schools in Miami-Dade County do not provide Spanish classes for monolingual students until the second grade. Thus, we have the problem where graduating students are not biliterate and are not able to function in the international business marketplace in South Florida (Manzo, 1996).

Many immigrant parents as well as teachers object to transitional bilingual education (TBE), an accepted methodology nationwide for teaching limited English proficient (LEP) students. The goal of TBE is to "transition" students from their native language to English in about three years. Other research states "…students participating for at least 4-5 years in bilingual education programs tend to score high on standardized tests in English" (Gonzalez & Maez, 1995). Advocates claim that "language minority" children will make a smoother transition to English if they first master their native language. However, a certain level of proficiency is needed for the transfer to occur. In programs that provide no support for the first language, students take a long time to catch up with their peers. Therefore, those with more stable homes whose families actively support their educational goals show greater success in acquiring both content and language skills than do students lacking these factors. When parents and children speak the language they know best, they are working at their actual level of cognitive maturity. They can develop their home language skills at home by asking questions, solving problems together, building or fixing something, cooking, and talking about life experiences. To more fully understand the processes occurring in language acquisition during the school years, it is important to recognize the complex, lifelong process that we go through in acquiring our first language and the parallel processes that occur in second language acquisition (Collier, 1995).

Miami-Dade County's extended bilingual program that teaches in both English and Spanish may give students the best advantage. Several studies indicate that children taught in this manner are higher achievers (Hornblower/Westminster, 1995). This "two-way bilingual" model attempts to bring both native Spanish and English speakers to full biliteracy. When examining interactions among student background variables and instructional treatments and their influence on student outcomes, Thomas and Collier (1997/98) found that two-way bilingual education at the elementary school level was the most promising program model for the long-term academic success of language minority students. As a group, students in this program maintain grade-level skills in their first language at least through sixth grade and reach the 50th percentile or NCE (normal curve equivalent) in their second language generally after four to five years of schooling in both languages.

One additional feature in the Miami-Dade program is the extended study time for the "second" language. In all models of bilingual programs, Griego-Jones (1994) has found that the most overlooked, but important factor to success in biliteracy lies in student attitude about learning a second language. Personal attitudes held by teachers and expectations for their students influence the quality and quantity of instruction (Barba & Reynolds, 1998). This process is enhanced by the stimulation and interaction provided by a community of teachers whose goal is to appropriately implement a bilingual program. Teachers need to make classrooms open to this multicultural bilingual exchange to realize their intentions. As a result, part of our job in developing biliteracy becomes one of helping students learn to like their native language and their second language (Griego-Jones, 1994). The success of biliterate development also depends on students' understandings of biliteracy and what it means for them. Ultimately, to accomplish biliteracy, a bicultural environment is needed. The sociocultural context in which students are schooled is equally important to students' long-term success in second language schooling. Contrary to the popular idea that it takes a motivated student a short time to acquire a second language, research reported by Collier (1995) examining immigrants and language minority students in different regions of the United States and with many different background characteristics indicated that four to twelve years of second language development were needed for the most advantaged students to reach high academic proficiency and to compete successfully with native speakers.

Some teachers do not feel that culturally diverse children can succeed academically, especially in science. Sweeney and Gallard (1996) suggest that "majority" or mainstream students, teachers, school professionals, and the whole educational system in general have low academic expectations of culturally and linguistically diverse students. This attitude of predestined failure is detrimental to children who are trying to adjust to a new culture, language, and lifestyle. Thus, many minority students enter the science class with a low expectation of success. In order to overcome this problem, teachers must be willing to learn about the cultures of their students. Because of individual differences, even children in the majority culture do not come to science class with the same experiences. Children living in conditions of poverty, for example, face enormous disadvantages. If the school does not take into account the fact that some children face greater disadvantages than others, these children may take their place in society with undesirable habits. In a *Miami Herald* front page article, Santiago (1996) discussed some of the difficulties encountered by Latino youths. These problems included joining gangs, getting involved with drugs, or turning to robbery and other crimes. Identity crisis was also reported as a major problem. A possible solution to this situation may be for teachers to understand their students' culturally diverse backgrounds and adjust the curriculum and styles of learning to take advantage of the diversity. Keeping the constructivist view in mind, the students' strengths and needs are of primary concern in constructing science knowledge.

The school must take the responsibility of guiding each child in constructing his or her own knowledge and feeling of accomplishment. Children need to be able to use all their facilities of language when communicating in science, not just a target language, that is, English. If children are to feel comfortable constructing science concepts, then they must be allowed freedom to express themselves in any language with which they feel at ease. This may include drawings, graphs, or diagrams, as well as written or oral language. "Language," "cognition," and "society" are not separate entities in interaction but aspects of a common system constructed by individuals in processes of discourse and exchange (Slobin, 1982, p. ix).

In order for children to build science concepts, they need a forum for testing the validity of what they think they perceive.

In order for children to build science concepts, they need a forum for testing the validity of what they think they perceive. This forum is often classroom or small-group discussions. As the students come together in the classroom, they become a community in discourse. "In a community that is learning science, one might expect to see students engage in ways such that the discourse of a class would become more science like over time" (Tobin, 1998a). Children need opportunities to explain to their peers how they see the world, how it works, and how it makes sense to them. Given these opportunities, students can begin to contribute significantly to the discussions and test new ways of talking about the nature of knowledge (Roth & Lucas, 1997). By listening to explanations, one can usually understand how a science concept is constructed. Children are comfortable with small-group discourse and gain confidence in expressing their beliefs to the entire class. This concept of direct experience, coupled with opportunities for reflection and elaboration, is central to successful science teaching (Bruce, Bruce, Conrad, & Huang, 1997, p. 72).

Children engaged in science discourse begin to negotiate with each other the meaning each has constructed for various concepts. Each brings his or her own spoken language and discursive competencies to the encounter. As the interaction progresses, the group usually arrives at a common meaning. This process of finding common ground to communicate is called *co-participation*. Co-participation implies the presence of a shared language that can be accessed by all participants to communicate with one another such that meaningful learning occurs (Tobin, 1997). Co-participation is vital to young children in their search for the relevance of science to their own lives. Children must engage in a discourse about experiences in their lives. Karen Gallas (1995) states, "I believe that when a community of learners begins with the act of dialogue about the world, and when that dialogue occurs outside of the theoretical or conceptual influence of the teacher, it moves more naturally toward theory and readiness for instruction and study. In this process the students take on the voice and the authority of scientists" (p. 3). Students begin to bring their prior knowledge and their experiences to the classroom and discuss them to find relevance to the scientific world around them. The facilitator poses questions to provoke their thinking. Children coming together in class for the purpose of discussion about science topics is known as *Science Talks*. In this type of learning, the children discuss their thoughts about a given science topic. The teacher stays quiet most of the time and listens to the children. From the children's dialogue, the teacher can see how children's constructions of concepts develop (Gallas, 1995, p. 18).

Methodology

Documenting observations of how individual children learn is best communicated by means of a case study. These particular case studies employed an emergent design as described by Guba and Lincoln (1989, p. 180). As the research began and the children were observed in class, new questions took shape. It became evident that new interpretations of the data would be necessary. This is consistent with Ritchie, Tobin, & Hook's (1997) observation that "interpretive research is flexible in that the focus or terms of reference for an inquiry may change in response to the researcher's perceptions and understandings of classroom events" (p. 227).

Along with parent interviews, the two children identified for case study were also surveyed. Observations of the students were made while they were actively involved with their science groups during class time and their responses in *Science Talks*. Records of observations and student science journals became an important data source. A chronological account of the research was kept in teacher journals.

The questions asked of the parents were

- What are your feelings about the bilingual program in our school?
- What are your feelings about your child's learning two languages?
- Does your child talk about school experiences at home?
- Does he or she tell what he or she learned?
- What are your feelings about being bilingual?

The questions asked of the students were

- What did you learn about plants/insects?
- Did you enjoy learning about plants/insects in Spanish?
- Do you find it easy or hard learning in Spanish? Why?
- Do you like learning to speak two languages?
- What do you like the most about learning to speak Spanish?

The two-teacher bilingual team used a thematic approach incorporating science concepts with language and literature lessons in both English and Spanish. The teachers planned together and worked on the same thematic units in the same time frame—each in their respective language. Plants and insects were the two units of study used as the backdrop for this inquiry.

Findings and Interpretations

Case Study: Student A

Student A was a six-year-old Caucasian male whom we will call John. He was born in Ohio and lived there until age three when the family moved to South Florida. He had only one other sibling, a sister, born at about the time the family moved. John's mother reported that he loved school and often mentioned class events at home. She further stated that John talked about things he learned in both the Spanish and English classes. However, he discussed the English class most. Until John moved, he had no exposure to the Spanish language. In South Florida, John had two cousins who were bilingual and spoke

Spanish. The children played together occasionally, and John learned a few Spanish words. His parents felt that it was extremely important for John to learn to speak Spanish, as well as English, because of the bilingual job market in the community. The bilingual program previously described provided this opportunity. When school began and Spanish classes were initiated, John was reluctant to try speaking Spanish. As he became more familiar with the program, his attitude changed, and he became motivated to learn Spanish.

During *Science Talks*, John would sometimes get so excited about giving an explanation that he would literally jump out of his chair.

John's English vocabulary and language usage were well-developed. This enabled him to quickly communicate to the teacher and his peers how he was constructing his knowledge. He was eager to talk about almost any science-related topic and brought an abundance of prior learning to the classroom. When other children asked questions, John would often offer his answer. When demonstrations or explanations were given, he was attentive. Small-group work with materials found John constantly on-task and actively involved. During *Science Talks*, John would sometimes get so excited about giving an explanation that he would literally jump out of his chair. He listened for new science vocabulary and incorporated it into his work. As time when on, he would tell a Spanish word for the subject matter we were investigating in English.

In small-group activities, John was a leader in accomplishing the task at hand. When we planted seeds, the children took turns digging soil, dropping seeds, and watering. John was giving directions step-by-step and talking about the process. He correctly predicted within a day or two when the plants would appear from beneath the soil. Each day John would enter class and immediately observe the vegetable garden to see any changes and remind us that they needed water to grow. When the sprouts came up and turned toward the sunlight, John was one of the first children to notice this phenomenon. One of the *Science Talks* was "How Do Plants Grow?" In this discussion, John concluded that the plants needed the sunlight to grow and were turning to the light. This child brought a wealth of prior knowledge to the classroom. He talked about things he had done with his parents and grandparents. These experiences enabled him to make many reliable science constructions. For example, in an interview, John related how he and his grandmother planted lemon seeds. These kinds of direct experiences empowered him to come to reasonable and viable conclusions.

Both teachers interviewed the student at the same time. We asked him to tell us what he had learned about plants. He was able to talk for about 15 minutes. John felt comfortable sharing his experiences with us and informed us of the following constructions:

- Plants need air, sunlight, and water to grow; water comes from the roots to feed the tree and goes into the leaves.
- Leaves block sunlight and make shade where it is cool for us to sit.
- Plants come from seeds, but not always.
- Oranges may not always come out as oranges because they take a branch of one tree to put on another. (This idea of grafting was discussed in the English class after children brought orange seeds from the cafeteria.)
- In Ohio, in fall, the leaves fall down because there is not enough heat.
- In springtime, everything gets green again because the sun is out longer.

After the unit covering insects, we held another interview. In this conversation, he very seriously spoke about a "squirt bug" that shot orange juice out of a nostril that looked like an elephant's trunk. We asked where he had seen such a creature. Finally, he admitted, with a chuckle, that he had seen it in a cartoon. He did, however, have some real-life constructions regarding ants, bugs, flies, caterpillars, roaches, and termites. He knew that termites ate wood and roaches ate crumbs. The physical description of insects was accurate. The life cycle of the caterpillar was correctly explained, including what the caterpillar ate.

John said that he enjoyed Spanish class and was able to say a few words. We asked how he knew what was happening in the Spanish class. He stated that sometimes his friends, who are bilingual, whispered to him in English. Some words sounded similar and picture clues also helped. Yadira asked John, "If I talked about insects and another child drew an elephant, would you draw an elephant too?" John replied, "No! I would know that was not right!" We asked him what helped in understanding what was happening. From his comments, we concluded that verbal cues, context clues, and intonation were conducive to his learning.

Case Study: Student B

Student B was an African-American female whom we will call Cheree. She was a mature and very independent five-year-old who was born in South Florida. Cheree came with a background full of experiences. She often traveled to Millen, Georgia, to visit her great-grandparents. There, Cheree enjoyed being outdoors and one of her favorite autumn pastimes: collecting pecans in her great-grandparent's yard.

Cheree came from a single-parent home. Her mother was a fifth grade science teacher and exposed her to many different funds of knowledge. She strongly encouraged the acquisition of a second language. Due to the diversity of the community in which they lived, Cheree's mother believed it was of utmost importance to speak Spanish. She felt that South Florida was full of career opportunities and that being able to speak two languages would secure her daughter's future.

Cheree was very motivated to learn Spanish. Cheree's mother shared during a parent-teacher interview that at home she played school for long periods of time. She would announce, "Today, we will be talking in Spanish." She then proceeded to imitate the teacher's actions using the vocabulary heard on a daily basis. Her students at home were usually her two older cousins (who were currently taking Spanish as a second language) and her mother.

As her teachers, we noticed that Cheree learned from observing models in her life such as her mother and teachers. She role played these influential people, as in playing school. At home she constantly talked about patterns, plants, insects, the moon, and other things discussed in class. While Cheree was eager to learn, she also enjoyed the social aspects of class, interacting with peers. During the *Science Talk* on plants, this child related her visits in Georgia to her learning about plants. For example, she said, "My granddad had a lot of fruit trees in his backyard. He planted them, and we have watched them grow."

In a small group setting, Cheree enjoyed following the task at hand in planting the seeds for the vegetable garden. She insisted on being in charge of watering the plants daily. After a weekend, she immediately observed that the plants were wilted and knew that they needed water. Later, the plants revived, and she noted the difference. In her science journal, she illustrated changes in plant growth that she perceived.

While working on the insect unit, the children had the opportunity to bring insects to examine. Cheree brought in a unique insect observation box made of clear plastic with a magnifying glass on the lid. Under her direction, the group enjoyed scrutinizing their bugs. She was able to tell the body parts and correct number of legs. This unit was particularly interesting to her. During the initial interview, the teachers asked Cheree to tell what she knew about plants. She discussed how to plant and water seeds, then watch them grow. Sun, water, and wind were things mentioned as necessary for growth. She stated, "Sometimes, the plants need extra food like fertilizer to grow better." Her experiences with her great-grandfather and his trees enabled her to make this construction.

Following the insect unit, we interviewed the child again. Cheree shared the following constructions: some insects fly and others walk, and insects eat wood, plants, and food in the kitchen. She noted characteristics of their bodies as hard, wet, or soft. She discussed habitats for a number of different insects. This unit also stimulated her curiosity about other animals.

In Spanish, this child made many connections and transferred knowledge from one language to the other. She named color and number words in Spanish, as well as many other vocabulary words. Songs and rhymes were easily recalled. Often in class, she asked the teacher how to say specific words in Spanish. Picture clues were a vital way for her to comprehend new words.

Member Check

As part of Guba and Lincoln's (1989) hermeneutic dialectic process, all of the stakeholders were interviewed individually once again to establish credibility in the research. "The identification of high-salience issues is, in part, an interaction process between inquirer and participants and depends on an intense study of analyzed constructions and reconstructions" (p. 153). The structure of this part of the interview process focused on the parents' concerns and issues in regards to the findings of the study. The parents felt that their child's interests and constructions were fairly represented. Trust is an integral part of an evaluation such as this. It was clear that the parents trusted the evaluators' interpretations of their children's learning.

> The parents felt that their child's interests and constructions were fairly represented. Trust is an integral part of an evaluation such as this.

John's parents noticed that he was beginning to speak more words in Spanish at home. He was able to name objects in the home, which indicates signs of emergent acquisition of a second language. His parents were also eager for him to learn Spanish. If he did not know the vocabulary, they encouraged him to ask his teachers. This positive attitude is important in the continuing process of second language learning. While playing with a bilingual cousin, his parents noticed that John communicated more in Spanish.

In the classroom, both teachers noticed that John was making connections between the two languages. In reading class, John would talk about how the beginning sounds of words in Spanish were the same or different from the word in English. This discrimination showed how John was analyzing the learning of two languages. He stated that he felt more comfortable participating in Spanish activities. In science, John continued to be an excellent observer. While actively engaged, he questioned and predicted outcomes of class experiments. John's interactions provided good evidence that he was constructing concepts in science, as well as acquiring a new language.

As a science colleague, Cheree's mother closely followed our research. This teacher holds a Specialist's degree in Science Education. In our member check process with this parent, our inquiry was carefully analyzed and compared to other available research. She was confident that our observations and constructions were reliable and valid. Emphasis was focused on sharing our research with associates interested in bilingual education.

Cheree displayed evidence in the classroom that she could comprehend everyday Spanish vocabulary. In her discussions with classmates, she understood conversations and contributed even though she possessed limited spoken proficiency. Science class found this student observant and actively participating regardless of the language of instruction. At home, Cheree continued to share experiences in Spanish with her family. This student appeared to be efficiently acquiring a second language. However, according to McLaughlin (1992), it will take many years of instruction before fluency and proficiency in the second language are acquired.

Conclusions and Implications

The curriculum used in the Spanish portion of the bilingual program employed songs and rhymes to teach the vocabulary and concepts. This technique was well-liked and made it easier for the children to remember new vocabulary. Through music, young children get the repetition needed to acquire a new language without the boredom of drill.

The effectiveness of this bilingual program relied on the children's positive attitudes in the acquisition of a second language. The interesting material motivated the students in internalizing the science concepts. Learning ideas in a new language did not hinder the children in making constructions. They drew from their previous experiences and also used contextual and verbal clues to help in their understanding. An important instructional strategy used with them was to explain an activity in their home language to check for understanding, since language use in and of itself is not the critical issue (Gonzalez & Maez, 1995). We concluded that learning a second language did not interfere with the children's continuing to build their constructions in science.

Plans for the continuation of this two-way bilingual program include extending instruction throughout the students' elementary and secondary years. However, the school district needs to provide adequate training, materials, and support for such a program to be successful. "Such a plan runs into serious practical roadblocks in secondary schools: availability of qualified teachers, scheduling, graduation requirements, and so on.…serious attention must be focused soon on identifying practical strategies for providing effective continuation of two-way programs at the secondary level" (Christian, 1994).

> Through an inadvertent error, Wagner was sent to the workshop held in Spanish. She experienced how her monolingual English students must feel during their instruction in Spanish.

The bilingual department of the Miami-Dade County Public Schools held workshops to train teachers in implementing the extended foreign language program. The initial workshop was conducted in English for all involved teachers. However, later workshops were in Spanish as those teachers faced greater difficulties in acquiring materials to implement the activities. Through an inadvertent error, Wagner was sent to the workshop held in Spanish. She experienced how her monolingual English students must feel during their instruction in Spanish. While the other participants were supportive and helped her with unfamiliar terms and phrases, she still felt some apprehension. Wagner was amazed at how much she comprehended and communicated in that sociocultural context. According to Collier (1995), educators must understand the complex variables influencing the second language process and provide a sociocultural context that is supportive while academically and cognitively challenging.

When making constructions on the needs of plants, the students developed their physical and intellectual abilities of scientific inquiry. As stated by the National Science Education Standards, "Students at all grade levels and in every domain of science should have the opportunity to use scientific inquiry and develop the ability to think and act in ways associated with inquiry" (National Research Council, 1996, p. 121). Students were fully engaged in observations, using manipulatives, making verbal descriptions, and drawing conclusions to meet this standard.

Constructing viable models that explain natural phenomena enables children to see how the science they experience at school is related to their world. Regardless of the language used as the medium of instruction, students will still attempt to make sense of their environment. Teachers need to focus their attention on ways to interest and motivate students to weave these concepts together. Science instruction must provide opportunities for children to construct products and engage in dialogue about their products (Shepardson, 1997).

Epilogue

As a result of ongoing literature research, we encountered a wealth of information regarding bilingual education that dates back to the 1960s. Throughout the United States, there is a growing number of schools engaging in dual language instruction—even in areas where there is not a large bilingual population. Reading these articles helped us understand the process of acquiring a second language. The experience of other researchers aided us in avoiding pitfalls in our program. We learned that there are no quick and easy solutions to complex situations. "Second language learning by school-aged children takes longer, is harder, and involves a great deal more than most teachers have been led to believe" (McLaughlin, 1992).

Our case studies involved two monolingual English children who were part of a culturally diverse group. As part of our learning environment, students engaged in cooperative learning, peer coaching, and other formats of interactive learning. One of the biggest advantages of two-way programs for language development is the presence of native-speaker models for both languages (Christian, 1994). This aspect was clearly evident in our classrooms as the target children quickly learned vocabulary from their peers.

In our community, the School Board has formed a multilingual task force. This group recommends that all high school students take three years of a foreign language to graduate. However, what seems to be lacking is the educational funding for such a program. As our nation strives to attain "high standards for all students," and as we seek to include language competence in one of our National Education Goals, two-way bilingual programs offer great promise (Christian, 1994). We see our contribution as fitting this need of academic excellence in expanding our nation's language resources. English-speaking students acquiring another language—as well as minority students preserving their home language—augment understanding and appreciation among cultures (Christian, 1994). It is exciting to be an influential factor in this national trend. ◆

CHAPTER FOURTEEN

Science Teaching and Learning as a Vehicle for Literacy of Hispanic Illiterate Children at Risk

Celia Ormes
Riverside Elementary School, Miami, Florida

Celia Ormes has been a Dade County elementary school teacher since 1979. Previously, she was a University instructor at the University Matias Delgado in El Salvador, Central America. She holds a Bachelor's degree in Spanish Literature and Communications, a Master's degree in Teaching ESOL from Florida International University, and a Specialist's degree in Science Education from Florida State University. Her main interests are research on bilingual education.

Abstract

Although it is commonly assumed that language minority or LEP designated children are not able to communicate adequately (that is, read and write) using the English language, instructional interventions are made all the more complex if students are functionally illiterate not only in the language of the mainstream society, but also in their native language. This study presents and describes the success of a teacher—generated initiative based on science instruction as a vehicle for achieving bilingual English/Spanish literacy and the development of a viable scientific community of discourse in the classroom with these students.

Background and Purpose of the Study

In 1989, due to unexpected and massive immigration, immediate action was needed to meet the needs of many refugee children who were entering the Dade County school system with limited, interrupted, or no schooling due to war conditions or deprivation in their homelands. These children were functionally illiterate in their native language (Spanish), were between the ages of 8-12, had no formal schooling, and had not developed basic skills of reading or writing. They did not have good study habits and had never experienced the school socialization process in their own countries. In synthesis: they couldn't follow any classes in any language. Teachers at Riverside Elementary School undertook the *New Beginnings* project, an action research initiative to help these Hispanic children to succeed in school.

During the six years of the project, three homeroom teachers and a Spanish teacher collaborated to implement a science-based curriculum to bring Hispanic illiterate children to grade level. Of the 107 Hispanic students in the six-year study, 85 percent increased their reading competence to third grade level by the first year. The other 15 percent were either performing at diverse grades of competence or had been referred to a Child Study Team for further evaluation.

The reflections herein are a compilation of events, memories, and student records maintained by students, the homeroom teachers, and myself. The *New Beginnings* project at Riverside was essentially a team effort. This presentation also is a product of the comments of my colleagues, who during those six years, continued to search for solutions to address the problem of these illiterate Hispanic children.

The children of the *New Beginnings* program often come back to the school to tell us stories about their lives—their successes and their failures. This communication and mutual respect made it possible to include in this narrative an interview with Maylin Solis, one of the first students in the *New Beginnings* program. She was eight years old at the time and had came from Nicaragua, not able to read or write in her native language. Ten years later, she explained in perfect English what the *New Beginnings* program, with its emphasis on science, meant to her life, to her career goals, and to her aspirations in life.

In the early 1980s, the Miami area was particularly challenged by an unexpectedly massive immigration of families fleeing war and poverty in their native Caribbean and Central American countries. In Dade County, classes were overcrowded and resources were in short supply. Many of the new arrivals were even more impoverished and ill prepared for school than were previous immigrants. Not only were these children not literate in English, but they also could not read or write in their native language. Although these children were bright, they were up to four years behind their peers in school. The situation threatened to aggravate the alarming dropout rate of Hispanic students, already the second largest rate in the country.

Riverside Elementary is an urban school in Dade County, Florida, one of the areas of highest concentration of Hispanic population in the state. This area also has one of the largest enrollments of Limited English Proficient (LEP) students in Florida.

> Teachers were faced with the challenge of educating children who, at 8-12 years of age, did not know how to read and write in English or Spanish.

The school was originally built to host 800 students but due to overcrowding, during the time in which this study was conducted, served up to 1,400 students from the inner cities of Little Havana and Overtown. Most of the students came from low socioeconomic status Hispanic families (95 percent), mainly from Cuba, Central, and South America. Five percent were black children who were bused from Overtown. Due to integration policies, after kindergarten our children have to be bused to other schools for first, second, and third grade instruction. These children come back to Riverside when they are at fourth grade to complete their elementary instruction. For students below poverty level, Title I funds are provided for free lunches.

In November of 1989, just six months after I entered the school system in Dade County, the impact of a large immigration of children from other countries was felt at Riverside Elementary. Teachers were faced with the challenge of educating children who, at 8-12 years of age, did not know how to read and write in English or Spanish. These children had either never attended school in their country or had limited or interrupted school experiences. They not only did not know English, but they did not have the background or the literacy skills needed to progress in school in their own language. They did not have transferable academic backgrounds or skills, and they could not perform academically in any language.

These students needed special attention, and homeroom teachers were overwhelmed in already very overcrowded classrooms of 50 or 55 students. Budget cuts had eliminated teaching assistants, and paperwork had turned into a maze of records and requirements. As a result, most of these children would show either disruptive behavior or an apparent lack of interest and motivation. In too many cases, they were perceived by their teachers (especially those who were monolingual) as children with learning disabilities or with emotional handicaps. Consequently, many of these students were continually referred to Special Education or the Learning Center, or they were being constantly reprimanded for their behavior. They were considered mentally retarded, emotionally handicapped, or merely ungrateful for the opportunities offered to them by this country. On the other hand, children with special abilities were largely being under-referred to the gifted program classes.

In November of 1989, I volunteered to teach these students how to read and write in Spanish. I would be responsible for developing the Curriculum Content in Home Language (CCHL) program. I was coupled with a bilingual homeroom teacher in an English for Speakers of Other Languages (ESOL) self-contained class. Children were grouped homogeneously.

Organizing the Program

While searching Dade County's procedures to identify information that would help us find strategies to use in the program, we discovered four important issues. The first concerned placement procedures. These Hispanic illiterate children had been placed by age, not by academic knowledge in fourth, fifth, or sixth grade. This was done without giving them any tests in their home language. The only available assessment instrument was an oral test in English language that would determine their literacy level in English; there were no procedures using the home language to determine appropriate academic level. Secondly, it seemed that academic programs in Dade County had not considered the possibility of illiteracy and its associated implications for teaching and learning. The current transitional bilingual programs—English for Speakers of Other Languages (ESOL), and Bilingual Curriculum Content (BCC)—were not designed to meet the special needs of bilingual illiterate students. The elementary and secondary level ESOL and CCHL instructional programs were based on the assumption that students already possessed literacy and academic skills in their native language and that they could readily transfer those skills to the new language of English. Therefore, the students in question had a dual problem: lack of English language proficiency and lack of literacy and academic skills in both English and Spanish. Third, the time allocated to instruct children in CCHL was 45 minutes a day for mathematics, social studies, and science. This was largely insufficient, since the English language component was not articulated with the content area. Fourth, promotion of students was almost automatic in elementary school, with the criteria for advancing these children being measured only by their improvement in oral performance in English or ESOL level.

Goals and Objectives of the *New Beginnings* Program for Illiterate Hispanic Children

The following proposal was presented to the school principal indicating that the *New Beginnings* program at Riverside Elementary would be a transitional bilingual program for Hispanic illiterate children with the following goals:

- To provide the rapid acquisition of basic academic and literacy skills in both English and Spanish
- To accelerate the necessary academic and literacy skills to enable students to fully benefit from elementary ESOL and CCHL courses
- To elaborate a screening procedure to identify children with illiteracy problems
- To design an early intervention procedure to prevent disproportionate referral of Hispanic students to Special Education and under referral to gifted programs

- To design an accelerated curriculum as a means to impact the high failure and dropout rate among Hispanic students with illiteracy problems
- To investigate strategies to satisfy the real needs of illiterate students, which would allow progress in the classroom

Getting Started (November 1989)

Permission was obtained to group 29 illiterate children in a homogeneous ESOL self-contained classroom with a Spanish/BCC teacher for two hours per day and a bilingual homeroom teacher for the ESOL component.

We also soon realized that we were not only confronting a lack of academic and literacy skills but also a much more complex and demanding problem: many of the students were psychologically affected by the traumas of war, were alone in the country, or had witnessed devastating situations of death and famine in their own countries.

Implementing *New Beginnings* was not easy, and finding the right educational resources was difficult. Books to teach how to read and write were either too childish for children between the ages of 8 and 12, or they were designed for children whose psychosocial maturation was in the early stages. Our children had not only developed physical maturation, but they had undergone experiences and developed abilities that had allowed them to survive being illiterate. Many of them had streetwise abilities, and many had been working already in the countryside or with their parents in their businesses. We also soon realized that we were not only confronting a lack of academic and literacy skills but also a much more complex and demanding problem: many of the students were psychologically affected by the traumas of war, were alone in the country, or had witnessed devastating situations of death and famine in their own countries. Many had seen their parents killed. In spite of these circumstances, we realized in our initial interview assessments that the children brought with them a wealth of previous experiences that we could use as a basis for our instruction.

I obtained permission to buy the phonetic Spanish book *Victoria* that is widely used in Latin America at all levels to teach how to read in Spanish. It had been successfully used in my own country, Mexico, to teach illiterate children and adults. In searching for materials, I came across a set of old science books for fourth and fifth grade, published in Spanish by Harcourt, Brace, and Jovanovich. I decided to use them to teach the children the structure of a book and to develop their vocabulary with the hope of motivating them to become interested in learning in their own language. While I was sure that the Spanish materials (such as *Victoria*) for reading instruction would be effective, I did not know at that time the impact that the Spanish version of the science books would have on my students. The testing of these materials allowed me to see the reactions of the children concerning the teaching and learning of science and to develop an effective way to interact with them. The children felt assured and familiar with the themes in science. They had made many observations themselves about their surroundings, and they brought to the class their previous experiences and knowledge which they used to relate to the material being taught.

Many of them had experience in observing animals and natural phenomena and in taking trips across the countryside. They told stories about their countries, their rivers and mountains, the plants and flowers they had seen, and the foods they had eaten. With many coming from Central America, an earthquake was for them a lived experience. They knew about the seasons, the wind, and the rain. They had witnessed the explosion of a volcano. They had been shoulder to shoulder with their parents or their friends while casting iron shoes for horses, and they knew about remedies and medicines made from plants. Many, unfortunately, had witnessed the effects of alcohol abuse. Others had assisted their mothers in giving birth and had witnessed animals mating. Rivers and lakes were familiar to many, and being experts in helping to manufacture them, they knew why canoes and little boats float. Many knew stories about the moon and its phases, when and how the seeds on the ground grow, and the nature of different crops. They could appreciate the importance of a rainy season and the terrible consequences of drought. I would read to them aloud, asking them to put their finger on the pictures and showing them the structure of the book (for example, "This is an index. This is the glossary. This is the way to look for information"). This, I reasoned, would allow them to become familiar with more complicated textbooks.

Because they were physically mature, it was just a matter of days before they could handle a pencil and perfect their writing. After all, it was only the learning of symbols that would allow them to transfer their highly developed thoughts and feelings to the paper. These incredibly artistic children would use pictures to develop their ideas and portray their conceptual struggles. After just a very short time, these children were using their science books to actually read in Spanish, and in only a year they had advanced at least three grade levels in their native language. Their ESOL level advancement was the same as for the regular children in ESOL. This was confirmed in their post-test. The children who didn't advance, we would refer with confidence to a child study team, knowing that they might have a problem besides that of the language and confident that they had been trained in basic skills. The results sent in the report after only one year were so unexpected and so spectacular that the school principal gave us her total support and decided to reinforce the program to make it extend to other children with similar problems.

Expanding *New Beginnings*

Based on the success of the initial *New Beginnings* group, our principal decided to expand the program to include three classrooms. One participating class from grades four, five, and six provided opportunities to assist the children across three grade levels and also to comply with the county requirements of placement by age.

As one of the 20 schools selected to participate in the Dade County Instructional Project, we were able to present a proposal to buy materials for *New Beginnings*. I was awarded a $10,000 grant from the Florida Department of Education to purchase instructional technology. On the recommendation of the science supervisor, I looked at the videodisc-based curriculum published by Optical Data Corporation. When I evaluated *Windows on Science*, I quickly realized the tremendous potential held by this curriculum to help bilingual students (illiterate or not).

No other set of instructional materials or computer applications I reviewed at this time had the potential of this curriculum. A large part of my grant money went to buy *Windows on Science* and the *Language Laboratory*, a set of correlated readers that emphasized reading and writing skills. *Windo ws on Science* built on students' existing audio and visual skills to help them learn Spanish and English as they learned science content. I used the Spanish narration on the *Windows on Science* videodiscs to introduce students to science principles such as photosynthesis, kinetic energy, or volcanic action. After the videodisc-based lessons, my students applied their newly acquired content knowledge in reading and writing exercises using the correlated nonfiction science reading passages in the Language Laboratory.

Empowering Technology

The technology of the videodisc is enlightening and empowering. It not only empowers teachers and students to learn through dialogue and interaction but also develops scientific literacy in the teachers themselves. Soon my own interest in science increased, and I was able to develop (through preparation for my classes) not only organized knowledge, but also my confidence in delivering my lessons with a powerful tool. The use of videodisc technology in science teaching not only improved my own capacity for teaching and expanded my knowledge and information but also transformed me into a technologically literate person.

Videodisc technology instruction facilitates the effectiveness of science instruction. At the touch of a button on the videodisc player remote control, I could provide my students with immediate and concrete visual experiences.

Videodisc technology instruction facilitates the effectiveness of science instruction. At the touch of a button on the videodisc player remote control, I could provide my students with immediate and concrete visual experiences.

Abstract and complex science concepts such as those developed in the chapter on motion and forces came alive and demonstrated concepts impossible to illustrate in a book with motionless pictures. With a *Windows on Science* video clip, I could take my students on a videodisc-based roller coaster ride. I could show them simple and complex machines at work. As the roller coaster slowly climbed a steep incline and then hurdled down the other side, my students gained a vivid and memorable understanding of the principles of potential and kinetic energy. As I moved through a video lesson, displaying first a colorful graphic or a motion video clip and a color slide, I asked questions about the images. Frequently, hands shot up as students volunteered answers and posed their own questions. In this highly interactive, energized, and language-intensive environment, students realized that science was not beyond their reach. They connected what they already knew to the new material and discovered that science was relevant to their lives.

I followed the videodisc lessons with correlated hands-on activities. In one lesson, the class investigated potential energy as related to the height of an object. I had my students drop balls made of different materials from various heights. The children used a meter stick to measure the height and frequency of subsequent bounces. They then graphed their results. The activity allowed my students to use kinesthetic and tactile learning channels to test and examine the concepts they had learned in the video lesson. The lesson on energy could then be followed by a reading passage from the Language Laboratory, which had been developed to follow the same sequence as the images on the videodisc. Drawing a concept map and completing the non-fiction science reading passage verified and extended the connections made during the videodisc-based lesson and hands-on activity. It also built a foundation for the transfer of the concept into the English language. Finally, a writing exercise from the reading passage helped students begin to communicate what they had learned. As they wrote, they built stronger links between familiar and newly learned ideas. The science concepts became part of their own private stock of knowledge—owned and transformed by them—to be used in the future to make sense of the world and to serve as the basis for new ideas.

Increased Motivation and Interest in Reading

With the use of the videodisc, my students took an active part in their own education, increasing their self-confidence and motivation. My students maintained their enthusiasm throughout lessons for more than an hour at a time. They were more interested in reading following the videodisc lessons. They enthusiastically searched the library for books on topics such as botany, zoology, physical science, and microbiology. *Windows on Science* has become a success at Riverside Elementary. Behavioral problems have diminished, the attention span of the children has increased, and best of all, students feel—in spite of their academic disadvantages or language barriers—the powerful incentive of success.

When children enter the *New Beginnings* program, they are not literate in English or Spanish and are years behind in school. When they graduate from *New Beginnings*, they can read and write in English and Spanish, are technologically literate, and study science at the appropriate grade level. Many of them advance two or three grades in less than a year. The children in the *New Beginnings* program are happy and well-adjusted in school and are self-confident, enthusiastic, and capable learners. These students are our future. With the assistance of the *Windows on Science* multimedia program, the future looks bright.

Longitudinal Outcomes

After four years of consecutive work and research, the children served by the *New Beginnings* program showed an average advancement of three grade levels per year in native language, with a high correlation in acquisition of the English language.

For three consecutive years, I was able to follow a group of students with excellent results. This follow-up has permitted me to draw some conclusions about the importance of enhancing the curriculum with videodisc technology. Annual reports were presented to the principal showing the improvement by grade level. A link was established with the teachers from Special Education and the school district psychologists, who were informed about the action research taking place at Riverside. This facilitated the referral of children with problems other than language to child study teams for proper evaluation. Those children who were referred had already improved their skills and were more academically prepared than before.

By June 1996, and after four years of consecutive work and research, the children served by the *New Beginnings* program showed an average advancement of three grade levels per year in native language, with a high correlation in acquisition of the English language. By 1992, the program had served a total of 107 children: 65 percent reached grade level in less than two years in both English and Spanish. By 1995, a total of 194 children had successfully exited the program and transferred to regular ESOL classes with improved basic skills, developed learning abilities, and improved self esteem and motivation.

During the six years of its operation, the *New Beginnings* project was widely recognized as a pioneer program in assisting illiterate children who were at risk of failing to benefit from schooling. It was recommended for replication in other areas with similar problems. Unfortunately, no expansion of the program has been possible.

Teachers' Perspectives

Below are some of the reflections collected at teachers' meetings with respect to the successes and failures of the program. "Why do we think this approach was so successful?" we asked each other. One of the most effective strategies responsible for the success of the program was the teamwork. We worked so closely together for years that we could coordinate our classes and objectives so that the children could benefit with improved learning environments. The following points are worth mentioning for further analysis:

- There was full support from the school administration, from the county, and from the bilingual department.
- The objectives and goals of the *New Beginnings* program were thoroughly discussed among all stakeholders (the school administration, the teachers, the parents, and the students).
- We arrived at a consensus that equal attention should be given to the learning of skills in English and in Spanish. We put aside the political

The age of the students (8-12 years old), their maturity, and their already developed physical abilities—coupled with their previous life experiences—proved to be powerful foundations for subsequent learning.

tensions associated with questions of which language should be used as a method of instruction. We also followed recommendations of recent research showing that skills development in native language are fully transferable to a second language. The use of the native language was shown to improve student interest in learning a second language.

- The age of the students (8-12 years old), their maturity, and their already developed physical abilities—coupled with their previous life experiences—proved to be powerful foundations for subsequent learning. The use of manipulatives was important, and the alternative uses of science books with basal readers in Spanish allowed me to develop non-fictional, academic vocabulary and reading and writing activities that would set a solid foundation for increasing levels of sophistication.

The implementation of an organized science curriculum with videodisc technology allowed for the following:

- The inclusion of technology in the classroom and a modern, up-to-date interactive mode of instruction
- The possibility of applying a constructivist philosophy of teaching and learning and the enhanced role of the teacher as a facilitator for interactions and learning
- The possibility of using a fully bilingual method of instruction that could assist the children to acquire concepts and skills transferable to a second language
- Increased possibilities for developing multisensory modes of learning with the incorporation of visual, tactile, and audio experiences (Shared experiences yielded an increased development of critical skills and the empowerment of students.)
- Native culture to be appreciated and used to bring the children from the familiar to the new, while discovering unique characteristics of American culture and its similarities to their own (This strategy, in particular, increased the students' self-pride and self-respect and, therefore, created an increased motivation and a dramatic improvement in behavior and participation.)

A Student's Perspective

The following excerpt is from an interview (July 20, 1997) with one of the first students in the *New Beginnings* program. Ten years after the experience, she tells us what science learning has done for her life. Maylin, the student, relates her story as follows:

> I arrived in the United States in 1988. I was then eight years old. At that time, I did not know how to read or write in my own language: Spanish. As soon as I arrived, I began to attend third grade of elementary school. I remember feeling very sad because I could not understand anything, and I could not do any work at school like the other children. I was bored all day without being able to do what the teachers asked me to do, and I always felt ashamed and afraid to tell them that I didn't know how to read and write. Besides, I didn't know English like the other children. The teachers thought that I was lazy and that I didn't want to do my work. They even thought that I was retarded and used to take me to the counselor all the time. But nobody had realized that my problem was that I had been in school very little

in my country and that I did not know how to use a pencil. The school I attended was Frederick Douglass Elementary. I went to this school for one year until I was promoted to the next grade level. Then I attended Riverside Elementary for my fourth grade year.

There I met Mrs. Ormes. She was my Spanish teacher. When Mrs. Ormes realized that I couldn't read or write, she selected me to be in a school program named *New Beginnings*, where she taught. *New Beginnings* was a school program made for students who could not read and write in Spanish. There, Mrs. Ormes taught me Spanish, math, and special science classes. Here is when I realized that I found some interest in science. I remember that we started from learning the vowels, like little children, but we advanced very fast. Things began to be better for me. Very soon, Ms. Ormes had us reading very interesting things. I remember that we had some purple science books in Spanish, and she would read to us every day. She would show us the pictures and explain to us everything about the plants, the animals, about our body, and about the planets. We would go to the library, and we all began to pick up science books of what Ms. Ormes had taught us in the classroom. She always had beautiful books and magazines, all related to science. But those were not children's books, but books that I later found in the high school. They were more like science encyclopedias, magazines, and books that will show all kinds of animals, plants, machines, technology, and a lot of biology. She spent hours talking about our body, about the viruses that could make us sick, and how could we prevent illness with good nutrition. I remember Ms. Ormes teaching us about our ears, for example, and we would learn about how we listen to sounds and music, and how the sound gets into our ears to the brain. Then she would talk about the telephone, the microphone, and all kind of things that were connected. She also taught us about machines and light and many other things. I learned a lot during those years.

This program also helped me a great deal with my disability. Ms. Ormes explained to me that the disability that I had was dyslexia because she realized that I switched letters and numbers when I wrote. We both worked together with that, and that helped me a lot because I knew what was the problem, and I was able to explain it to other teachers that came after her. I was not scared. As you may know, dyslexia is a disability that never cures itself, but knowing it made me more secure and confident to work with that.

This program was of great benefit to me. Thanks to this program, I am now able to read and write, though not perfectly, maybe because of my disability.

After I completed the sixth grade, I was promoted to the next grade level, which was the seventh grade. I went to Booker T. Washington Middle school. Here I attended for seventh, eighth, and ninth grade. During these years I studied many types of science, and it was very easy because Ms. Ormes had taught us so much. When I began my eighth grade, I participated in an Honors program for two months. For the summer of my ninth grade year, I attended Miami Beach Senior High School for the course of Physical Science Honors. When I completed my course at Miami Beach, I returned to Booker T. Washington to start my regular ninth grade school year.

During this school year, I had two Honors classes. These classes were Biology and History. During this year, I also volunteered 86 hours of my time to dedicate to cleaning up the school. At the end of my ninth grade year, I filled out an application to attend William H. Turner Technical Art High School. Within a month, I received notice that I was accepted for their Health Academy. Here I started my tenth grade year. During this year, I had Chemistry and Geometry. During my eleventh grade school year, I had Physics I Honors, Algebra II, and Nursing Assistant classes. Now I have the honor of having acquired my diploma in Nursing. Now in my twelfth grade school year, I plan to get my certification in EKG/Home Aide and Health Career II.

My dream is to graduate from high school. I would like to become a pediatrician to help people. I would like to help those people that need financial and health assistance and food. I would also like to help my family and friends in all ways. And like all teenagers, my dream is to become married and have a family. This is why I wish to accomplish a lot of things in life. This is my life history until now. I have learned a lot of beautiful things, I have became deeply involved in science, thanks to the *New Beginnings* program, and I expect to learn more as I grow up.

Conclusion

Every child who was in the *New Beginnings* program was able to attain some level of success in school.

We were fortunate to keep in contact with our students. Maylin is only one of many stories of the children of the *New Beginnings* program who were able to succeed at school. Other cases were not as successful. However, every child who was in the *New Beginnings* program was able to attain some level of success in school. Almost everyone, with the exception of two, who had severe learning disabilities, learned to read and write in both languages. Many of them are, like Maylin, now ready to graduate from high school. Most of them were motivated by learning science. They tell me stories about how easy it was for them to understand science in secondary school. Many of them, like Maylin, were on honor rolls. However, many have been killed, are active members of gangs, or have served time in jail. Some are mothers and fathers already, and my question always is, “Have these students been able to fully overcome their illiteracy?” My answer is “yes,” because the mind stretched by a new idea never returns to its original way of thinking.

There is much more to be accomplished. The results of the *New Beginnings* program show that there are still alternative strategies to be explored that can prove successful to assist Hispanic illiterate children at risk. Unfortunately, the efforts made to expand this program to other children in similar situations have been limited. The existing literacy programs in Dade County are, for the most part, language-centered—and not content-based—and in most cases they have not yet incorporated technology.

But this is only the beginning. The technological development of schools is slowly presenting the viability of using educational alternatives based on science. There is a proliferation of science programs on CD-ROMs, videodiscs, and encyclopedias of every kind. The Internet is opening the world to science and the world in general to students as never before. The patterns of teaching and learning are dramatically changing, but it is not due only to technology. It is still the teacher, in learning how to use these tools effectively, who creates associations with the students to become empowered and empowering in the process of this transformation. When teachers act in these ways, they are seeds for reform, equity, and social justice. ◆

Language, Discourse, and Learning in Science:

Improving Professional Practice through Action Research


BOO

CONCLUSION

Language, Discourse, and Learning in Science: Implications for Science Teacher Education and Further Study

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Educational researchers are now beginning to focus more closely on how studies of communication and patterns of discourse in the classroom might inform their work within academic content areas as they are traditionally defined (for example, science, mathematics, language arts, social sciences). Educational standards across domains (especially true for science) now frequently advocate that students need to be able to communicate in ways that reflect authentic disciplinary practices. Children need to be able to "talk math" and "talk science" in order to participate fully in the intellectual and social practices that characterize those disciplines (Hicks, 1995). Researchers who explore relations between classroom discourse and children's learning draw primarily upon a model of language as a cognitive resource. Language unquestionably serves as a symbolic mediator of children's thinking and learning, and this is the central theme of the sociocultural, constructivist approach to learning and associated discourses that has emerged largely in response to Vygotsky's writings on "mind in society" (1978) and "thinking and speech" (1986; 1987). As exemplified by the research studies presented in this monograph, within the current educational context in which all schools are being called upon to provide access and equity to increasingly heterogeneous student populations, the tensions between official discourses and minority discourses are becoming principal focuses for educational research. In order to address the problems of cultural and language minority underachievement (particularly in science), a systematic attempt to build on minority discourses in schools, classrooms, and other public institutions should be undertaken.

Pertinent to science teacher education, several recommendations may be made to address these concerns:

- The recruitment and retention of greater numbers of qualified bilingual and minority science and mathematics teachers into the public education system
- Implementation in teacher preparation programs of courses in cross-cultural differences and corresponding analyses of common educational practices which help some students and inhibit others
- Implementation in teacher preparation programs of courses in cross-cultural educational and social psychology—all students do not learn or make "cognitive connections" in the same way (learning styles), and respective cultural backgrounds influence the ways in which students learn (Sweeney, 1997b)

In terms of critical discourse analysis and the elucidation of the characteristics of different discourses, investigations into the following suggest themselves as fruitful areas for further theoretical, methodological, and empirical work:

1. How are certain texts and discourses affiliated with different kinds and levels of cultural capital and social power in institutional contexts? This would require the analysis of "linguistic markets," social fields, and the contingency of cultural capital on the availability of other forms of social, economic, and symbolic capital (Bourdieu, 1991).

2. How and in whose interests are new media of communication generating differing fields of discourse, social relations, and subjectivity? If one of the effects of new technologies is the creation of new social realities, cultural networks, and textual representations, then critical discourse analysis needs to begin describing emergent knowledge-power relations and interests at work in these domains (Green & Bigum, 1993; Ross, 1991; Sofia, 1993).

3. According to what criteria should educators and researchers make decisions about which media, texts, and discourses should be taught in the classroom? If all texts and discourses reflect particular political investments and interests, then critical discourse analysis needs to make explicit judgments about which texts and discourses are of educational, social, and political value for particular communities of educators and students (Luke, 1995).

4. Which reading and writing positions and practices should be encouraged in the classroom? If all reading and writing involves normative social relationships of power, then critical discourse analysis can be used as a curricular and instructional strategy for multicultural education and for multiple and critical literacies (Fairclough, 1989; 1992).

Although the present restructuring of science education in the American public education system of the 1990s is appealing, the current approach to such restructuring does not consider equity of race, language, culture, and ethnicity as central components of educational improvement (McLeod, 1994). Issues relating to the bridging of primary and secondary discourse communities, minority students' cultural capitals, experienced symbolic violence, and co-participation also need to be addressed in terms of such equity. Only when race, language, culture, and ethnicity are introduced as part of the centerpiece of the discourse on educational reform will the current plight of language and minority culture children in science be addressed and redressed. It is only then that the future educational, economic, and political success of this country will begin to be assured. The challenge rests with us as science educators and teacher-researchers to begin the transformation of this possibility into an attainable reality. ◆

BIOSKETCHES

Biosketches of Editors and Invited Contributor

Aldrin E. Sweeney is an Assistant Professor of Science Education in the Department of Instructional Programs at the University of Central Florida and completed his doctorate in Science Education at Florida State University. His research interests draw largely on theoretical perspectives from science education, social and cultural anthropology, critical theory, semiotics, discourse theory, social constructivism, and sociolinguistics. Currently, he is pursuing further research in science education concerning the influence of cultural and linguistic background on cognition and demonstrated learning styles in science. Related academic and research interests center around two main fields: science (especially chemistry) and spoken and written language. Of particular interest to him are the perceptions of science that K-12 students have, the philosophies underlying science education and contemporary scientific thought, the involvement of minorities in science at both the high school and undergraduate levels, and the role that structured language plays in human cognitive development.

Kenneth Tobin is a Professor of Science Education and Director of the Teacher Education program in the Graduate School of Education at the University of Pennsylvania. He taught science and mathematics in high schools in Australia for ten years and in England for one year and has been a faculty member of two universities in Australia and two in the United States. He joined the faculty at the University of Pennsylvania in the fall of 1997 after a ten-year tenure at Florida State University. Prior to that, he was on the faculty at Curtin University (WAIT, 1984-1987) and Edith Cowan University (Graylands and Mount Lawley campuses, 1974-1983) in Perth, Australia. He holds Bachelor's degrees in physics and education and graduate degrees in educational administration and physics. His doctoral degree—from the University of Georgia—is in science education. He has taught graduate and undergraduate courses in science education, teacher learning and change, curriculum, and qualitative research methods. His research interests focus on the teaching and learning of science at all levels and on the process of reform in schools, school districts, and states. His present research projects are focused on teaching and learning in urban settings, particularly where equity is an issue and efforts are being made to enact a curriculum that is transformational in a cultural and social sense. He is an active member of numerous professional associations including the American Educational Research Association, the Association of Teacher Educators, the National Association for Research in Science Teaching, and the Association for the Education of Teachers of Science.

Okhee Lee is an Associate Professor of Science Education in the School of Education at the University of Miami in Coral Gables, Florida. Her research areas include science education, culture and language, and teacher education. She was awarded a 1993-1995 National Academy of Education Spencer Post-Doctoral Fellowship and was a 1996-1997 fellow at the National Institute for Science Education at the University of Wisconsin-Madison. She has directed a number of research and teacher enhancement projects funded by the National Science Foundation, U.S. Department of Education, Spencer Foundation, and the Florida Department of Education, respectively. With support from the National Science Foundation for the past several years, she has been conducting research to design and implement instructional interventions in promoting science learning and language development for students from diverse language and cultural backgrounds. ◆

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APPENDICES

Appendix A
(from page 58)

Resources to Support a Science Program

The Great Kapok Tree by Lynne Cherry
Tropical Rainforests by Wendy Weir
Midnight on the Moon by Mary Pope Osborne
The Fascinating World of… (series) by Angels Julivert
I Wonder Why… (series) by Amanda O'Neill
Science Silver by Burdett and Ginn (our class textbook)
I Wonder Why the Sun Rises by Brenda Walpole
Here is the Tropical Rainforest by Madeline Dunphy
Window on the Universe Our Star: the Sun by Lucy Baker
Discovery Box Planets (series) from Scholastic
Rain Forest Nature Search by Dr. Paul Sterry and Dr. Michael H. Robinson
How and Why Wonderbook (series) from Wonderbooks
Tuck Everlasting by Natalie Babbitt
The Secret Garden by Frances Hodgson Burnett
Charlotte's Web by E. B. White
Julie of the Wolves by Jean Craighead George
One Day in the Woods by Jean Craighead George
Island of the Blue Dolphins by Scott O'Dell
The Haymeadow by Gary Paulsen
Why is a Frog Not a Toad? by Q. L. Pearce
Chessie the Meandering Manatee by Carol A. Amato
Flashy Fantastic Rainforest Frogs by Dorothy Hinshaw Patent
The American Alligator by Dorothy Hinshaw Patent
Voices from the Wild by David Bouchard

They also listed some music that affected their feelings about the Earth:

Our Mother Earth
Rainforest Daydream
Heal the World (Michael Jackson)
Environmental tapes which I play in our room

Television programs that students said taught them about their environment and which received high marks from them were

Bill Nye The Science Guy	Channel 10 WPLG
Newton's Apple Channel 2	WPBT, WLRN
The Magic Schoolbus	Channel 2 WPBT, WLRN
A variety of programs	The Discovery Channel
National Geographic Series	Channel 2 WPBT
When Animals Attack	(TV Special)

Films listed by students as having taught them meaningful information were

Ferngully: The Last Rainforest	Fox Video
Fly Away Home	Columbia Pictures
See How They Grow	Video science series by Sony Wonder

Appendix B
(from page 73)

		YES	NO
1.	Writing helps me study.	37	3
2.	Sometimes we work in small groups to do science.	35	5
3.	Learning science is fun for me.	38	2
4.	My teacher asks me questions in science class that make me think.	36	4
5.	In science class, my teacher helps me if I don't understand what to do.	37	3
6.	Sometimes we go outside to study science.	31	9
7.	Our science projects and work are shared with others.	28	12
8.	In science class, my teacher uses things such as movies, tapes, films, trade books, or the computer to teach science.	37	3
9.	The things we do in science make me think about how to solve problems.	33	7

10. My feelings about writing in science, like making books, and taking science tests are (free response question)

(The following is a selection of verbatim student written responses to question # 10.)

- *That making books is much easier than taking science tests and I get to write things that I know.*
- *Making a book because is fun to make a book and is fun to read a book.*
- *Great! I feel happy making those books from science because science is fun but very fun.*
- *I learn more in the books that we do because we do more things in it.*
- *I learn more by writing a book because we learn neat things.*
- *I think that what makes me learn is writing and reading books.*
- *I feel happy making books. Why, because it is fun and I learn a lot of things I didn't know.*
- *Doing a book is great and good to learn and because I like it.*
- *When I write books it makes me feel good and I like writing books.*
- *I think I learn more by writing books because I know more words than the tests.*
- *When I do a book it makes me happy because I learn better things and new things.*

Appendix C
(from page 74)

		YES	NO
1.	Writing helps me study.	20	7
2.	Sometimes we work in small groups to do science.	27	0
3.	Learning science is fun for me.	24	3
4.	My teacher asks me questions in science class that make me think.	22	5
5.	In science class, a teacher helps me if I don't understand what to do.	24	3
6.	Sometimes we go outside to study science.	27	0
7.	Our science projects and work are shared with others.	23	4
8.	In science class, my teacher uses things such as movies, tapes, films, trade books, or the computer to teach science.	27	0
9.	The things we do in science make me think about how to solve problems.	23	4

10. My feelings about writing and science, like making books and taking science tests are (free response question)

(The following is a selection of verbatim student written responses to question # 10.)

- *I prefer doing projects to going to P.E. and playing whatever we want. Even if coach lets us run around.*
- *I like to do experiments.*
- *Sometimes there are too many things to write about.*
- *Going outside to do (science) stuff is fun.*
- *I like to make things in science like gunk.*
- *I like to write stories.*
- *I had fun when I got to work with my friends on the book about science projects.*
- *I want to write about our turtles.*
- *I thought that it was nice to write about all the kinds of seeds that could grow.*
- *I love science especially science projects or science experiments. Science is my favorite subject.*
- *I like it when we get to pick who we want to work with when we do science.*

Appendix D: Poems Used in the Study

(from page 80)

Butterfly

Look at my big wings that,
help me stay in flight.
My two large eyes,
help me with my sight.

My long antennas help me
smell and touch,
the flowers that,
I love so very much.

My mouth is like,
a long tube,
that helps me sip,
my sweet, sweet food.

My legs,
I have six in all,
help me hold onto flowers,
big and small.

Camouflage

I can see you,
but you can't see me.
I'm a hornworm,
on the branch of a tree.

I can see you.
I hope you don't see me.
I don't want to be your lunch,
at half past three!

I can see you,
but you can't see,
that I'm the same color,
of everything around me.

Survival

When you hear a strange noise,
don't you want to hide?
So do our animal friends.
That's how many survive.

A muskrat builds a home,
away from others, in a pond.
A duck hides her eggs,
to keep them from harm.

A woodchuck hibernates,
to stay alive.
A squirrel buries its,
acorns to survive.

Seeds

Fly away, fly away, fly away seeds!
Dandelion, maple, and milkweed.
Carried by the wind to a new home.
On wings they travel, on wings they roam.

Seeds with hooks can travel, too.
Carried by animals and man alike.
They stick to sweaters and fur.
Have you ever seen a Sticktight?

Habitats

Some habitats are cold.
Some habitats are hot.
Is the meadow a habitat,
for a frog? I think not!

A habitat is a home,
with food and water and air.
A cold habitat is the home,
of our friend, the polar bear!

Appendix E: Related Children's Literature

(from page 92)

Bendick, J. (1965). *The shape of the Earth.* NY: Rand McNally & Co.

Branley, F. (1973). *The beginning of the Earth.* NY: Thomas Crowell Co.

Catherall, E. (1991). *Exploring soil and rocks*. Austin, TX: Steck-Vaughn Co.

Challand, H. (1982). *Activities in the earth sciences*. Chicago, IL: Children's Press.

Clark, J. (1992). *Hands on science earthquakes to volcanoes*. NY: Gloucester Press.

Dineen, J. (1991). *Natural disasters, volcanoes*. NY: Gloucester Press.

Elting, M. (1990). *Volcanoes and earthquakes*. NY: Simon & Schuster Inc.

Hooker, M. (1993). *Volcanoes*. Vero Beach, FL: The Rourke Corp., Inc.

Keene, M. (1966). *The beginner's story of minerals and rocks*. NY: Harper & Row.

Lauber, P. (1986). *Volcano: The eruption and healing of Mount St. Helens*. NY: Bradbury Press.

Poynter, M. (1980). *Volcanoes: The fiery mountains*. NY: Messner Books.

Rhodes, F. (1972). *Geology*. NY: Golden Press.

Thomas, M. (1991). *Volcano!* Mankato, MN: Crestwood House.

VanCleave, J. (1991). *Janice VanCleave's earth science for every kid: 101 easy experiments that really work*. NY: John Wiley.

Wood, J. (1991). *Volcanoes, fire from below*. Milwaukee, WI: Gareth Stevens Children's Books.

Appendix F: Questions from the Constructivist Learning Environment Scale
(from pages 121 and 122)

DIRECTIONS: Circle the number that best describes your opinion of science. There are no right or wrong answers.

3—Almost Always   2—Sometimes   1—Almost Never

In my science class…

1. I learn about the world outside school.	3	2	1
2. I learn how science can be part of the world outside school.	3	2	1
3. I talk with other students about how to solve problems.	3	2	1
4. I explain my ideas to other students.	3	2	1
5. I ask other students to explain their ideas.	3	2	1

Note: The survey above was administered to both groups in September 1996 and March 1997. The survey administered in March 1997 to both groups contained the additional free response question below:

Question: Name something that you have learned in science this year that can affect your life outside school.

Appendix G: Results of Surveys: Percentage of How Students Responded to Each Statement
(from page 122)

GROUP 1

	September 1996			March 1997		
Statement	1	2	3	1	2	3
I learn about the world outside school.	83%	17%	0%	17%	33%	50%
I learn how science can be part of the world outside school.	83%	17%	0%	0%	33%	67%
I talk with other students about how to solve problems.	33%	50%	17%	17%	17%	66%
I explain my ideas to other students.	33%	67%	0%	0%	33%	67%
I ask other students to explain their ideas.	67%	33%	0%	17%	17%	66%

GROUP 2

	September 1996			March 1997		
Statement	1	2	3	1	2	3
I learn about the world outside school.	67%	33%	0%	0%	33%	67%
I learn how science can be part of the world outside school.	67%	33%	0%	0%	17%	83%
I talk with other students about how to solve problems.	33%	50%	17%	0%	33%	67%
I explain my ideas to other students.	50%	50%	0%	17%	17%	66%
I ask other students to explain their ideas.	67%	33%	0%	17%	17%	66%

1—Almost Never   2—Sometimes   3—Almost Always

Language, Discourse, and Learning in Science: Improving Professional Practice through Action Research

is an assembly of 14 action research studies undertaken by practicing elementary and middle school science teachers enrolled in a science education distance learning graduate program at Florida State University. These teachers became action researchers when they designed and conducted studies to examine some phenomena of concern in their classroom.

Language, discourse, and the learning of science in urban environments within varying contexts of learner diversity is the theme that unites all the studies presented in this monograph. Several studies are presented on each of the following topics:

- Conceptual change teaching and learning
- Learning through hands-on activities
- Science discourse and language development

The studies included in this monologue were written by educators who teach in diverse classrooms in Miami-Dade County. The findings and processes described in these studies will prove beneficial to other teachers with similar challenges and interests in improving teaching and learning through action research in their own classrooms.

Teachers say it best:

This action research study has given me many opportunities to reflect upon my teaching and the students' learning. I believe that the experience has helped me reach for new heights and grow from each experience.

—Lizette Aladro

The action research I did with my students has been a true learning experience. I was in awe of the way the students handled the discussions and the thoughtful theories and ideas they proposed. I would recommend action research to all science teachers who wish to improve teaching and learning in their classrooms.

—Dolores M. Rodriguez

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