A Dissertation

Entitled

The Contextual, Academic, and Socio-Cultural Factors Influencing Kindergarten Students' Mathematical Literacy Development

by

Mary Kane Mather

Submitted as partial fulfillment of the requirements for the Doctor of Philosophy Degree in Curriculum and Instruction

Adviser: Eileen Carr

Judythe Patberg

George Shirk

William Weber

College of Education

Graduate School

The University of Toledo
December 2004

Copyright © 2004

This document is copyrighted material. Under copyright law, no parts of this document may be reproduced without the express permission of the author.

An Abstract of

The Contextual, Academic, and Socio-Cultural Factors Influencing Kindergarten Students' Mathematical Literacy Development

Mary Kane Mather

Submitted as partial fulfillment of the requirements for the Doctor of Philosophy Degree in Curriculum and Instruction

The University of Toledo

December 2004

This ethnographic case study of a constructivist classroom examined the contextual, academic, and socio-cultural factors that influence kindergarten students' mathematical literacy development. This study was done during the crucial junction between informal and formal mathematics and during the junction between informal and formal discourse that occurs in a kindergarten classroom. It also examined how disciplinary knowledge in mathematics is presented through classroom discourse. Five lenses drawn from the research literature were used to examine the data: (a) socio-cultural perspectives, (b) constructivist learning theory, (c) kindergarten curriculum, (d) language and discourse development, (e) mathematical process and content. A final framework was developed from the data collected. It included an (a) active restructuring of the environment (socio-cultural perspectives and constructivist learning theory),

(b) language and discourse development, and (c) mathematical processes and content. This framework also delineated the elements observed in the classroom that support the final framework categories. The choice of curriculum should support collaboration between children and adults as well as collaboration between children. The choice of curriculum should encourage the complex use of language and support the transition to formal mathematical discourse (one of the dominant academic discourses). Children's initiation and choice within the curriculum were found to be other key elements in this constructivist classroom. A system of continuous assessment and subsequent differentiation of instruction were two other essential elements in this reform mathematics classroom. Each of these key elements was shown to be important to foster mathematical literacy for all children. The role of socio-cultural perspectives ranging from Dewey's structuring of the environment through Freire's problem-posing curriculum to Delpit and Gee's work on dominant discourses was highlighted in this complex study of a constructivist reform mathematics classroom. Areas for further research were also delineated.

Dedication

To the families and children of the City of Chicago who deeply influenced my socio-cultural perspectives and taught me to view the world through more than one lens.

To the families and children of St. Mary's School in Toledo, Ohio who continued my growth and love for diverse perspectives while nurturing my talents as a teacher.

To my family:

To my husband and best friend Charlie,

To our beautiful and talented children,

Christina Ughrin,

Elizabeth Mather,

Stephen Mather,

David Mather,

To their spouses

John Ughrin,

Anthony Kozar,

April Luginbuhl Mather,

Amy Crippen,

To our grandchildren,

Victor Dmitri Ughrin,

Kathryn Elizabeth Ughrin

Acknowledgements

An incredibly diverse group of people have influenced my teaching and my research. I wish to acknowledge the love, the support, and the teaching that my parents, Mary Dowling Kane and James Francis Kane, provided over the years. While neither of my parents had college degrees, they encouraged and expected their children to read, to reason, to think, to write, and to love learning. My brother, Jim Kane, inspired me to read and discuss philosophy and the great thinkers of the world. Many of my professors at Loyola University in Chicago fostered my growth in these areas during my undergraduate years. Three that stand out in my memory are Dr. Charles Hart, Dr. Joseph Ryan, and Dr. Peter Maxwell.

Several outreach education programs were instrumental in my initial attraction to the areas of teaching and learning. The most powerful of these was Odyssey of the Mind. My years as a coach taught me to be a facilitator of constructivist learning. When I began my teaching career at St. Mary's School in Toledo, I drew on that experience and extended my learning through my experiences in working with exceptional teachers and professors in the field of education. These teachers include: Dr. William Armaline, Dr. Eileen Carr, George Cowdrey, Adele Dahlin, Jackie Dreps, Dr. Lynne Hamer, Stephen Mather, Nancy Meredith, Linda Mosely, Dr. Judythe Patberg, Dr. George Shirk, Dr. Mark Templin, Christina Ughrin, and Dr. William Weber.

Technical support was provided by Elizabeth Mather and Charles Mather.

During the years that I have worked on this study, my committee provided consistent support and inspiration. I wish to extend a special *thank you* to Dr. Eileen Carr, Dr. George Shirk, Dr. Judythe Patberg, and Dr. William Weber.

Table of Contents

List of Tables

List of Figures

Figure:

Chapter 1

The Need for a Study of Mathematical Literacy Development

Background of the Study

Literacy in the new global economy is significantly different from the literacy that was required as the present generations of teachers were growing up. Shopkeeper math and basic levels of reading and writing allowed most people in this country to succeed in supporting families at a comfortable level. Indications are that this will no longer be the case. In the last decade, many voices have called for improved literacy of various kinds for all students (National Council of Teachers of Mathematics [NCTM], 1989, 2000; National Research Council [NRC], 1989; National Council for Social Studies [NCSS], 1994). As the National Research Council (1996) states: “More jobs demand advanced skills, requiring people to be able to learn, reason, think creatively, make decisions, and solve problems” (p. 1).

The definition of literacy has expanded to include multiple skills for knowing, communicating, thinking and approaching the solution of problems (Brown, 1991). Eisner (1991) points out that literacy is not limited to text but extends to understanding and using any of the forms in which meaning is conveyed. Literacy involves ideas, concepts, data, and other information that are shared though the use of reading, writing, speaking, listening, and mathematical language which are often integrated in their presentation. The major subject-matter organizations (NCTM, 2000; NCSS, 1994;

National Council of Teachers of English [NCTE] & International Reading Association [IRA], 1996; National Research Council [NRC], 1996) support an interdisciplinary approach to K-4 curricula that teaches students to use a wide variety of sources and to learn to use many different symbol systems to learn and present knowledge. These symbol systems may be drawn from language, music and art as well as from mathematics. Because of the integrated nature of literacies, an integrated approach to gaining multiple literacies may be the most powerful approach for lifelong learning.

Traditionally, mathematics was considered to require a series of skills distinct from literacy. However, mathematician James Bullock (1994) discusses mathematics as a language, stating "Mathematics can be…regarded as a form of language, developed by humankind in order to converse about the abstract concepts of numbers and space" (p.735). Mathematical literacy increases a person's ability to think, to imagine, and to express thoughts and imaginings in ways that cannot be accomplished solely with traditional literacies. At the same time, Bullock (1994) states, "Mathematics is not so different from other expressions of the human intellectual capacities for communication and imagination" (p. 739). Literacy is the goal of all true education-preparing people for a lifetime of learning. Whitin, Mills, and O'Keefe (1990) support Bullock's position, stressing that learners become mathematically literate in the same way that they become literate in reading. Numbers, like letters in reading, are only a portion of mathematics.

Cuoco (2001) posits that we need to learn much more about how our students learn mathematics, about how our students develop the habits of mind that are so important to their success in learning mathematics and about how misunderstandings develop in the course of the learning process. In particular, he stresses the need to know how students build representations of concepts and phenomena in mathematics. Cuoco defines representation as a map that is neither the source nor the target. It is found in the correspondence or relationship between the source and its target which is the object that we wish the student to better understand. Representations are more than something which matches something else. They also preserve the structure of those relationships. According to Goldin and Shteingold (2001), mathematical representations cannot be discussed without taking into consideration the wider system from which they came because each of the representations are deeply related to others within the system. Meanings and conventions surrounding their use have already been established.

Within the area of representation theory in mathematics education, there is a central dialectic between internal and external representation (Cuoco, 2001). External representations are easily communicated. They include the writing on the paper, drawings, geometric sketches, and equations. Goldin and Shteingold (2001) include base ten numeration, the real number line, Cartesian coordinates, visual imagery, spatial representation, problem solving strategies and expressions of affect in regard to students' view of mathematics in the category of external representation.

Internal representations, on the other hand, are quite difficult to observe. They exist in our minds and include images that we create of mathematical processes and phenomena (Cuoco, 2001). Goldin and Shteingold (2001) divide these internal representations into several different kinds:

1. Verbal/syntactic which includes students’ natural language abilities, mathematical as well as nonmathematical;

2. imaginistic which includes visual, spatial, and kinesthetic, auditory, and rhythmic mental images;

3. formal notational representation in which students mentally manipulate numbers and do arithmetic operations, as well as perform strategic and heuristic processes for problem solving; and finally,

4. students' affective systems that include emotions, attitudes, beliefs, or values about mathematics or about the students' abilities in mathematics.

These internal representations cannot be seen but can be inferred from the evidence of external representations. As indicated above, representations in mathematics are to varying degrees dependent on students' natural language development. Spoken and written language are both important in the understanding of mathematical representation. Students need to learn to read and write within the discipline of mathematics. Reading and writing in mathematics involve all levels of external representation and their corresponding internal systems of representation.

In the United States, the area of reading within mathematics instruction has been most challenging for students. National and International assessments (Kouba, Brown, Carpenter, Lindquist, Silver, Swafford, 1988; Martin & Kelley, 1998) have indicated that students struggle with problem solving which is highly dependent on reading and writing ability. Correlations between mathematics tests that stress problem solving and students' reading scores have been very high (Muth, 1988). Achievement in mathematics is positively correlated to the ability to read and understand written mathematical material as indicated by many authors (Ballew & Cunningham, 1982; Chase, 1961; Earle, 1976;

Jackson & Phillips, 1983; Muth, 1984; Nolan, 1984; 1986; Schell, 1982). Reading is an important part of problem solving (Muth, 1988). Cox and Wiebe (1984) pointed out that "The ability to understand written mathematical vocabulary and to read text containing mathematical terms and discussions is an important component of literacy" (p. 402).

Written external representations of mathematics are also extremely important. State mandated proficiency tests have increasingly used problem solving to assess students' competency. These tests ask the students to reflect on their thinking and provide a written explanation for how they solved the problems. Students are being asked to draw more upon multiple literacies in demonstrating their mathematical proficiency.

In response to these needs for mathematical literacy, a reform movement has been underway in the United States (NCTM, 2000). According to Simon (1995), constructivist perspectives have been a major component of research and in theory development in mathematics education, strongly influencing reform efforts in this area. Simon (1995) describes constructivism as a philosophical position which holds that humans "construct …knowledge of the world from …perceptions and experiences which are themselves mediated through …previous knowledge" (p. 115). He suggests that it will be a great challenge to restructure mathematics pedagogy from a constructivist viewpoint because the theory does not deal directly with how to teach mathematics.

Purpose for Study

"Our understanding of child development and curriculum has undergone significant change. As a result, a more current framework for analyzing early childhood models is needed" (Goffin & Wilson, 2001, p.14). In particular, the continuing implementation of reform approaches to mathematics teaching has led to changes in the way that communication competencies are being integrated into the classroom. In an effort to provide more authentic practices in mathematics, teachers are engaging with their students in new forms of discourse (Hicks, 1995).

The NCTM (2000) stresses that, in kindergarten through fourth grades, teachers should provide many opportunities for representing, discussing, reading, writing, and listening to mathematics. These communication competencies are essential in the learning and use of mathematics. Children, at this level, should learn to relate manipulatives, pictures, and diagrams to the mathematical concepts through reading, writing, discussing, and listening. Finally students should learn to relate the language that they use in everyday life to mathematical concepts, terms, and contexts. This is the important area of informal mathematics on which all later mathematical learning is built (Baroody, 1987).

The National Council of Teachers of Mathematics’ (1989, 2000) efforts have strongly emphasized communication in all aspects of mathematics education; however, the research into best practices in the classroom seems to lag far behind the philosophy. A search of journal articles in the last decade yields very few research articles on any of the areas of writing or reading in mathematics. Cobb’s (1997) study is a notable exception. His study explores the relationship between classroom discourse and mathematical development in a first grade classroom. It addresses representation, social interaction, semiotic mediation and the teacher’s role.

Research into specifically situated socialist constructivist classrooms will help to inform researchers and teachers of how classroom discourses can be used to help children to participate in formal academic discourses in authentic ways. Study of these discourse practices in a constructivist reform kindergarten would be particularly helpful because kindergarten students are at the transition between informal and formal mathematics as well as at the intersection between informal discourse and more formal academic discourses. As children begin their formal education in kindergarten, they bring with them expectations of language as complex and powerful (Halliday, 1969). “What is common to every use of language is that it is meaningful, contexualized, and in the broadest sense social” (p. 195). After their first years in school, many children lose the expectation that language about mathematics will be meaningful.

“Understanding learning as a process of individual and social construction gives teachers a conceptual framework with which to understand the learning of their students” (Simon, 1995, p.117). The constructivist viewpoint emphasizes that students learn by meaning making. Communication is essentially a meaning making or a meaning-understanding enterprise (Schulte, 1996). Therefore, the use of the constructivist philosophy in constructing solutions to problems in mathematics literacy seems an appropriate fit. Some of the essentials of constructivist learning are that children learn by active participation, especially through hands-on materials and through collaboration with others. Students are at different levels of understanding and can clarify their ideas by sharing them with each other and with the teacher (Schulte, 1996). Children need to hypothesize, predict, manipulate objects, pose questions, research answers, imagine, investigate, and invent. In order for learning strategies to be one with the theory of constructivism, they must be compatible with teaching for understanding which “is one of hallmarks of current reform efforts in teacher education” (Eisenhart, Borko, Underhill, Brown, Jones, & Agard, 1992, p. 8). A major premise of this study is that constructivist classrooms offer potential for enhancing mathematical literacies and should be observed in order to understand how they provide exemplary learning environments.

Research Questions

The following research questions guide this study:

1. In a constructivist reform classroom, what are the contextual, academic, and social/cultural factors that influence kindergarten students' mathematical literacy development?
2. How is disciplinary knowledge in mathematics presented through discourse in this constructivist classroom?

Overview of the Chapters of the Study

This ethnographic case study will focus on the contextual, academic, and social factors that influence the mathematical literacy development of kindergarten students in a constructivist reform classroom. It is a collaborative study with the kindergarten teacher taking the role of teacher-researcher. Data have been collected through interviewing of the teacher and students, a review of students' documents and reports, and participant-observation of the daily classroom routine over the period of a school year, as well as with information gathered by the teacher-researcher.

This chapter introduces the study, setting the purpose and significance of the study to the early childhood, mathematics, and language education fields. Chapter 2 delineates some of the pertinent literature in regard to the contextual, academic, and social/cultural factors influencing the development of mathematical literacy in kindergarten students. In Chapter 3, the research methodology used in this situated ethnographic study is explained and the lenses through which the data have been analyzed are delineated in the form of five different analytical frameworks. Chapter 4 provides a detailed description of the classroom culture, curriculum, and other contextual, academic and social/cultural factors observed in the classrooms. Chapter 5 discusses the implications of the study for application in the classroom and the direction of future research needed in this area. A bibliography follows the final chapter.

Chapter 2

Review of Literature

In Chapter I, it was stated that, because of changes to a new global economy, voices in many of the national educational organizations have called for improved literacy for all of our students. This call for improved literacy is accompanied by a redefinition of literacy to include integrated multiple literacies in all areas of education including mathematics, music, and art. While many of these reform efforts have emphasized the role of communication, there are still few research articles on the areas of discourse, writing, reading, or listening in the mathematics classroom. A study of the language development of kindergarteners in a reform mathematics classroom was proposed because a study of this kind promises to inform us of the contextual, academic, and social/cultural factors that influence students' mathematical literacy development at the crucial junction between informal and formal mathematics study and between informal and formal academic discourse.

Historical and Socio-Cultural Foundations

This chapter explores some of the current and historical literature that informs this study. First, I discuss the National Council of Mathematics Standards (1989, 1991, 2000), the new goals in mathematical literacy and their historical and socio-cultural foundations. Current constructivist learning theory is also explored and critiqued as to how it fulfills the new literacy goals proposed in the reform effort. Issues in kindergarten curricula are then explored from a historical and from a current perspective. In the next section of this review of literature, language development and discourse with young children are discussed. The final section discusses the interrelationships between mathematics and literacy highlighting the communication standard from the National Council of Teachers of Mathematics (NCTM, 1989, 2000) and the Professional Standards (1991) that address mathematical discourse in the classroom. This study continues to draw from the earlier NCTM academic and professional standards (1989, 1991) because the Michigan Frameworks and Standards, which the London Consolidated School District uses to guide its pupil objectives, is based on the original NCTM reform documents from 1989 and 1991.

New Goals in Literacy: Their Foundations. Education in the United States in the post-industrial twenty-first century calls for new social goals as well as new goals in literacy for all of its people. According to the NCTM (1989), “The educational system of the industrial age does not meet the economic needs of today. New social goals for education include (a) mathematically literate workers, (b) lifelong learning, (c) opportunity for all, and (d) an informed electorate. Implicit in these goals is a school system organized to serve as an important resource for all citizens throughout their lives” (p. 3). This statement of the NCTM echoes the position of John Dewey near the turn of the twentieth century.

Many representatives of the various traditions of constructivism trace their roots to the work of Dewey (DeVries & Kohlberg, 1987; Nager & Shapiro, 2000; von Glaserfeld, 1985). Dewey (1916), in his book, *Democracy and Education*, lays a foundation for all democratic schooling. According to Dewey (1916), growth and reproduction are synonymous with the continuance of life. Education is the agent through which social life is continued just as nutrition and reproduction sustain physiological life. Education sustains social life through communication. As the complexity of a society increases, the need for formal schooling also increases.

In order for children to experience an educative environment, they must take part in joint activity with others in the environment. For children who come from cultures different from the mainstream this means that the environment cannot be totally cut off from their own cultural experiences and values or they will be unable to take part in the joint activity within the educative environment. Dewey (1916) speaks of the necessity of creating a wider and better environment. This could be assumed to be an assimilist stance but he calls on the schools to assume “a steadying and integrating office” (p. 22) which coordinates the influences of the various codes a person experiences in the different social environments through which he/she passes.

This learning that sustains social life cannot be conveyed directly. Beliefs, emotions, and knowledge are conveyed through the environments in which students experience learning. These environments are educative in the ways in which the student takes part in joint activity with others in the environment. The complexity of our modern society necessitates a carefully crafted environment in which children are nurtured as they learn through these joint activities. Three of the essential purposes for this ideal environment are “…simplifying and ordering factors of the dispositions it wished to develop; purifying and idealizing the existing social customs; creating a wider and better balanced environment than that by which the young would be likely, if left to themselves, to be influenced” (Dewey, 1916, p. 22). Children are educated through the careful building of the environment in which they learn.

Our understanding of Dewey's (1916) second essential purpose of the environment of the schools (purifying and idealizing the existing social customs) must be understood within the context of Dewey's writings on the ideal democratic society.

> Since education is a social process, and there are many kinds of societies, a criterion for educational criticism and construction implies a particular social ideal. The two points selected by which to measure the worth of a form of social life are the extent in which the interests of a group are shared by all its members, and the fullness and freedom with which it interacts with other groups. An undesirable society, in other words, is one which internally and externally sets up barriers to free intercourse and communication of experience. A society which makes provision for participation in its good of all its members on equal terms and which secures flexible readjustment of its institutions through interaction of the different forms of associated life is in so far democratic. Such a society must have a type of education which gives individuals a personal interest in social relationships and control, and the habits of mind which secure social change without introducing disorder. (p. 99)

The purifying of social customs is not, for Dewey (1916), a matter of eliminating other cultural influences but an opening of mainstream social customs to other influences. In order for members of society to share values, mainstream society must allow itself to be influenced equally by a give and take with those other who are considered "other." If this give and take of values does not exist, "The influences which educate some into masters, educate others into slaves" (Dewey, 1916, p. 84). The influences of mainstream society often provide the basis for the hegemony that allows schooling to become an experience that keeps groups outside of the mainstream. Freire (1970) points to the banking system of education as one of the elements in this hegemony. Passive learning leads students to adapt to the conditions of the society, fitting the world of the oppressors without questioning. “Verbalistic lessons, reading requirements, the methods for evaluating ‘knowledge,’ the distance between the teacher and the taught, the criteria for promotion: everything in this ready-to-wear approach serves to obviate thinking” (Freire, 1970).

Problem-Posing Education. One of the purposes for schooling in an ideal democratic society is learning to critically think, analyze, and problem-solve. Freire (1970) contrasts the traditional banking model of education, wherein teachers deposit knowledge in students much as a banker does with money in a bank, with problem-posing education. In problem-solving education, the educator trusts students and their creative possibilities. He/she becomes a partner in efforts at critical thinking and a partner with the student in viewing each other as human. The teacher and student roles in the problem-posing education merge. The teacher becomes a learner as the communication with the learner transforms the relationship. “The problem-posing educator constantly re-forms his reflection in the reflection of the students. The students – no longer docile listeners – are now critical co-investigators in dialogue with the teacher” (p. 68).

hooks (1994) brings together Dewey’s (1916) emphasis on the structuring of the environment and Freire’s (1970) emphasis on the teachers and students as co-learners and co-teachers. She (hooks, 1994) speaks of witnessing teachers “… striving to create participatory spaces for the sharing of knowledge” (p.15). She endorses a progressive, holistic education, which emphasizes wholeness of mind, body, and spirit, supported by an engaging pedagogy.

Power and Pedagogy. Constructivist and whole language approaches would seem to fit well with the positions of Dewey (1916), hooks (1994), and Freire (1970). However, Delpit (1995) brings forward an analysis of some forms of constructivist and whole language approaches that calls into question the use of these for "education as the practice of freedom (hooks, 1994)" in marginalized communities. She warns that uncritical adoption of these approaches can become another element in the imbalance of power in this nation. Knowledge and use of the dialect that is spoken by those in power in the United States often determines the socio-economic level of an individual.

The issue of constructing schools to include rather than exclude, to draw from and enhance our diverse population, is an incredibly complex task given the need to address the influences on all levels that work either for or against that construction. On the broadest level are the issues of a global economy and the deindustrialization of our cities. One of the ramifications of these changes is an increasing need to fully include our diverse population in a productive work force. Inclusion in the work force brings to the fore considerations of inclusion in the dominant discourse which, in current reality, acts as a gateway for employment opportunities. There are other important issues at this broad societal level that affect the schools in complex ways but the issue of the dominant discourse is one that teachers can directly impact in the classroom.

Gee (1989) sees this dominant discourse as an identity kit that includes the ways that people speak, write, value, believe, as well as do things. He posits that if a person is not part of the dominant culture, acquiring this discourse is distinctly difficult within the classroom. He also posits that the acquisition of the dominant discourse may cause major conflicts with a person's primary discourse. Delpit (1995) views these beliefs about dominant and primary discourses as dangerously deterministic for our diverse population. In opposition to this viewpoint, she speaks of many individuals who have developed fluency in the dominant discourse in classrooms across America.

Teachers who believe that students cannot gain the dominant discourse in the classroom will react in a similar manner to those teachers who accept child-deficit assumptions. Delpit (1995) posits that child-deficit assumptions lead to teaching less instead of more. Other well-meaning teachers may accept Gee's (1989a) assertion that a person who has a non-dominant discourse will experience major conflicts when acquiring the dominant discourse. With this assumption, teachers may not teach the dominant discourse because they may feel that it denies their students' primary identity. Both of these positions (belief in inability to learn the dominant discourse and conflicting value structures) may lead to students being unable to obtain gainful employment because they have not learned the dominant discourse.

In "The silenced dialogue: Power and pedagogy in educating other people's children," Delpit (1995) sets her argument within the current literature of the sociology of education, delineating three of the aspects of the culture of power that she describes as basic tenets in this literature. These tenets maintain that (a) issues of power exist at the school level, (b) there are rules that govern participation in this power, and (c) these rules are a reflection of the rules of the mainstream culture. She proposes two more aspects of the culture of power that she feels are rarely addressed in the literature which indicate that (d) explicit instruction in these rules of mainstream culture help those outside of the culture of power to more easily acquire that power, and (e) those who are immersed in mainstream culture do not acknowledge that the culture of power exists while those who are excluded are very aware of it. By culture of power, Delpit is referring to the mainstream American culture with a particular emphasis on the power that that culture possesses in terms of jobs available and benefits that can be obtained as a member of that culture.

Liberal educators may sincerely want to provide the same quality education for each of the children in their classrooms but do not realize that mainstream children have already internalized the codes of the culture of power, while those children who are outside of the mainstream need more instruction in its discourse, if they are to participate on an equal basis. According to Delpit, these minority children and other children outside of the culture of power need direct instruction in “discourse patterns, interactional styles, and spoken and written language codes that will allow them success in the larger society” (p. 29). There is much support in the literature (Gee, 1989 a, b; Giroux, 1997; McLaughlin, 1989) for Delpit’s (1995) position that the issues of the culture of power include rules and language codes that govern participation in that culture and that these rules are a reflection of the mainstream culture from which they come.

In order to strengthen her position about the culture of power, Delpit (1995) compared two approaches to literacy instruction: Whole Language (a process approach) and Direct Instruction. Whole language presumed that children come to school with much knowledge of discourse patterns including the spoken and written language codes. This, she feels, works for the mainstream students better than for those who are outside of the culture of power. She contends that there is no evidence that this process approach works for children of color or other children from lower socio-economic groups. In the process approach, mainstream children are building on the discourse they already know. Children outside the culture of power should be provided with the language content that other students learn at home.

Delpit (1995) sees the process approach and whole language, in particular, as methods that have used only implicit instruction, building on the discourse that mainstream children already have when they come to school. Often students from lower socio-economic groups do not have the background knowledge of the language codes and rules of the culture of power. Taylor (1991) advocates movement from implicit instruction to explicit instruction. She uses this process in teaching dialect differences through contrastive analysis to her students.

During the height of the Whole Language Movement, many people who called themselves whole language teachers relied solely on implicit instruction but several major names in the movement (Atwell, 1991; Calkins, 1986; Routman, 1991) included explicit instruction in writing conventions and techniques in mini-lessons and in individual conferencing. While acknowledging the contributions of Whole Language, many reading and language teachers have moved toward a more balanced approach to literacy that includes more explicit instruction in knowledge of language codes (Cunningham, P. & Hall, D., 1996; Fountas, I. & Pinnell, G. 1996).

While relying on implicit instruction can be problematic, process approaches do stress the critical thinking which Freire (1970) indicates is essential for democratic schooling. Delpit (1995) feels that minority students are very capable of critical thinking. Heath (1982) agrees, stating that minority students have the "...ability to metaphorically link two events or situations and to recreate scenes that are not tapped in the school" (p. 70). She also states that these students learn to give "reason explanations" rather than the "what explanations" that mainstream preschoolers and primary students are expected to give, strengthening the critical thinking skills of the minority students.

Delpit (1995) proposes that it is essential that teachers instruct students on the conventions of print while having them engage in real writing and speaking with authentic audiences. Teachers should act as experts while at the same time acknowledging their students' expert abilities in areas in which the students are competent. The instruction in the mainstream discourse should be accompanied by helping students to understand that the rules and power relationships are arbitrary but that these relationships hold power in many areas of life.

Neither Direct Instruction nor some implementations of whole language have been found to be ideal for democratic schooling; whole language because of its frequent assumptions of knowledge of language and culture capital and Direct Instruction because of its ties to the "banking model" that Freire (1970) discusses in *Pedagogy of the Oppressed.* A closer look at the constructivist learning theory holds some promise of a learning theory that is closer to the ideal for democratic schooling.

Constructivism

Overview of constructivism. Constructivist theory holds promise for democratic schooling despite the criticisms of whole language, which is situated in constructivist learning theory. It is important to differentiate the description of constructivism as a teaching approach from constructivism as a learning theory. Constructivism, in reality, is a learning theory, and translating constructivist-learning theory into classroom practice is very difficult to do.

According to Abdal-Haqq (1998),

> Constructivism is an epistemology, a learning or meaning-making theory, that offers an explanation of the nature of knowledge and how human beings learn. It maintains that individuals create or construct their own new understandings or knowledge through the interaction of what they already know and believe and the ideas, events, and activities with which they come in contact. Knowledge is acquired through involvement with content instead of imitation or repetition. Learning activities in constructivist settings are characterized by active engagement, inquiry, problem solving, and collaboration with others. Rather than a dispenser of knowledge, the teacher is a guide, facilitator, and co-explorer who encourages learners to question, challenge, and formulate their own ideas, opinions, and conclusions (p.1).

Constructivism is contrasted with Freire's (1970) "banking model" in which the "… teacher fills the students with deposits of information considered by the teacher to be true knowledge and the students store these deposits, intact, until needed (Abdal-Haqq, 1998, p.2). This " banking model" is comparable to the viewpoint of the empiricists who, according to Kamii (2000), view knowledge as based in external reality. She stresses that empiricists assume that "…knowledge has its source in the environment and is acquired by each child by internalization through the senses" (Kamii, 1989, p. 3). According to Kamii (1991), "language acquisition is the most obvious example of the constructive process (p.18), showing that children construct knowledge rather than acquire it from the environment.

Drawing the theoretical basis of her work on her study with Piaget, Kamii (2000) delineates three kinds of knowledge “based on their ultimate sources and modes of structuring: physical knowledge, social knowledge, and logio-mathematical knowledge” (p. 4). She contrasts this approach with the empiricists’ approach to knowledge. Physical knowledge (color, weight, etc.) is only partially located in external reality because a child cannot gain that knowledge without relating it to knowledge that is already organized in the child’s brain. With physical knowledge, we can concentrate on one property of the object (for example, color) without considering the others such as weight or size by using empirical abstraction. Similarly, social knowledge is located partially in the child’s brain and partially in conventions made by people. Logico-mathematical knowledge, however, uses constructive or reflective abstraction.

> Logico-mathematical knowledge, on the other hand, consists of relationships created by each individual. For instance, when we are presented with a red bead and a blue one and think that they are “different,” this difference is an example of logico-mathematical knowledge. The beads are indeed observable, but the difference between them is not. The difference is a relationship created mentally by each individual who puts the two articles into this relationship. (Kamii, 1989, p. 5)

Another relationship between the same two beads could be based on weight or on the material from which the bead was constructed. We might thus establish the relationship as same rather than different.

von Glasersfeld (1979), a radical constructivist, agrees with Kamii that relationships are not located in the objects but gives his interpretation a different twist: "…relationships are not in things but between them" (p.187). Elsewhere von Glasersfeld (1985) establishes the location of all knowledge to be within the individual. In discussing social knowledge, Kamii would stress the social aspect of conventions locating some knowledge as partially in the child's brain and some as partially in the social context. Physical knowledge for Kamii would be partially located in external reality whereas for von Glaserfeld even physical knowledge is located within the individual. Goldin and Shteingold (2001) interpret von Glaserfeld (1991, cited in Goldin and Shteingold, 2001) in a similar manner stating that von Glaserfeld holds that "…all knowledge was seen as constructed from the individual's subjective world of experience.

Constructivism is not a single unified theory. There are three major interpretations of the theory, represented by three of the great thinkers associated with each interpretation: (a) Psychological or Piagetian, (b) Social or Vygotskian, and (c) Radical (represented by von Glasersfeld). The three strands differ in the main subject of study, in views about how cognition develops, and in how liberating the derived teaching approaches become (Abdal-Haqq, 1998).

vonGlasersfeld (1995) defines radical constructivism as

> …an unconventional approach to the problem of knowledge and knowing. It starts from the assumption that knowledge, no matter how it is defined, is in the heads of persons, and that the thinking subject has no alternative but to construct what he or she knows on the basis of his or her own experience. What we make of experience constitutes the only world we consciously live in. It can be sorted into

> many kinds, such as things, self, others, and so on. But all kinds of experience are essentially subjective, and though I may find reasons to believe that my experience may not be unlike yours, I have no way of knowing that it is the same. The experience and interpretation of language are no exception. (p. 1)

Abdal-Haqq (1998) contrasts social constructivism and Piagetian constructivism stressing that Piagetian constructivism is more child-centered with an emphasis on individual development. Students come to the classroom with pre-conceived ideas that must be altered or modified through "… tasks and questions that create dilemmas for students" (p. 2).

DeVries and Kohlberg (1987) situate Piagetian Constructivism squarely in the tradition of Dewey. She sees Dewey's educational philosophy as a cognitive-developmental ideology that holds that "…knowledge evolves from an internal psychological core through an interaction or dialogue with the physical and social environment rather than by biological maturation or direct learning of externals given from the environment" (p. 7). DeVries and Kohlberg (1987) describe cognitive development as invariant, hierarchical and sequential. Abdal-Haqq (1998, citing Vadeboncoeur, 1997) differs somewhat in his view of Piagetian constructivism, saying that it "…assumes that development is an ingrained, natural, biological process that is pretty much the same for all individuals, regardless of gender, class, race, or the social context, in which learning and living take place" (p.2). A learning theory that de-emphasizes the learning context would disregard the power issues to which Delpit (1995) so eloquently speaks.

In contrast to the Piagetian emphasis on the individual child, the emphasis in Vygotskian constructivism (Abdal-Haqq, 1998) is on the sociocultural context. This interpretation would seem to be more supportive of education for social transformation. In Vygotskian learning theory, students construct knowledge through interactions within sociocultural contexts. Development flows from the social interactions as cultural meanings are shared by the group and subsequently adopted by the individual. This brings about changes in both the environment and the individual. Power relationships and cultural assumptions are no longer silenced (Delpit, 1995). From the perspective of Dewey (1916), we can "…measure the worth of a form of social life …(by) the extent in which the interests of a group are shared by all its members, and the fullness and freedom with which it interacts with other groups" (p.99).

DeVries and Kohlberg (1987) would object to Abdal-Haqq's (1998) characterization of Piagetian constructivism, however. Her description of knowledge development in the Piagetian tradition clearly refers to "…an interaction or dialogue with the physical and social environment" (p.7) and refers to the theory's setting within the tradition of Dewey. Many authors like Abdal-Haqq place Piaget in this individualistic learning tradition. However, Salomon and Perkins (1998) agree with DeVries (1987) that this is an incorrect reading of Piaget. Elkind has stated that "… Piaget's theory is the biggest and best Rorschach test that has ever been created" (Cited in personal communication from W. Gray, March, 2001).

Individual and socially mediated learning. Salomon and Perkins (1998) approach the comparison of individual and social learning from a different direction. “It is fruitful to view these conceptions as two levels of analysis, each of which sometimes neglects the other…although each process can be understood in its own right, understanding the interplay yields a richer and conceptually more satisfying picture” (p.2). We need to view individual and social learning as two different perspectives on the phenomena of learning, examining each in the light of the other. Vygotsky (1981) identifies these two levels.

> Any function in the child’s cultural development appears twice, or on two planes. First it appears between people as an interpsychological category. This is equally true with regard to voluntary attention, logical memory, the formation of concepts, and the development of volition…Internalization transforms the process itself and changes its structure and functions. Social relationships or relationships among people genetically underlie all high functions and their relationships (Vygotsky, 1981, p. 163).

For Salomon and Perkins (1998), social learning can take place in collectives such as societies, corporations, and teams as well as within an individual. These they refer to as complex webs of interaction. Whether an individual or a complex web of interaction, the learning entity “…must be able to construct a repertoire of new representations or behaviors based upon prior experience. Within this process, there are critical conditions that must be present in order for effective learning to take place:

1. The learning entity must be able to combine, recombine or refine the range of representations or behaviors.

2. Feedback from internal and external sources must be used in judging how well the learning process is progressing.
3. Information from many sources, ranging from text to modeled behavior, must be available.
4. Guidance in the learning process must be provided either by self-regulation or by others.
5. The challenge faced must be neither too easy nor too difficult.
6. "The learning entity will also need conditions that sustain motivation and energy" (p. 3).

These critical conditions are provided by learning systems that facilitate these critical learning conditions. One example of such a learning system would be a peer collaborative learning group that facilitates deeper learning through the deliberations around the acceptance of different alternative representations provided by the members of the group. This learning system could be describing a Literacy Circle in a reading classroom or a corporate team working on a solution to a design flaw.

The critical conditions can provide guidance for us in assessing how well learning systems facilitate individual and collective learning. Successful learning systems will provide all six critical conditions. Salomon and Perkins (1998) criticize typical instruction in its prototypical form such as lecture or question-and answer, stating, "…it often does not meet the critical conditions of learning very well" (p. 4).

Other theorists (i.e. Wertsch, 1995, cited in Wilkinson & Silliman, 2000) have elaborated on the theory of Vygotsky identifying human actions as central units of action:

"How individuals act, alone or with others, cannot be separated from their cultural tools which mediate interaction (Willkinson & Silliman, 2000, p. 342)."

Salomon and Perkins (1998) identify six meanings for social mediated learning:

1) Active social mediation of individual learning. This is what we typically think of in terms of socially mediated instruction. A teacher, parent, or team helps an individual to learn. The emphasis in this area is on the individual and his/her acquisition of knowledge and his/her conceptual change. The success of this learning system is dependent on the facilitation of the critical conditions: informative feedback, challenge at the optimum level, active guidance, and encouragement. Proponents have been greatly influenced by Vygotsky and the zone of proximal development he describes.
2) Social mediation as participatory knowledge construction. In this version of social constructivism, the knowledge is constructed and held by the collective. Proponents of this view of social mediation contend that individual learning cannot be studied outside of the social context in which it is learned because the learning is highly situated and is constructed jointly. "Knowledge, understandings, and meanings gradually emerge through interaction and become distributed among those interacting rather than individually constructed or possessed" (p. 8). The social context is not the background in which learning takes place but rather it is inextricably interwoven with the construction of knowledge.
3) Social mediation by cultural scaffolding. This meaning of social mediation focuses on the role of cultural artifacts such as texts, videotapes, statistical

tools and socially shared symbol systems in mediating social learning. Artifacts as tools have two roles: one is a means to act upon the world and the other is their role as a cognitive scaffolding which facilitates the action upon the world. For instance, "…memory is just not the same once certain language structures and writing have been acquired." (p. 11)

4) The social entity as a learning system. This meaning of social mediation views learning in teams in terms of the collective itself as learners not in their role as facilitators of individual learners. Teams and organizations can depict this interpretation. Sports teams, for instance, learn patterns of coordination in their sport that could not be used by an individual alone.
5) Learning to be a social learner. The focus of this interpretation is how individuals learn how to learn as well as learning content information. Individuals learn how to provide for themselves more of the critical conditions for learning within the social setting. This is the basis of strategy skill instruction highlighted by Pressley and Brainerd (1985) and Carr, Aldinger, and Patberg (2000).
6) Learning social content. "Social content includes such matters as how to get along with others, how to maintain reasonable assertiveness, how to collaborate in making decisions, and taking collective actions, and so on" (Salmon & Perkins, 1998, p. 6).

After Salomon and Perkins (1998) discuss the meanings of social mediation, they return to the false dichotomy of individual vs. social learning. They point out that every individual who is learning is more or less involved within a social context no matter how alone he/she appears. At the other end of the same spectrum, every socially mediated collective includes individual learning by the members as well as some learning that is distributed throughout the collective.

The reciprocal relationship between the individual learning and the collective learning can form a learning spiral, which intensifies the learning of the individual and the collective. “Students may learn more efficiently and thus reach a deeper understanding of the subject matter at hand, an achievement that they will walk away with, while the team may learn better as a team through participation in such spirals” (p. 19). The individual remains an important and essential part of the learning spiral, sometimes resisting the collective learning while espousing an independent point of view that can then better inform the group. This spiral learning reciprocity is neglected by the socio-cultural approach to learning because this approach does not clearly differentiate between individual learner and the social agent (Salomon and Perkins, 1998).

Analysis of socially-mediated learning. The version of socially mediated learning proposed by Salomon and Perkins (1998) has great potential as a theoretical basis for teaching and learning that will foster the development of multiple literacies in a democratic approach to education. It allows for the explicit instruction in this society’s cultural capital for all of our students in schools because the individual remains an essential part of the learning spiral and a shared cultural context is not assumed. It is only in this version of social constructivism that teachers can act as experts while at the same time acknowledge their students’ expert abilities in areas in which the students are competent, as Delpit (1995) has suggested. Freedom to espouse an independent point of view is essential in a learning system that would make "…make provision for participation in its good of all its members on equal terms" (Dewey, 1916).

The Salomon and Perkins (1998) version of sociocultural constructivism also supports the position of Freire (1970). The teacher and student roles merge. The teacher becomes a learner as the communication with the learner transforms the relationship. "The problem-posing educator constantly re-forms his reflection in the reflection of the students. The students – no longer docile listeners – are now critical co-investigators in dialogue with the teacher" (p. 68). This problem-posing education is supported by the description of the spiral learning reciprocity that Salomon and Perkins propose.

Salomon and Perkins (1998) call for an intentional, conceptually oriented approach to learning indicating, "… that good learning, whether individual or collective, depends on self-mediation or mediation by other agents" (p. 20). They go on to caution that the learning reciprocity can have a dark side "…as when a teacher forms a tacit contract with students (e.g., 'I won't ask too much if you do the little I ask')" (p. 21). This dark side is exemplified in the use of tracking across most of the schools in the United States. A watered-down curriculum is often offered to students who are viewed as less able while a problem-posing curriculum (Freire, 1970) is offered to those considered "gifted." Group placement affects the quality, quantity and pace of instruction. Students placed in lower ability grouping are expected to do less, are taught at a slower pace (covering less of the material) and in a manner not encouraging higher level thinking skills (Oakes, 1985; Pallas, Entwisle, Alexander, Stluka, 1994; Secada, 1992).

The desired learning theory for the development of multiple literacies for all citizens will include the elements of the work of Dewey (1916), Freire (1970), Delpit

(1995), Salomon and Perkins (1998) and others. This learning theory should be based in a democratic approach to education (Dewey, 1916) wherein provision is made for communication from and with all members of the society. A problem-posing curriculum, as opposed to the banking model of education prevalent in many schools (Freire, 1970), is also desirable. This curriculum should also include explicit instruction in the codes of mainstream society (Delpit, 1995). All of this should be set in learning theory based in sociocultural constructivism as delineated by Salomon and Perkins (1998) and Wilkinson and Silliman (2000) with special emphasis on the spiral of socially mediated and individual learning, necessary for the inclusion of each of the essential elements listed above.

Issues in Kindergarten Curricula

While the banking model of education has been prevalent in many elementary schools in the United States, traditional pre-school and kindergartens were heavily influenced by the progressive school movement and the development of the developmental-interaction approach to pre-school and kindergarten education (Goffin & Wilson, 2001). This influence included an "emphasis on developing the whole child, nurturing children's individual knowledge of themselves through a curriculum of experiences (a new notion at the time) and providing a variety of ways, most especially play, for children to express and represent the experiences they encountered (p. 173)."

The developmental-interaction model is a child-centered approach that echoes Dewey's (1916)attention to the child's environment. This approach sees the individual development of the child as a way of affecting social change and includes "…a dynamic conceptualization of teaching and learning" (Goffin & Wilson, 2001, p. 175). It establishes guidelines/principles but does not dictate how they are to be implemented. The developmental-interaction approach focuses on the development of the whole child. Play is seen "…as a mode of thinking and a vehicle for symbolic representation…as well as supporting children's expression of diverse emotions, for synthesizing the subjective and objective aspects of experience and providing a vehicle for symbolically resolving personal conflicts" (Goffin & Wilson, 2001, p. 76). Because of their emphasis on the whole child, the developmental-interaction approach draws from multiple theories in order to support the complexities of development. It has remained flexible in its use of current knowledge and theories of how children learn.

> It is a basic tenet of the developmental-interaction approach that the growth of cognitive functions—acquiring and ordering information, judging, reasoning, problem-solving, using systems of symbols—cannot be separated from the growth of personal and interpersonal processes—the development of self-esteem and a sense of identity, internalization of impulse control, capacity for autonomous responses, relatedness to other people. (Shapiro & Biber, 1972, p. 61, cited in Goffin & Wilson, 2001)

Goffin and Wilson (2001) describe this approach as a "…child-centered, experience-centered, process-oriented early childhood program promoting every aspect of a child's development in the direction of optimal human functioning" (p. 83).

Prior to the 1960's the developmental-interaction approach was the prominent one in pre-schools and kindergartens in the United States. During the 1960's and early 1970's, proponents of academic curricula such as the direct instruction model and Bereiter-Engelman Models surfaced in response to the search for interventions for preschoolers from lower socio-economic Status (SES) homes, the availability of federal money and the ascendancy of behaviorism in psychology. The academic curricula became successful in the twenty years that followed in part because of the narrowing of the purpose of Head Start to a focus on school readiness. The success of the academic approaches was also furthered by the launching of Sputnik by the former USSR, which fostered a return to academic learning in schools. Behaviorism seemed to hold promise for fostering learning through modifying the environment.

The conflict between proponents of academic curricula and developmental curricula continues. Between the mid-1980’s and the mid 1990’s, the National Association for the Education of Young Children (NAEYC) developed a very successful challenge to the validity of early childhood programs with an academic focus. In a book titled *Developmentally Appropriate Practice for Early Childhood Programs* (Bredekamp & Copple, 1997), NAEYC reframed the controversy between developmental and academic focus in terms that stressed developmentally appropriate practice (DAP) versus developmentally inappropriate practice. “The concept of DAP has helped unify early childhoods education’s various strands (nursery education, childcare, Head Start, kindergarten and pre-kindergarten programs)” (Goffin & Wilson, 2001, p. 123). The acceptance of DAP was affected by the publication of a study of the long term effects of a developmentally oriented program called High/Scope. The study supported the developmental approach by indicating the scientific validity of the success of the approach.

Recent early childhood theorists have challenged the developmental approach and the academic content approach because, from a historical, political and sociological perspective, both positions limit what children should learn (Kessler & Swadener, 1992; Lubeck, 1998). This returns to Delpit's (1995) concerns about the needs of students from lower SES homes and issues about cultural capital and implicit teaching. Swadner and Kessler (1991) argue that early childhood curriculum should be analyzed in terms of "whose interests are being served, and marginalized by curricular decisions" (cited in Goffin & Wilson, 2001, p. 196).

The second challenge to curricular models is that curricula have been assumed to be portable. Curricula have been conceptualized, taught, or presented to teachers in diverse locations and teachers have been expected to implement it as written. The Bank Street College, one of the proponents of the developmental-interaction approach has been the exception to this providing, guideline/principles rather than an implementation framework. According to Goffin and Wilson (2001), "increasingly, teachers are being described as creators and interpreters of curricula, not just as its implementers. This is supported by the idea of teaching as dynamic and curriculum as emergent in response to daily interactions among children and teachers" (p. 205).

The social nature of development along with the influence of nature and nurture provide the three key influences on child development.

> Appreciation of culture as a third, and significant contributor to development argues for a reexamination of reliance on white, middle-class norms. This recommendation is bolstered by the increasing cultural diversity of children in the United States who participate in early childhood programs, expanding understanding of cultural differences, and increasing appreciation for the fact that

> different cultural settings provide different (versus deficient) backdrops and opportunities for learning (Goffin & Wilson, 2001, p. 205).

Bruner and Haste (1987, cited in Goffin & Wilson, 2001) contend that a social revolution has taken place in which we consider the social nature of the child as "one who plays and talks with others [and] learns through interactions with parents and teachers" (p. 1). Through this playing and learning process, the child acquires a cultural framework for interpreting what he/she experiences.

General representational skills develop from dramatic play and are eventually applied in other areas such as reading and writing (Yaden, Rowe, Mac Gillivray, 2000). "Emergent literacy research tracks children's literacy knowledge and processes as they move from unconventional to conventional literacy events during holistic literacy events such as storybook reading or play" (Yaden, et al. 2000, p. 426). Emergent literacy refers to a constructivist theoretical stance that views literacy learning in young children (birth to age 6) with "… a focus on informal learning in holistic activities at home, pre-school, or kindergarten" (Yaden, et al. 2000, p. 426). Studies have shown that metaplay (children talking with peers about their play) is closely related to the development of later reading performance and symbolic transformations are closely related to emergent writing. Socio-dramatic play can then have a direct effect on written language development when it is used in contextualized situations such as a literacy-enriched restaurant play center where many opportunities are provided for play centered around authentic reading and writing.

Role of Classroom Collaboration and Dialogue

Part of this return to viewing a child as a social being can be traced to the guidance of Vygotsky's social constructivist theory in educational research during the last thirty years (Wilkinson & Silliman, 2000). This research shared three major assumptions about classroom language and literacy learning: (a) Learning is social; (b) oral and written language learning are integrated; and (c) learning requires active student engagement in classroom activities and interaction.

This classroom interaction cannot be separated from the "cultural tools which mediate action … The content and processes of learning are grounded in the social activities and mediated through cultural tool kits, which are made available through the dialogue scaffolds of teaching and learning" (Wilkinson & Silliman, 2000, p. 342). Through dialogue and non-verbal cues, more capable persons support novice learners to develop higher levels of conceptual and communicative competence. Ideally, this happens through supportive scaffolds that are based in dynamic assessments that inform teachers of students' understanding and allow them to change the level and type of support provided. Wilkinson and Silliman (2000) contrast supportive scaffolds with directive scaffolds which are teacher controlled and designed to assess student content knowledge and compare it to a predetermined standard. An example of directive scaffolding is the initiation-response-evaluation (IRE) conversational sequence. This approach relates closely to the assumptions of the banking model (Freire, 1970) where the teacher's primary function is viewed as a transmitter and assessor of knowledge and students are largely "taught to conform to adult authority through passive participation" (Wilkinson & Silliman, 2000, p. 344).

Supportive scaffolds, on the other hand, help students to acquire the "cultural tools that mediate how to understand, remember, and express one's perspectives in more literate ways" (Wilkinson &Silliman, 2000, p. 345). Control, responsibility, and monitoring are gradually transferred to the students as they gain in their learning and problem-solving abilities. Tharp (1993, 1994, cited in Wilkinson & Silliman, 2000) described the critical elements of supportive scaffolding:

1. Competence in instructional language is a “metagoal” of all instructional activities.
2. Instructional practices are grounded in culturally meaningful experiences that assist students in transferring classroom leaning to other settings, such as the home, community, and workplace.
3. Effective teaching and learning occur in collaboration where individual differences are respected due to the construction of “multiple zones of proximal development…through which participants can navigate via different routes and at different rates” (Brown & Campione, 1994, p. 236). Collaboration as a process of inquiry also enhances the motivation to learn.
4. The basic form of teaching is dialogue through instructional conversations. These dialogues integrate listening, speaking, reading, and writing as tools of inquiry serving multiple communicative purposes. Instructional conversation, when organized by thematic units and activations of background knowledge, function as formats for supporting the development of new conceptual understandings that have educational value. Through such collaboration, students invest in their own learning, seeking out challenging concepts in order to “form, express, and exchange

> ideas in speech and writing" (Tharp & Gallimore, 1988, cited in Wilkinson & Silliman, 2000, p. 345)

Supportive scaffolding fits the recommendations of organizations such as the NAEYC, NCTM, IRA, NCTE, NSF that call for the "…design of learning contexts that are learner-centered, value learning as the search for understanding provide opportunities for dynamic assessment and responsive feedback, and view the educational process as consisting of a community of learners" (Wilkinson & Silliman, 2000, p. 344). In order to meet these goals, Wilkinson and Silliman (2000) recommend that group discussions: (a) are guided (either by the teacher or the students), (b) include open-ended tasks that can be interpreted in multiple ways that are motivated by the topic, (c) retain friendly respect for individual differences, and (d) include student topics for discussion. As we examine instructional dialogue, we need to keep in mind that the students at the kindergarten level are at the transition between informal and formal learning. We need to examine the development of communication in young children in order to fully understand how young children use and learn language in the social setting of the kindergarten classroom.

Language and Discourse in Young Children

Although the study of child language has been a part of the study of human behavior for a very long time, major questions have remained unanswered and, in some cases, the posed answers are hotly contested. Research on the beginnings of language tends to follow one or both of two perspectives. "The first perspective emphasizes the referential or representational use of language and the close relations between language development and cognitive growth" (Franklin & Barten, 1988, p. 3). The other perspective emphasizes the social origin and nature of language. These perspectives closely parallel the major interpretations of constructivism.

According to Franklin and Barten (1988), Piaget emphasized the development of symbolizing capacities in young children, a referential or representational use of language. Piaget, according to Vygotsky (1986), discusses the early egocentric speech of the child neglecting to note the important transition to inner speech that occurs at about the time of entrance into school. For Piaget, the egocentric speech simply goes away as the child becomes more socialized. Vygotsky (1986) views the development of speech in a child as becoming *more* individualized. “Speech for oneself originates through differentiation from speech for others. Since the main course of the child’s development is one of gradual individualization, this tendency is reflected in the function and structure of his speech (Vygotsky, 1986, p. 23)” Vygotsky (1986) holds that the child’s egocentric speech becomes inner speech intimately connected with a child’s thinking. It is the child’s conscious understanding. Vygotsky (1986) stresses that this egocentric speech becomes less and less vocal as its structure and function become more and more complex. If, indeed, this happens around the time of a child’s entry into school, it is an essential understanding of language development at kindergarten.

Drawing on the work of Vygotsky (1986) and Bakhtin (1986), Hicks (1995) posits that “spoken and written language acquire meaning only through social usage. Meaning is socially constituted” (p. 52). Discourse and learning are essentially social meaning construction. For her (Hicks, 1995), the term discourse includes both linguistic form and social communicative practices. “One can talk of discourse in terms of oral and written texts that can be examined after the fact and socially situated practices that are constructed in moment-to moment interaction” (p.51).

Discourse is considered the mediator of children’s learning. Hicks (1995) points to this statement as a central theme of the social constructivist research that has followed the publication of Vygotsky’s work. She emphasizes that language is more than a cognitive resource in the relations between classroom discourse and children’s learning. Language is in addition, a social construct, and meaning is formed in the relationship between author and reader or speaker and listener. Discourse involves not only the oral or written texts but also the context and the discursive practices that accompany the texts. A Morning Circle or other recursive classroom context has structure that the children have learned through experience. An example of this type of structure and its importance can be seen in the work of Nelson and Gruendel (1979).

According to Nelson and Gruendel (1979), there has been a growing consensus that early speech is more social than researchers such as Piaget initially proposed. Dialogue with turn-taking, reciprocity and intent are established very early with their roots in prelinguistic mother-child communications. Reciprocity involves switching roles as listener and as speaker. In order to correctly interpret the intent of a speaker, the listener must correctly understand what the speaker is saying. Some conversations among pre-school children are collective monologues with turn taking, rather than true dialogues.

Nelson and Gruendel (1979) propose that, in order for children to participate in a dialogue, they must share two types of knowledge: (a) general rules of conversation and (b) a wide range of content knowledge in the area about which they are conversing. The appearance of egocentrism in children may be due to a difference between the participants in these two types of knowledge. They may each assume that the other shares the same context or either or both of them may not have developed conversational strategies to check that they are conversing with the same information. These conversational strategies include the use of repetition, questions for clarification, or disagreement. Beginning within the early mother-child interactions, conversational scripts are built up which “specify the structure and content of familiar events in the child’s experience” (p. 268). A script is “a conceptual structure that describes appropriate sequences of events in a particular context” (p. 267). When children share the content and structure of these scripts, their conversational skill is improved and the speech events will be more of a dialogue.

The duality of oral and written discourse as textual products and discursive practices must be included in any discussion of discourse as a mediator of children’s learning (Hicks, 1995). The writers in sociocognitive research have developed an extensive literature of studies of adult-child interactions showing how children are supported by discourse in what Vygotsky (1978) termed the “zone of proximal development (ZPD).” ZPD is the difference between what a child can do without help and what he/she can do with the assistance of a more capable person (peer or adult). The term scaffolding has been used to describe the learning interactions between the more capable person and child. The more capable person structures the learning situation or provides directions for the child’s activity, setting the goal beyond where the child is now successful. As the child reaches the goal, the goal is moved up. “Through her or his repeated engagement in activity that is often shaped by discourse, the child’s situational understandings are shaped so that she or he can be a full participant in a social world" (Hicks, 1995, p. 55).

Complexities of language use in schools. Halliday (1969) stresses that teachers need an adequate definition and description of language to guide them in their work: one that is more complex than a simple social or representational approach to language. Often teacher's views are more simplistic than the young child's experiences with language. "We tend to underestimate both the total extent and the functional diversity of the part played by language in the life of the child. …Much of his difficulty with language in school arises because he is required to accept a stereotype of language that is contrary to the insights he has gained from his own experience. The traditional first 'reading and writing' tasks are a case in point, since they fail to coincide with his own convictions about the nature and uses of language" (pp.189-190).

Traditional reading and writing in kindergarten was viewed in terms of reading readiness with assumptions that literacy began at school. "Emergent literacy, in contrast refers to knowledge children acquire about relationships among oral language, reading, and writing before entering school. Learning to read and write is not a matter of readiness, but is integrated with and naturally embedded in the many social interactions with literate adults encountered from infancy onward" (Wilkinson & Silliman, 2000, p. 347).

Halliday (1969) delineates seven models of language that children are aware of at the time they begin school:

1. Instrumental Model: Language is used as a means of getting things done. This is one of the first models of language that children use.

2. Regulatory Model: Language is used to regulate the behavior of others. This is the basis of the language of rules and instructions which become so important to young children.
3. Interactional Model: Language is used in the interaction between self and others. This includes communication that is the basis of complex interactional relationships with peers as well as relationships with significant family members and other adults.
4. Personal Model: Language is a form of individuality. This includes expressive language but also includes the personal side of interactional communication which deals with the development of self through interaction with others.
5. Heuristic Model: Language is a means of investigating reality. By kindergarten, children are aware of how to ask questions to gain knowledge and they generally have a meta-language to discuss the process of asking and answering questions.
6. Imaginative Model: Language can be used to create one's own environment. Children make up their own environment from rhythm and sound as well as from make-believe versions of people and things in their own experience. Young children have a meta-language to discuss this that includes terms such as make-believe, story, and pretend.
7. Representational Model: Language is a means of communicating about something. Teachers as well as other adults tend to be most conscious of

> this model of language. For the child, this is only a small portion of his/her awareness of language.

According to Halliday (1969), children expect language to be meaningful and many of the tasks that teachers present in early elementary school have little or no meaning for the child.

> Language is defined for a child by its uses; it is something that serves (a) set of needs … What is common to every use of language is that it is meaningful, contexualized, and in the broadest sense social; this is brought home very clearly to the child, in the course of his day-to-day experience. The child is surrounded by language, but not in the form of grammars and dictionaries, or of randomly chosen words and sentences, or of undirected monologues. What he encounters is "text": or language in use: sequences of language articulated each within itself and with the situation in which it occurs. Such sequences are purposive—though varied in purpose—and have an evident social significance. The child's awareness of language cannot be isolated from his awareness of language function, and this conceptual unity offers a useful vantage point from which language may be seen in a perspective that is educationally relevant (pp. 194-195).

Children, early in language development, are able to understand and choose to use alternative ways to express the same meanings. Within the regulatory model, for instance, a parent can directly ask the child to pick up his/her toys or the parent can say, "Your room is very messy," fully expecting that the child will comply and pick up his/her toys. Within the instrumental model, a child may directly ask, "Can I have something to eat?"

or whine, “I’m hungry!” Various linguistic and nonlinguistic factors influence a speaker’s choice of one form over another (Bowerman, 1981).

An important consideration in the classroom is the effect of cultural differences on choices of ways to express the same meanings. In some cultures, regulatory models tend to be more direct. Direct commands and demands are accepted from children as often as from the adults. In the classroom such demands and commands from students are often considered blatant disrespect, leading to an assessment of a behavior problem if the verbal behavior continues. “Becoming a fluent speaker requires not only mastering a body of linguistic forms but also learning which ones mean approximately the same thing and which circumstances favor the use of one variant over another” (Bowerman, 1981, p. 108).

This discussion points out that classroom discourses are never value free. “…Discourses always reflect ideologies, systems of values, beliefs, and social practices” (Hicks, 1995, p. 53). Delpit (1995), in discussing the culture of power and its ramifications for the classroom, mentions the differences in interactional styles and discourse patterns between middle-class parents or teachers and those from marginalized communities. Middle class parents and teachers are more indirect in their demands, couching their directives as questions. Their children usually know that these are not really requests with the option of choice. Many working class children when faced with such questions in school are confused when their refusal to follow the veiled commands is seen as direct disobedience. At home they are directly told what is expected and what is not acceptable. Mainstream teachers are often baffled by the students' reactions to their requests, usually interpreting the situation as one of defiance.

Research by Heath (1982) supports Delpit's (1995) discussion of the culture of power and the differences in discourse patterns between mainstream and African American families. Questions in the African American community that Heath (1982) studied are generally relational such as "What is that like?" or questions are asked to find out information that the questioner does not know (Hale-Benson, 1986). Questions are not used as implicit demands. The relational questions that are common in the African American community support the view that these children come to school ready for critical thinking but find that unfamiliar "what" questions fill the curriculum.

Academic discourses may involve values and beliefs that are contrary to the children's home culture or the children may never have been exposed to elements of the discourse (Hicks, 1995). These academic discourses contain ways of describing, explaining, and questioning that are very different than those used in normal conversations. Even story form may be different. Heath (1982) points out that some stories in some African American communities "... have no point- no obvious beginning or ending; they go on as long as the audience enjoys and tolerates the storyteller's entertainment." (p. 68)

Reform efforts in mathematics (NCTM, 1991) have stressed that students should be able to discuss their thinking processes and defend their solutions to problems. An examination of cultural practices in some Native American communities demonstrates how this can be problematic: Silence in the Native American community is used to communicate respect between people and a sense of unity (Nel, 1993). Silence is used within the Apache community, for instance, in six different social contexts: (a) when meeting strangers, (b) when courting, (c) when children return home after a long period of time, (d) when being verbally criticized, (e) when with someone who is grieving, and (f) when someone is going through a ritual (Plank, 1994). All of these situations have in common that the social relationships are uncertain or unpredictable. According to Nel (1993), this use of silence may come from genuine respect for the individuals and their feelings. Native American students are taught to think before they speak and are less likely to interject their comments when the teacher and another student are speaking (Nel, 1993). Hicks (1995) stresses that the intention of the NCTM's approach is "to enable all students to participate in an authentic disciplinary discourse, in this case a mathematical discourse… Classrooms are embedded communities of discourse; they can never be divorced from the community-based language practices that children bring with them" (p.75).

Understanding discourse and dialect differences is essential for teachers in our increasingly diverse society (Wilkinson & Silliman, 2000). Students need to view themselves as competent learners and communicators. This vision of themselves is directly affected by the attitudes of the learning community in which they find themselves.

Word meanings: Taxonomic versus thematic meanings. The complexity of a young child's use of language is also highlighted in the studies that have been done on the development of word meanings. Very young children often learn new words by pointing and the adult then supplies the word or the adult points and says the word. Markman and Hutchinson (1984) have demonstrated that children tend to assume that the word applies to things that are the same in some way (a taxonomic meaning) rather than things that belong together (a thematic meaning). This is the case despite the fact that young children before age seven tend to prefer sorting objects by a thematic meaning. A dog and his bone would be put in the same pile, for instance. Children also remember thematic relationships better than categorical ones. When specifically guided to form categories five and six-year old children can do it, however.

According to Markman and Hutchinson (1984), the assumption that a new word applies to a category points to a constraint on word meaning. “Thus, the hypothesis is that, regardless of native language, children look for categories of similar objects when they hear new nouns. …The small amount of research that bears on this milder form of linguistic determinism suggests that children can use abstract knowledge of the semantic correlates of form class to discover the concept to which a word refers” (p.156). This constraint on word meaning may indicate that language may influence the child’s gaining of new categories. When hearing a new word, the child may search for a new category.

Metaphor. Another area of language complexity related to children’s concept of word meanings is the area of metaphor. “Metaphor may be defined as a use of language in which a term (or phrase) customarily applied in one domain is transported across conventional category boundaries and applied in another” (Franklin & Barton, 1988, p. 299). Researchers disagree on how early children are able to use and explain metaphors (Billow, 1981; Vosniadou, Ortony, Reynolds, & Wilson, 1984; Winner, Rosenstiel, & Gardner, 1976) but a number of studies have reported that preschoolers spontaneously use metaphor (Winner, Rosenstiel, & Gardner, 1976). Whitin & Whitin (1996) have described children’s use of metaphor to express mathematical understandings. They pointed to the historical control of mathematical language in children’s education that textbooks have exhibited. “…Little attention has been paid to the language of children”

(p. 60).” Whitin and Whitin (1996) see the potential in metaphor to restore visual imagery to mathematical ideas. “Metaphors allow children to make personal connections to mathematical ideas. When children frame the concepts of mathematics in their own language, they develop ownership of these ideas. Metaphors also invite everyone into conversations. Since there is not one-to-one correspondence between a mathematical idea and its visual equivalent, all learners can draw on their personal backgrounds and experiences to offer unique comparisons (Whitin & Whitin, 1996, pp. 64-65).”

Goldin and Shteingold (2001) view the role of metaphor in mathematics education as an important one. They point out that metaphors are present any time images are used to develop, explain, or interpret mathematical ideas. Understanding mathematical relationships involves the use of analogy and metaphor with different representations of similar concepts as well as with the similarities and differences among representational systems.

Heath (1982) states that many minority students come to kindergarten with the “...ability to metaphorically link two events or situations and to recreate scenes that are not tapped in the school (p. 70).” The encouragement of the use of metaphor in mathematical language may be social-culturally advantageous for minority students.

Literacy and Mathematics

The National Council of Teachers of Mathematics (NCTM, 2000) places communication as one of the most important standards in mathematics education. It stresses that mathematical curricula should include many opportunities for students to represent, discuss, read, write, and listen to mathematics.

> Communication is an essential part of mathematics and mathematics education. It is a way of sharing ideas and clarifying understanding. Through communication, ideas become objects of reflection, refinement, discussion, and amendment. The communication process also helps build meaning and permanence for ideas and makes them public (p. 60).

Although recent reform efforts have brought about changes in approaches to teaching mathematics, the need for reading and writing, as well as the need for discussing and listening, have not decreased. With its emphasis on communication, the new mathematics standards (NCTM, 2000) actually call for a greater use of these language arts skills.

Transitions from Informal Mathematics to Formal Mathematics

"Communication plays an important role in helping children construct links between their informal, intuitive notions and the abstract language and symbolism of mathematics…"(NCTM, 1989, p. 26). This informal, intuitive way of knowing and understanding mathematics grows through a variety of experiences inside and outside of school. Students learn to relate the language that they use in everyday life to mathematical concepts, terms, and contexts. This is the important area of informal mathematics, on which, all later mathematical learning is built (Baroody,1987). "It is made up of intuitions, perceptual information, invented strategies, and other knowledge that has been acquired in dealing with everyday quantitative situations" (Payne, 1990, p.19).

By the time children enter kindergarten, they already know quite a bit about mathematics. Children spontaneously engage in activities that involve quantities and spatial relations. Through their play they develop simple procedures to solve problems. These procedures are built directly on their understanding. They can almost always tell if each child in their group has received a fair share at snack time. They usually can count up to at least twenty and often to a hundred. They have also had a lot of experience with building things, a substantial basis for knowledge in geometry.

Romberg and Carpenter (1986) noted that:

> The research on addition and subtraction suggests that the current [pre-reform] primary curriculum fails to capitalize on the rich informal mathematics that children bring to instruction. Children's strategies for solving addition and subtraction problems are frequently more efficient and more conceptually based that the mechanical procedures included in many programs (pp. 855-856).

The research suggests that it is not necessary to delay instruction in word problems until children learn to accurately compute. Word problems should be more completely integrated into the primary curriculum, using them to develop skill in addition and subtraction.

Formal mathematics is first introduced in school. It is the instruction that is most often associated with mathematics and "consists of methods, procedures, or rules for solving school mathematics problems" (Payne, 1990, p. 19). Baroody (1987) posits that formal mathematics can improve a child's ability to solve problems by freeing them from the concrete but that this formal mathematics must be firmly based on an understanding that flows from informal mathematics. "Formal mathematics enables children to think in more abstract and powerful ways and to deal efficiently with large-number problems" (Baroody, 1987, p. 34).

Teaching for understanding. If, when they enter school, children are taught procedures without the underlying meaning, they have great difficulty relating what they already know and understand to what has been introduced in a more formal way in the mathematics classes in school. If symbols and algorithms are introduced too early, children cannot relate these symbols and procedures to real world use of mathematics. It takes a lot longer to help students connect conceptual and procedural knowledge. But the initial investment of time and effort is well worth it. “Experiences and intuitive ideas become truly mathematical as the children reflect on them, represent them in various ways, and connect them to other ideas” (Payne, 1993, p. 6).

An article by Skemp (1978), “Relational understanding and instrumental understanding,” demonstrates the differences between teaching for understanding and simply teaching the procedures to obtain an answer. He does this by separating the two approaches to teaching mathematics into the relational understanding and the instrumental understanding method. These two constructs are comparable to conceptual knowledge and procedural knowledge. Instrumental mathematics teaches from a rule and practice base while relational mathematics is “knowing both what to do and why” (p. 9). Skemp holds that a mismatch between students’ expectation of approach and the one the teacher is using is the most damaging situation of all. Students who are used to the instrumental approach resist the relational approach saying, “Just teach me the rule and I’ll get the problems right.” Students who are taught in the instrumental method who are expecting mathematics to make sense come away confused and feeling inadequate.

Skemp (1978) lists the advantages of each method. Instructional mathematics is easier to understand, at least initially. More difficult concepts are just glossed over with a rule. The rewards come immediately with a page of correct answers and these are done more quickly and perhaps more reliably. Relational mathematics on the other hand is more adaptable to new tasks and is easier to remember since it comes from understanding the concept rather than from rote memory. It also can become a goal in itself so it is self-motivating. It does take more time to cover the individual concepts but because it is more global in nature, many individual rules do not have to be taught. Because concepts in relational understanding can be more easily retained, material does not have to be re-taught. The satisfaction from learning by relational understanding encourages students to seek out more material and new areas to explore. This is an intrinsic motivation. Oldfather & Dahl (1994) call this a continuing impulse to learn (CIL), defining it as “An ongoing engagement in learning that is propelled and focused by thought and feeling from the processes of constructing meaning. CIL is characterized by intense involvement, curiosity, and a search for understanding as learners experience learning as a deeply personal and continuing agenda” (p.142).

Research (Payne, 1993) has shown that all learning is an active process where new information is tied to our background knowledge. Relationships are the key basis for our learning. We connect new information to what we already know or we realize that a connection exists between two isolated parts information that we already knew. Procedures learned with understanding of the relationships involved are easier to remember. They transfer well to other problems because we understand why the procedure works and we see how it could be used in another situation.

According to the National Council of Teachers of Mathematics (1989), students do not automatically connect procedures with concepts, so teachers must make special efforts to develop the understanding of the concept and to connect it to the procedure that has been introduced. Developing the understanding of the concepts across different contexts helps to make these connections. For instance, developing the understanding of one-to-one correspondence through many different types of activities will insure that students use it in a variety of settings with different problems. They will be more likely to use it in a new situation. Similarly, Reehm & Long (1996) believe that the best place for students to learn the necessary reading skills to understand mathematical problems and to read mathematics texts is in the mathematics classroom because of the level of conceptual knowledge needed. Schell (1982) also believes that reading must be integrated in the content area, stating that “Reading is a process necessary to all subjects at all levels and must be integrated with course content” (p. 544). Many studies have shown that strategies taught in reading class do not readily transfer to content reading materials. Reading and mathematical skills must be integrated and applied in order for students to successfully solve problems (Henrichs & Sisson, 1980; Muth, 1984, 1986; Schell, 1982).

As children grow in both their informal and formal mathematics, they gain agility in reasoning mathematically. They learn to defend their thinking within the classroom discourse with peers and with teachers.

The roles of reasoning, problem-solving and defense. “At this level (K-4), mathematical reasoning should involve the kind of informal thinking, conjecturing, and validating that helps children to see that mathematics makes sense…Children should be encouraged to justify their solutions, thinking processes, and conjectures in a variety of ways” (NCTM, 1989, p. 29). The most recent standards (NCTM, 2000) stress that thinking clearly and “checking new ideas against what they already know” (p.137) as major goals for students in grades K-2. Being able to recognize patterns and being able to classify are the two areas that are essential in order to develop reasoning power at this age. Both recognition of patterns and classification are heavily dependent on language in the expression of children's reasoning in spoken, written, and visual forms.

According to the National Council of Teachers of Mathematics (NCTM, 1989), the main focus of mathematics instruction should be problem solving. It should provide the context in which all mathematical learning takes place. The standards for the year 2000 (NCTM, 2000) define problem solving as identifying and using current understanding to change strategies so that they can be used effectively in a new situation. "Classrooms with a problem-solving orientation are permeated by thought-provoking questions, speculations, investigations, and explorations (NCTM, 1989, p. 23)". All of these are heavily dependent on the use of spoken, written or drawn representations of language.

"Understanding learning as a process of individual and social construction gives teachers a conceptual framework with which to understand the learning of their students" (Simon, 1995, p. 117). The constructivist viewpoint emphasizes that students learn by meaning-making. Communication is essentially a meaning-making or a meaning-understanding enterprise (Schulte, 1996). The use of the constructivist philosophy in constructing solutions to problems in mathematics literacy seems an appropriate fit. Some of the essentials of constructivist learning are that children learn by active participation and through collaboration with others. Students are at different levels of understanding and can clarify their ideas by sharing them with each other and with the teacher (Schulte, 1996). Children need to hypothesize, predict, manipulate objects, pose questions, research answers, imagine, investigate, and invent. In order for learning strategies to be one with the theory of constructivism, they must be compatible with teaching for understanding which “is one of hallmarks of current reform efforts in teacher education” (Eisenhart, Borko, Underhill, Brown, Jones, & Agard, 1992, p. 8).

Mathematical ideas are usually presented in five different ways (Payne, 1993): (a) through the child’s real life experiences, (b) with physical manipulatives, (c) through spoken and written language, (d) through the use of pictures, and (e) through symbols. New ideas should be presented initially through real life experiences. Because it is the child who does the learning, possesses the information and builds on it, it should be the child who does the talking and explaining. To be developmentally appropriate, informal mathematics should be taught with an integrated approach utilizing all areas of growth; physical, emotional, social, and cognitive. The base curriculum should be built around the teacher’s observations of each child’s special interests and progress in development.

The mathematics that teachers present in the classroom should be reflective of the children’s experiences and developmental progress (Baroody, 1987). Learning as an interactive process demands learning situations that involve active exploration, interaction with adults and other children and hands-on interaction with the materials. These math activities and materials need to be real, concrete and based on the experiences of the young children that are being taught. They should stretch the children toward a wider range of interests and abilities. Teachers provide the scaffolding for the students to reach the next level of development, increasing the difficulty and complexity once that level is reached. Assessment should be an integral part of the activities (Payne, 1993).

Number sense. Helping children to understand how numbers make sense is as essential element in building mathematical literacy. This idea is directly tied to the use of constructivist theory in the work of Sowder and Schappelle (1994). Sowder and Schappelle (1994) have identified four common elements in reviewing the research literature about "classrooms wherein children acquire good number sense" (p. 342). Reys (1992) defines number sense in the following way:

> Number sense refers to an intuitive feeling for numbers and their various uses and interpretations; an appreciation for various levels of accuracy when figuring; the ability to detect arithmetical errors, and a common-sense approach to using numbers. Number sense is not a finite entity that a student either has or doesn't have…Above all, number sense is characterized by a desire to make sense of numerical situations (Reys, 1992, pp. 3-4).

In their description of a constructivist reform classroom, Sowder and Schappelle (1994) tie the elements that promote number sense to constructivist theory by their inclusion of Vygotsky's (1978) zone of proximal development. The elements are the following:

1. Sense-making is emphasized in all aspects of mathematical learning and instruction…
2. The classroom climate is conducive to sense-making. Open discussion occurs both in small groups and with the class as a whole…
3. Mathematics is viewed as the shared learning of an intellectual practice. Thus it is more than simply the acquisition of skills and information. Children learn

how to make and defend mathematical conjectures, how to reason mathematically, and what it means to solve a problem.

4. Children learn more mathematics than they do in more traditional classroom settings. Vygotsky (1978) speaks of the zone of proximal development as a place in the learning process where a child is just ready to learn something, and interacting with peers and other people help the child reach the next level of understanding. When children are operating at the edge of their understanding, they can learn more than when they lack this challenge. (p. 342)

In Kamii (2000), teachers are urged to foster the development of number sense through encouraging children in the following ways:

1. The creation of all kinds of relationships

   Encourage the child to be alert and to put all kinds of objects, events, and actions into all kinds of relationships.

2. The quantification of objects

   a. Encourage the child to think about number and quantities of objects when these are meaningful to him.

   b. Encourage the child to quantify objects logically and to compare sets (rather than encouraging him to count).

   c. Encourage the child to make sets with movable objects.

3. Social interaction with peers and teachers

   a. Encourage the child to exchange ideas with his peers.

b. Figure out how the child is thinking, and intervene according to what seems to be going on in his head (p. 27).

Perhaps the most challenging part of this approach to informal mathematics involves creating questions that will stimulate students to make connections and to think through the problem situations with which they are presented.

According to the National Council of Teachers of Mathematics (NCTM, 1989), evidence of children's number sense can be seen in: (a) their understanding of number meanings, (b) their knowledge of multiple relationships between numbers, (c) their knowledge of the relative magnitudes of numbers, (d) their understanding of the effect of operations on numbers, and (e) their ability to informally measure familiar objects in their environment. Young children's ability to understand number should not be underestimated (NCTM, 2000). Number sense is gained through young children's communication with students and teachers in the classroom. Communication about mathematical thinking makes that thinking observable which helps children to grow in their understanding.

Discourse in the mathematics classroom. According to the Professional Standards of the National Council of Teachers of Mathematics (NCTM, 1991):

> The discourse of a classroom—the ways of representing, thinking, talking, agreeing and disagreeing—is central to what students learn about mathematics as a domain of human inquiry with characteristic ways of knowing. Discourse is both the way ideas are exchanged and what the ideas entail…The discourse is shaped by the tasks in which students engage and the nature of the learning environment; it also influences them (p. 34).

In the mathematics classroom, one of the essential roles of the teacher is to structure classroom discourse so that students learn to talk with each other as well as answer the teacher's questions and comments. Mathematical reasoning, ideas, and knowledge in the classroom are part of collaboration within an intellectual community. Teaching for understanding demands that the students provide scaffolding for each other's knowledge as ideas are exchanged. Mathematical reasoning and evidence rather than the power of the teacher is the source of right and wrong. "In order for students to develop the ability to formulate problems, to explore, conjecture, and reason logically, to evaluate whether something makes sense, classroom discourse must be founded on mathematical evidence" (NCTM, 1991, p. 34). Writing is an essential part of the mathematics classroom discourse and students need within that context to learn formal tools of mathematical discourse: the special symbols, unique terms, visual representations, physical models, graphs, and diagrams.

It is also the teacher's role to foster student learning within a culture that can favor some students over others. "Engaging every student in the discourse of the class requires considerable skill as well as an appreciation of, and respect for, students' diversity (NCTM, 1991, p. 34).

According to NCTM (1991), the teacher of mathematics should orchestrate discourse by

1. posing questions and tasks that elicit, engage, and challenge each student's thinking;
2. listening carefully to students' ideas;

3. asking students to clarify and justify their ideas orally and in writing;
4. deciding what to pursue in depth from among the ideas that students bring up during a discussion;
5. deciding when and how to attach mathematical notation and language to students' ideas;
6. deciding when to provide information, when to clarify and issue, when to model, when to lead, and when to let a student struggle with a difficulty; and
7. monitoring students' participation in discussions and deciding when and how to encourage each student to participate (p. 35).

Students also need to assume different roles than many of them are used to in traditional mathematics classrooms. Students have often been passive, trying to learn or memorize procedures that often had little meaning to them. The National Council of Teachers of Mathematics (1991) has established expectations for teachers to foster this change in students' discourse. The teacher of mathematics should promote classroom discourse in which students:

1. listen to, respond to, and question the teacher and one another;
2. use a variety of tools to reason, make connections, solve problems, and communicate;
3. initiate problems and questions
4. make conjectures and present solutions;
5. explore examples and counter examples to investigate a conjecture;

6. try to convince themselves and one another of the validity of particular representations, solutions, conjectures, and answers; and
7. rely on mathematical evidence and argument to determine validity (p. 45).

Mathematical literacy in the new global economy calls for expanded and multiple tools that will help students to “construe meaning in any of the forms used to create and convey meaning” (Eisner, 1991, p. 120). Teachers of mathematics should encourage students to use:

1. computers, calculators, and other technology;
2. concrete materials used as models;
3. pictures, diagrams, tables, and graphs;
4. invented and conventional terms and symbols;
5. metaphors, analogies, and stories;
6. written hypotheses, explanations, and arguments; and
7. oral presentations and dramatizations. (NCTM, 1991, p. 53).

Throughout the mathematics class, the teacher needs to make sure that each student is learning sound mathematical ideas and understandings and that each student is developing a positive attitude towards mathematics and their abilities to do the mathematics presented. The effects of the assignments, discourse and learning environment must be examined and altered if necessary. Plans need to be made and adapted based on the teacher’s evaluation of the student’s understandings. Feedback needs to be given to the students, parents, and school officials. Teachers also need to assess their teaching to insure that problem solving, reasoning, and communication abilities are being modeled by them and developed by their students. A teacher should be able to provide evidence that he/she “engages student in mathematical discourse that extends their understanding of problem solving and their capacity to reason and communicate mathematically” (NCTM, 1991, p. 95).

The learning environment should show evidence that the teacher:

1. conveys the notion that mathematics is a subject to be explored and created both individually and in collaboration with others;
2. respects students and their ideas and encourages curiosity and spontaneity;
3. encourages students to draw and validate their own conclusions;
4. selects tasks that allow students to construct new meaning by building on and extending their prior knowledge;
5. makes appropriate use of available resources;
6. respects and responds to students’ diverse interests and linguistic, cultural, and socioeconomic backgrounds in designing mathematical tasks; and
7. affirms and encourages full participation and continued study of mathematics by all students (NCTM, 1991, p. 115).

Observing the Carefully Crafted Environment

As we examine the environment that NCTM (1991) recommends for instruction in a mathematics classroom, we cannot help but be reminded of the environment that John Dewey recommended at the turn of the twentieth century. In order for children to experience an educative environment, they must take part in joint activity with others in the environment. The learning that sustains social life cannot be conveyed directly. Beliefs, emotions, and knowledge are conveyed through the environments in which students experience learning. These environments are educative in the ways in which the student takes part in joint activity with others in the environment. The complexity of our modern society necessitates a carefully crafted environment in which children are nurtured as they learn through these joint activities.

This chapter has discussed the theory that underlies the study of the contextual, academic, and social/cultural factors that influence students' mathematical literacy development (this carefully crafted environment in which children are educated) at the crucial junction between informal and formal mathematics study and between informal and formal academic discourse.

I began in the first section of this literature review by discussing the new goals in mathematical literacy and their historical and socio-cultural foundations. Current constructivist learning theory was explored in detail because it informs the building of that carefully crafted environment for student learning. Theories of constructivist learning were critiqued as to how each of them can fulfill the new literacy goals proposed in the reform effort. Issues of implicit versus explicit teaching of cultural capital were discussed. Issues in kindergarten curricula were then explored from a historical and from a current perspective. In the next section of this review of literature, I discussed language development and discourse with young children and how they shape the needs and strengths of a constructivist reform kindergarten. The final section discussed the interrelationships between mathematics and literacy, highlighting the directives of the communication standard from the National Council of Teachers of Mathematics (NCTM, 1989, 2000) and the Professional Standards (1991) that address mathematical discourse in the classroom.

In the next chapter, I will discuss how the research was conducted and how it provides the framework or lenses through which we can view an actual classroom in order to further our understanding of how this type of environment can effect pedagogical change. In addition, the research will show us how these lenses can inform us of daily details of the contextual, academic, and social/cultural factors that influence students' mathematical literacy development at the crucial junction between informal and formal mathematics study and between informal and formal academic discourse.

Chapter 3

Methods

Introduction

This chapter will discuss the methods used in this study of the contextual, social, and academic factors that influence kindergarten students' mathematical literacy development in a constructivist reform classroom. The purposes for this ethnographic case study are directly supported by Wilkinson and Silliman's (2000) challenge to explore "…how instructional conversations are actually used in literacy instruction" (p. 353). This study centered on the classroom interactions in an integrated kindergarten program and highlights the perspective of the teacher-researcher, Victoria (a pseudonym), and her perceptions of and reflections on that classroom interaction. The choice of an ethnographic case study is supported by Erickson (1986) who emphasized that the central concerns of qualitative classroom research are:

> (a) the nature of classroom as socially and culturally organized environments for learning, (b) the nature of teaching as one, *but only one,* aspect of the reflexive learning environment, and (c) the nature (and content) of the meaning-perspective of teacher and learner as intrinsic to the educational process. (p.120)

He posits that the interpretive approaches are more appropriate for study of the constructivist classroom than traditional approaches. "The theoretical conceptions that define the primary phenomena of interest in the interpretive study of teaching are very different from those that underlie the earlier mainstream approaches to the study of teaching” (p. 120).

This ethnographic case study focused on the factors that influence the mathematical literacy development of kindergarten students in a constructivist reform classroom. It was a collaborative study with the kindergarten teacher taking the role of teacher-researcher. In keeping with the tradition of ethnographic study, the university researcher is often referred to in the first person. “Writing in the first person singular fits the nature of qualitative inquiry” (Glesne & Peskin, 1992, p. 167). Data were collected through interviewing of the teacher, an examination of curricular materials including the two curricular packages in use in the classroom (Baratta-Lorton (1995); Russell, Tierney, Mokros , & Economopoulos (1995), a review of students’ documents and reports, and participant-observation of the daily classroom routine by the university researcher, as well as with information gathered by the teacher-researcher. At each step of the process the teacher-researcher was an active partner in the process.

Design

A major premise of this study is that constructivist classrooms offer potential for enhancing mathematical literacies and should be observed in order to understand how and if they provide exemplary learning environments. The ethnographic research process was chosen because, as Wiersma (2000) described it: It is “the process of providing holistic and scientific descriptions of educational systems, processes, and phenomena within their specific contexts” (p. 249). This process allowed the researcher to holistically observe these constructivist kindergarten environments and to describe the educational processes that occur within them.

Because it is a study bounded by time and space that “has interrelated parts that form a whole” (Creswell, 1998, p. 249), the case study form of qualitative research was chosen. Creswell (1998) differentiates between an ethnographic study and a case study. The case study is “much more circumscribed than that of an ethnography. It does not study the entire culture of a group but one case or example of it” (p. 114). Time and expense limited the resources available for a full ethnographic study and the study of one classroom and teacher can begin to inform us of the directions needed for future study. The research extended over a semester of the school year but also drew on an earlier pilot study. The development of mathematics literacy is a complex issue dependent on many interrelated factors within the kindergarten classroom and can best be explored using the case study method.

This was a collaborative study with the kindergarten teacher taking the role of teacher-researcher. This teacher was selected because of her reputation as an exemplary reform teacher within the education community, her self-reported constructivist viewpoint, and her willingness to take part in the study. O’Brien, Stewart, and Moje, (1995) stress that literacy researchers need to become better informed about the pedagogy, curriculum, and culture of schools from an insider’s perspective. Strategies should be developed with knowledge of the discourse of the subject area. This should be paired with an examination of how literacy and the institutionalized forms of knowledge and teacher practices change. This research can best be done in a collaborative effort with teachers and other stakeholders in the education of students.

Procedures

The procedures used in this study were drawn from the qualitative research design for a case study. The case study involved the exploration of a “case over time through detailed, in-depth data collection involving multiple sources of information rich in context…Multiple sources of information include observations, interviews, audio-visual material, documents and reports” (Creswell, 1997, p. 61). It was a collaborative study with the kindergarten teacher taking the roles of teacher-researcher. The site, the teacher-researcher, and the students were chosen with purposeful sampling. The site and its staff have been involved in constructivist teaching for over thirty years.

Site. The site was a kindergarten classroom in what had been a progressive education school since the 1960’s. It was located in a rapidly growing suburban area. The school system had five elementary schools, one junior high, and one high school. All schools were North Central accredited. The faculty and administration identified their school as having a long history of multi-age classrooms, team teaching and differentiated instruction for over 600 students in grades K through 6.

In most classes, two teachers team taught forty to fifty children. In the primary and upper grades, most of the classrooms or pods were multi-age. The two kindergarten classes were taught separately within the same large room. Planning and some activities were team efforts between the two kindergarten teachers. These teachers identified themselves as constructivist teachers. This site was selected because of its long tradition of teaching from a constructivist viewpoint. I have been involved in many discussions with the teachers about their philosophies of teaching over the years and the staff has expressed this philosophy at parent and school meetings.

Students. The predominant socioeconomic status of the students was Middle to Upper-Middle Class although mobile homes and other low income housing was also present in the area served by London Elementary. Before the recent expansion of new housing, the majority of families were dependent on jobs in the automotive industry. Despite the economic diversity, students were generally descendants of immigrants from Eastern and Northern Europe. Students were protected by the use of pseudonyms, composite pictures, and the emphasis on the perspectives of the teacher-researcher.

Teacher-researcher. The teacher-researcher was chosen because of her extensive experience in teaching kindergarten. She had a reputation as an excellent reform teacher. Many of her former students noted that if they had had more teachers like her, there would be no limit to how far they could have gone in their learning.

Victoria's knowledge of and attitude toward the importance of the application of research in education made her a unique contributor as a teacher- researcher. Selections from her interviews match each area of the review of literature. Her comments and input as co-researcher guided the selection of areas for the review of literature. Her constructivist philosophy and her interest and ability to be involved with the study as a teacher-researcher were also extremely important to the study. She had extensive coursework in early childhood education and has taught early childhood education courses at the university level. She was recommended by the school principal and has been involved extensively in conducting teacher professional development within the area. The teacher-researcher has been known to the university researcher for close to twenty-five years. She has been involved with the research at every step and has had opportunities to read and review for accuracy and suitability any of the writings that have come from this research.

Personal notes on the teacher-researcher. The teacher that I have observed is an exemplary teacher who has been a role model to me for my own teaching. My real learning as an educator began when my own children attended London Elementary and I worked as a parent volunteer and later as a substitute teacher. Victoria was one of the forces behind my becoming a teacher. As such I thought of her when I became interested in the discourse and literacy and its relationship to elementary mathematics. I knew that Victoria somehow infused her whole curriculum with math and science without slighting the language arts. I was curious to see how she does it. I focused in my site visits on math learning, questioning, and communication in the classroom. When viewed this way her program is so math rich that it permeates almost all of the activities.

I felt extremely comfortable in observing Victoria because I have been an observer of her teaching ever so often through the last twelve years. When I was stressed with my own teaching, I have just stopped in her room for the joy of it. I have always come away with a fresh perspective. Working with children in her classroom, today, I realized how much I miss being in the classroom.

This familiarity with the classroom could be considered a *subjective I*. The *subjective I* is the collective term for the personal perspective and relationships that are possible problem areas of subjectivity for the researcher and should be clearly indicated in the report of a research study (Glesne & Peshkin, 1992). My role as a university methods instructor is another *subjective I*. The student teacher was very aware of whom I am and the lead teacher, Mary Ann, was interested in whether I was in the building in that role. In my role as a former elementary teacher, I was very tempted to jump in with my own teaching agenda and purposely chose the role of interested listener instead. This is another *subjective I*.

University researcher and her role in the classroom. As university researcher I observed the interactions of the students and the teacher in the classroom in a naturalistic setting in order to record indications of the contextual, social, and academic factors that influence kindergarten students' mathematical literacy development. I used audio recordings, participant-observation, and field notes to record these interactions. My involvement in the classroom was restricted to that of a participant-observer. No experimental treatment was used. Alteration of the teacher-researcher's typical teaching approach or teaching environment was not requested or expected. The children's, teachers' and school's identities will continue to be kept confidential through the use of pseudonyms.

One of the strengths of the interpretive approach of ethnographic case study is the naturalness of the setting in which teaching and learning are studied. Some critics (Wiersma, 1994) are concerned about the effect of the researcher on the naturalness of the setting. This can be addressed in part by the culture of the classroom under study. Students in this setting are accustomed to interacting with many adults within their classroom. During this study, I was treated by the students as just another helping adult within the classroom.

My biases include the relationship with the teacher researcher whom I have known for twenty-five years, my relationship with the school where my children attended and my role as university educator whose students are placed for fieldwork in this school and with this teacher. These personal biases, however, also allow me to more easily understand the viewpoint and philosophies of the insider perspective. This relationship has also facilitated access to the site for research

Site access. Access to the site was facilitated by the long time relationship between the teacher-researcher and me. Victoria seemed excited by the possibilities of working with me on this study. She stated that it would give her someone to “roll things around with.” I was very aware however that as a participant-observer in her classroom, I would not be taking the role of a co-teacher but rather that of an adult-helper. She would remain the main facilitator and planner of educational events in her classroom.

The principal of the school knew me as both the parent of four children who had attended the school and as a university supervisor for mathematics methods classes. He was enthusiastic in offering any assistance that he could. He stated that he was dedicated to research in the classroom. Letters were given to the principal, the teachers of both kindergartens, and sent to each of the parents of children in the two kindergarten classrooms explaining the proposed study and seeking permission under the rules of the university human subjects committee. All parties were assured in writing that participation or non-participation would have no effect on the relationship between the university and the school or on the child’s placement or grades in the school.

Assumptions

This study was of a social-constructivist reform kindergarten and as such presumes a social constructivist philosophy of learning and teaching which has been further delineated by the work of Salomon and Perkins (1998), writing on spiral learning reciprocity and Wilkinson and Silliman (2000), writing on developments in research on classroom language and literacy learning as discussed in the review of literature in Chapter 2. Essential to the understanding of the assumptions of this study is an understanding of the principles of a kindergarten curriculum based on developmentally appropriate practice, the socio-cultural issues affecting best practices in early childhood education and the perspectives of reform mathematics which stresses teaching for understanding as opposed to the “banking model” discussed by Freire (1970). Each of these philosophical bases was delineated in the review of literature in Chapter 2.

The use of an ethnographic case study restricted the generalizabilty of this study. It described the case of a single teacher and her interactions with two classrooms over a limited time span. While this study included a range of students, socio-economically, it included a limited number of students from diverse ethnic and racial backgrounds. The research is not directly transferable to other classroom but can indicate some beginning answers to the research questions within one constructivist classroom and give guidance to possibilities for further study.

The researcher’s biases include the relationship with the teacher researcher whom she had known for twenty years, her relationship with the school where her children attended and her role as university educator whose student’s were placed for fieldwork in this school and with this teacher. These personal biases, however, also allow the researcher to more easily understand the viewpoint and philosophies of the insider perspective. This relationship also facilitated access to the site for research.

One of the strengths of the interpretive approach of ethnographic case study is the naturalness of the setting in which teaching and learning are studied. Some critics (Wiersma, 1994) are concerned about the effect of the researcher on the naturalness of the setting. This can be addressed in part by the culture of the classroom under study. Students in this setting were accustomed to interacting with many adults within their classroom. During this study, the university researcher was treated by the students as just another helping adult within the classroom.

Validity and Reliability

Validity and reliability in a qualitative study are different from that of a quantitative study (Wiersma, 1995). “Validity of qualitative research for the most part is established on a logical basis and providing an argument for validity requires well-documented research and a comprehensive description” (p. 223). The following discussion of validity in a qualitative study draws on the literature in the field of qualitative research and indicates the logical basis and comprehensive description of the research that is addressed in this study.

Marshall and Rossman (1994) discuss the elements that must be present for all research to be considered valuable. They view these elements in light of two larger domains: “responding to criteria for soundness of the project; and demonstrating the usefulness of the proposed work to the conceptual framework and research questions initially proposed” (p. 142). The latter has been addressed in the needs section of this research.

The trustworthiness or soundness of the project can addressed through the answers to four questions:

1. How can we be reasonably sure that the findings would be replicated if the study were conducted with the same participants in the same context? [dependability]

2. How transferable and applicable are these findings to another group of people? [tranferability]

3.How credible are the particular findings of the study? By what criteria can we judge them? [credibility]

4. How can we be sure that the findings are reflective of the subjects [participants] and the inquiry itself rather than a creation of the researcher's biases or prejudices? (Marshall & Rossman, 1994, p. 143). [confirmability]

How can we be reasonably sure that the findings would be replicated if the study were conducted with the same participants in the same context? The first question deals with dependability which Marshall and Rossman (1994) contrast with the quantitative concept of reliability, which assumes a constant universe where replication is possible. Qualitative research is based on the assumption that the social world is always being constructed and is therefore always changing. These changing conditions and the qualitative design which is continually changed in response to the refinement of understanding of the events under study prevent qualitative study from meeting the reliability criteria of quantitative research but provide for a standard of dependability. Wiersma (2000) emphasizes the role of "a well-organized, complete persuasive presentation of procedures and results" (p. 222) in providing external reliability in qualitative research. This is provided in the research report. Wiersma (2000) also suggests that internal reliability which he defines as "consistency in the research process" (p. 222) can be provided through the proper training of multiple observers. This study utilized the teacher researcher as well as the university researcher, providing for multiple observers.

How transferable and applicable are these findings to another group of people? The second question of Marshall and Rossman (1994) addresses the generalizability or transferability of the study. Its external validity is dependent upon this area and is considered by many in the research field to be a weakness of qualitative research (Marshall & Rossman, 1994). Wiersma (2000) posits that the position of most writers is that qualitative research is generalizable with qualifications.

External validity in qualitative research is more concerned with the "…comparability and the translatability of the research. Comparability refers to the extent to which the characteristics of the research are described so that other researchers may use the results to extend knowledge. Translatability refers to the extent to which theoretical constructs and research procedures are used so that other researchers can understand the results" (Wiersma, 1995, p. 223).

The extensive descriptive research report addresses the issue of comparability. Marshall and Rossman (1994) suggest the use of the theoretical underpinnings to support the generalizability of qualitative research to other populations and settings. "To counter challenges the researcher can refer to the original theoretical framework to show how data collection and analysis will be guided by concepts and models (p. 144). Data collection and analysis of this study were based in the theory and writings of the reform mathematics literature. The variables chosen have come from the writings of the National Council of Teachers of Mathematics (1989,1998) and other experts in the field (e.g., Baroody 1987; Reys, 1992; Sowder & Schappelle, 1994; etc.). The use of triangulation with four sources of data and the collaboration with the teacher-researchers also provided strength to the generalizability of this study. Erickson (1986) suggests that researchers should be looking for patterns of generalizability within the case study itself rather than looking for ways that a study is generalizable to other studies. So internal validity is more important from this perspective.

Wiersma (2000) stresses that internal validity in a qualitative study "involves the interpretation of research results with confidence" (p. 272). He discusses the naturalness of the setting and the need for controlling the effect of the observer on that setting. He also posits "the naturalness of the data enhances the validity" (p. 274). Internal validity is described by Marshall and Rossman (1994) in terms of credibility and confirmability.

How credible are the particular findings of the study? In answer to the third Marshall and Rossman (1994) question, the in-depth description of the setting, the participants, and the complexities of the interactions and variables within the setting will provide a rich data base that will demonstrate the validity of this research study. Extensive quotation from this database will provide credibility for the findings of the researcher. This fits well with Wiersma's (1995) view that validity in ethnographic studies flows from the naturalness of the setting. Erickson (1986) approaches the question of validity from assertions about the patterns found in events of the study. "In conducting such analysis and reporting it, the researcher's aim is not proof, in a causal sense, but the demonstration of plausibility…" (p. 149).

How can we be sure that the findings are reflective of the subjects [participants]and the inquiry itself rather than a creation of the researcher's biases or prejudices? The fourth question of Marshall and Rossman (1994) deals with the issue of confirmability. Can the findings of this study be confirmed by another study? This issue touches on the question of the subjectivity of the researcher and is therefore a question of internal validity. One of the advantages of a participant-observer approach is that the researcher enters into the world of her/his informants and is able to describe the complex system of social interactions. This provided the researcher with more of an insider's view of the situation being studied, helping to validate his/her findings. This same advantage can be construed as a situation that might encourage bias in the researchers reporting of data and so must be balanced with controls. Use of collaborative teacher-researcher provides an insider who can challenge the interpretations of the researcher. A constant check for rival hypotheses or negative instances also provides control. The use of value-free note taking with separate personal and analytical notes provides a more unbiased approach.

Erickson (1986) suggests a combination of participant observation with use of audio recordings and/or videos recordings. This is the approach that was used in this study. Video and audio recordings (microethnography) provide capacity for completeness of analysis. The video and audio recordings can be replayed and analyzed through a number of different analytical lenses. At the same time, the contextual information is not available when only using recordings. Erickson (1986) suggests a combination of both techniques. "Both limitations of microethnography—the absence of participation as a means of learning, and the absence of contextual information beyond the frame of the recording—can be overcome by combining regular ethnography with microethnographyy (p. 145)."

Data Collection

Data used in this study are described in Table 3.1. The first section of data was gathered in the form of audio recordings of teacher interviews and written notes of participant-observation in a pilot study conducted during the 1997-1998 school year. The second section of data was gathered in a semester long participant-observation with audio recordings during 2000. Field notes (descriptive, analytical and personal) were taken. Students' work and curriculum documents were also gathered. Formal interviews of the teacher-researcher and her student teacher were conducted several times during the study.

Table 3.1. Summary of Data Sources

Type of Data	Description of Data Pool	Dates of Data Collection	Number of Data
Time Spent Observing Classroom	Field notes and audiotapes	See Field notes and audiotapes	62 hours
Time Spent Conferring with Victoria	Formal and informal dialogue	8/98 through 5/02	At least 126 hours
Audiotapes	Teacher and student teacher interviews and classroom interactions	10/30/98 11/99 through 5/6/00	2 tapes 32 tapes/1 hour each
Field Notes	Teacher and student teacher interviews	10/7/98 through 11/10/98 11/1/99 through 5/00	35 pages
	Classroom interactions	11/1/99 through 5/00	256 pages
	Personal field notes	10/7/98 through 5/00	105 pages
	Analytical field notes	10/7/98 through 5/00	156 pages
Documents: Mathematics Curricula	Investigations in Data, Time, and Space Math Their Way	10/98 and 11/99 through 5/00	6 teacher's manuals Beyond Arithmetic 1 teacher manual
Documents: Student Work	Class assignments and response journals	11/99 through 5/00	5 samples –one for each of 20 students
Documents: Descriptions and Pictures of Classroom Centers	Multiple learning centers which change seasonally, monthly, and sometimes weekly	10/98 through 11/98 10/99 through 5/00	16 + centers Descriptions in Field notes and in pictures

The fieldwork research for this study involved long term participation in a kindergarten classroom recording the events and interactions of the teacher, student teacher, and children. Field notes were written, audiotapes recorded, interviews conducted, and examples of student work recorded. Jotted field notes were taken during participant observation time, interviews, and directly after each of these times. These jotted notes contained three types of field notes which were color coded during word processing: (a) descriptive field notes, (b) personal field notes, and (c) analytical field notes. Descriptive field notes were collected during the participant observation time. Descriptive field notes are taken (a) of the site during early visits, (b) of physical environment changes, and (c) of situations taking place during observation. Any personal responses to the observations were separated and put into personal notes. Personal notes were also written directly after the time spent in the classroom. Personal notes are the researcher’s subjective response to the participant-observation and are used to track the researcher’s subjective reactions which affect the researcher’s perspectives on the observations. Analytical notes were composed at later time in response to the descriptive and personal notes that had been gathered as well as during and after the participant observations. They are used to clarify theoretical connections to appropriate literature and thought in the field. According to Glesne and Peshkin (1992),“Analytical noting is a type of data analysis conducted throughout the research process; its contribution ranges from problem identification, to question development, to understanding the patterns and themes in your work” (p. 47). Documents were collected ranging from student work to mathematics curricula from the two mathematics programs used by the teacher-researcher.

Data Analysis

Data Collection and data analysis in an interpretive or qualitative study is more of a spiral than a linear process. "…Data analysis inheres in the data collection phase of research" (Erickson, 1986, p. 120). Data were analyzed through the entire data collection process as analytical notes are taken by the researcher and in this study as the teacher-researcher reflected on her own teaching and on the classroom interactions. The frameworks or lenses used for analysis also developed and changed as the study progressed. An essential part of this interpretive study was to expand and develop the constructivist frameworks that were used throughout the study for the analysis of the data. These lenses were constantly being reviewed and refined as more data was collected and as data was subsequently analyzed. Elements in many of the frameworks overlap. The frameworks were developed in the six areas covered in the literature review .

The initial framework (see Table 3.2) was developed from the socio-cultural literature from individuals such as Delpit (1995), Dewey (1916), Freire (1970), and hooks (1994). The second framework (see Table 3.3) was drawn from the literature review of constructivist learning which was based on interview data from the teacher-researcher about the theory and best practices that she felt were at the foundation of her teaching. The third framework (see Table 3.4) is drawn from the professional and teaching standards of the National Council of Teachers of Mathematics (1991). This earlier document was chosen because it was used to develop the state standards on which the school district based its own curricular frameworks. The fourth framework (see Table 3.5) is drawn from the Principals and Standards for School Mathematics (NCTM, 2000) and reflects the academic standards of the reform mathematics movement. The fifth framework (see Table 3.6) is from the Curriculum and Evaluation Standards for School Mathematics (NCTM, 1989). This is included because the *Michigan Curriculum Framework* (Michigan Department of Education, 1997) which was used in this classroom is based on this version of the NCTM Standards. These initial frameworks were used to establish that this was a constructivist reform classroom and that the contextual, social, and academic factors that have been reported in the literature to be present in such a classroom were indeed present.

Table 3.2 Socio-Cultural and Learning Community Considerations

Considerations	Delpit	Dewey	Freire	hooks
1.Structuring Environment		X		X
2. Knowledge Construction/ Co-investigators	X	X	X	X
3. Role of Social Customs	X	X	X	X
4. Cultural Capital	X	X	X	
5. Banking Model		X	X	
6. Dominant Discourse	X		X	X
7. Importance of Diverse Perspectives	X	X	X	X

Table 3.3 Constructivist Learning Theory

General Category	Yaden, et al.	Salomon & Perkins	Wilkinson & Silliman	Magnusson, Palincsar & Templin	Thorp
1. Social Collaboration		Information from many sources	Invitation to participate in conversation	Teachers provide opportunities to take part in activities that mirror those of scientific communities	Collaborative activities with teachers and peers
2. Social Motivation		Conditions that sustain motivation		Scientific communities provide motivation to sustain individual inquiry	Collaborative process of inquiry is motivating
3. Social Dialogue	Adult and peer mediated dialogue	Information from many sources	Invitation to participate in conversation	Scientific communities provide opportunities for communication to sustain	Dialogue through instructional conversations
				Mediate everyday conversational discourse, intersection between everyday and scientific	
4. Social Scaffolding		Guidance	Direct explanation and re-explanation	Scientific communities provide opportunities for structures that sustain individual inquiry	Competence in instructional language--goal
		Explicit modeled behavior	Explicit modeled behavior	Social context actively facilitates individual cognition	Culturally-meaningful experience assist in transfer to other settings
		Feedback	Verifying and clarifying student behavior	Support students in the articulation of their ideas by revoicing and seeding	
5. Individual Challenge	Allow to experiment without duress	Neither too easy or too hard	Opportunity to practice unconventional yet emerging skills		Individual differences respected/different routes, different rates
6. Self-Scaffolding	Able to combine, recombine, or refine range of representations or behaviors	Self-regulated guidance			Internal Feedback

Table 3.4 Kindergarten Curriculum Considerations

Considerations	**Progressive School Movement**	**British Infant School**	**Developmental-Interaction Model**
1. Child-Centered	X	X	X
2. Development of whole child	X	X	X
3. Play as a mode of thinking and symbolic representation		X	X
4. Process oriented	X		X
5. Experience centered	X	X	X
6. Scaffolding			X
7. Importance of environment	X	X	X
8. Collaboration	X	X	X

Table 3.5 NCTM (1991) Professional Discourse Standards for Teachers

Social Categories	Teacher's Roles	Student's Roles	Discourse Tools	Learning Environment
1. Social Collaboration	Listening to student ideas	Listen to, respond to, and question the teacher and one another		Conveys that mathematics is to be explored and created in collaboration
		Initiate problems and questions		Affirms and encourages full participation
2. Social Motivation	Monitoring students' participation and deciding when and how to encourage each student to participate			Affirms and encourages full participation and continued study of mathematics by all students
3. Social Dialogue	Listening to student ideas	Use a variety of tools to communicate	Invented and conventional terms and symbols	
		Listen to, respond to, and question the teacher and one another	Metaphors, analogies, and stories	
		Make conjectures and present solutions	Written hypotheses, explanations, and arguments	
			Oral presentations and dramatizations	
4. Social Scaffolding	Asking students to clarify and justify their ideas orally and in writing	Try to convince one another of the validity of particular representations, solutions, conjectures, and answers	Computers, calculators and other technology	Selects tasks that allow students to construct new meaning by building on and extending prior knowledge
	Deciding what to pursue in depth from student's ideas	Initiate problems and questions	Metaphors, analogies, and stories	
	Deciding when and how to attach mathematical notation and language to student's ideas		Written hypotheses, explanations, and arguments	

Table 3.5 NCTM (1991) Professional Discourse Standards for Teachers Cont.

Social Categories	Teacher's Roles	Student's Roles	Discourse Tools	Learning Environment
	Deciding when to provide information, when to clarify an issue, when to model, when to lead		Oral presentations and dramatizations	
5. Individual Challenge	Posing questions and tasks that elicit, engage, and challenge each student's thinking	Make conjectures and present solutions		Conveys that mathematics is to be explored and created individually
	Deciding when to let a student struggle with a difficulty			Respects students and their ideas and encourages curiosity and spontaneity
				Respects and responds to students' diverse interests and linguistic, cultural, and socioeconomic backgrounds
6. Self-Scaffolding		Use a variety of tools to reason, make connections, and solve problems	Computers, calculators and other technology	Encourage students to draw and validate their own conclusions
		Explore examples and counter examples to investigate a conjecture	Concrete materials used as models	Selects tasks that allow students to construct new meaning by building on and extending prior knowledge
		Try to convince themselves of the validity of particular representations, solutions, conjectures, and answers	Pictures, diagrams, tables, and graphs	
		Rely on mathematical evidence and argument to determine validity		

Table 3.6 Language Development

Topics	Goldin & Shteingold	Piaget	Vygotsky	Nelson & Gruendel	Hicks	Halliday	Markman Hutchinson	Whitin & Whitin
1.Representational	Representational systems	Referential or representational use				Representational Model		
2.Individualization			Gradual individualization			Personal Model		
3.Meaning through social usage			Zone of proximal development	More social than previously thought	Social meaning construction	Interactional Model Heuristic Model		
4.Cognitive resource	Understanding mathematical relationships	Representational	Inner speech			Representational Model	Language influence on gaining categories	
5.Scripts				General rules of conversation	Contexts and discursive practices			
6.Complexities	metaphor		Structure and function of egocentric speech			Models of Language	Taxonomic vs. thematic	metaphor
7.Discourse as a mediator of learning			Zone of proximal development		Discourse as a mediator of learning	Heuristic Model		
8.Cultural Differences or the basis for cultural differences effect on language development					Linguistic form and social communication practices		Language influence on gaining categories	Metaphor allows students to draw on background
9.Means of getting things done						Instrumental Model		
10. Regulate behavior of others						Regulatory Model		
11. Create one's own environment						Imaginative Model		

Table 3.7 Principles and Standards for School Mathematics (NCTM, 2000)

Principles	**Guidance for Teacher Decisions**
1. Equity	High expectations and strong support for all students
2. Curriculum	Coherent, focused on important mathematics, and well articulated across grades
3. Teaching	Understanding what students know and need to learn and then challenging them to learn it well
4. Learning	With understanding, actively building new knowledge from experience and prior knowledge
5. Assessment	Should support learning of important mathematics and furnish important information to both teachers and students
6. Technology	Is essential in teaching and learning, influencing mathematics that is taught and enhances student learning
Standards	**Pre-Kindergarten through 12**
1. Number and Operations	• Understand numbers, ways of representing numbers, relationships among numbers, and number systems • Understand meanings of operations and how they relate to one another • Compute fluently and make reasonable estimates
2. Algebra	• Understand patterns, relations, and functions • Represent and analyze mathematical situations and structures using algebraic symbols • Use mathematical models to represent and understand quantitative relationships • Analyze change in various contexts
3. Geometry	• Analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships • Specify locations and describe spatial relationships using coordinate geometry and other representational systems • Apply transformations and use symmetry to analyze mathematical situations

Table 3.7 Principles and Standards for School Mathematics (NCTM, 2000) Cont.

Standards	**Pre-Kindergarten through 12**
4. Measurement	• Understand measurable attributes of objects and the units systems, and processes of measurement • Apply appropriate techniques, tools, and formulas to determine measurements
5. Data Analysis and Probability	• Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them • Select and use appropriate statistical methods to analyze data • Develop and evaluate inferences and predictions that are based on data • Understand and apply basic concepts of probability
6. Reasoning and Proof	• Recognize reasoning and proof as fundamental • Make and investigate mathematical conjectures • Develop and evaluate mathematical arguments and proofs • Select and use various types of reasoning and methods of proof
7. Communication	• Organize and consolidate mathematical thinking through communication • Communicate mathematical thinking coherently and clearly to peers, teachers and others • Analyze and evaluate the mathematical thinking and strategies of others • Use the language of mathematics to express mathematical ideas precisely
8. Connections	• Recognize and use connections among mathematical ideas • Understand how mathematical ideas interconnect and build on one another to produce a coherent whole • Recognize and apply mathematics in contexts outside of mathematics
9. Representation	• Create and use representations to organize, record, and communicate mathematical ideas • Select, apply, and translate among mathematical representations to solve problems • Use representations to model and interpret physical, social, and mathematical phenomena

Table 3.8 Curriculum and Evaluation Standards for School Mathematics (NCTM, 1989)

Process Standards	**Pre-Kindergarten-4**
1. Problem-Solving	• Use problem-solving approaches to investigate and understand mathematical content; • Formulate problems from everyday and mathematical situations; • Develop and apply strategies to solve a wide variety of problems; • Verify and interpret results with respect to the original problem; • Acquire confidence in using mathematics meaningfully (p.23).
2. Communication	• Relate physical materials, pictures and diagrams to mathematical ideas; • Reflect on and clarify their thinking about mathematical ideas and situations; • Relate their everyday language to mathematical language and symbols; • Realize that representing, discussing, reading, writing, and listening to mathematics are a vital part of learning and using mathematics (p. 26).
3. Reasoning	• Draw logical conclusions about mathematics; • Use models, known facts, properties, and relationships to explain their thinking; • Justify their answers and solutions processes; • Use patterns and relationships to analyze mathematical situations; • Believe that mathematics makes sense (p. 29).
4.Mathematical Connections	• Link conceptual and procedural knowledge; • Relate various representations of concepts or procedures to one another; • Recognize relationships among different topics in mathematics; • Use mathematics in other curriculum areas • Use mathematics in their daily lives (p. 32).
Content Standards	**Pre-Kindergarten-4**
5. Estimation	• Explore estimation strategies; • Recognize when an estimate is appropriate; • Determine the reasonableness of results; • Apply estimation in working with quantities, measurement, computation, and problem solving (p. 36).

Table 3.8 Curriculum and Evaluation Standards for School Mathematics (NCTM, 1989) Cont.

Content Standards	Pre-Kindergarten-4
6. Number Sense and Numeration	• Construct number meanings through real-world experiences and the use of physical materials; • Understand our numeration system by relating counting, grouping, and place-value concepts; • Develop number sense; • Interpret the multiple uses of numbers encountered in the real world (p. 38)
7. Concept of Whole Number Operations	• Develop meaning for the operations by modeling and discussing a variety of problem situations; • Relate the mathematical language and symbolism of operations to problem situations and informal language; • Recognize that a wide variety of problem structures can be represented by a single operation; • Develop an operation sense (p. 41).
8. Whole Number Computations	• Model, explain, and develop reasonable proficiency with basic facts and algorithms; • Use a variety of mental computation and estimation techniques; • Use calculators in appropriate computational situations; • Select and use computation techniques appropriate to specific problems and determine whether the results are reasonable (p. 44).
9. Geometry and Spatial Sense	• Describe, model, draw, and classify shapes; • Instigate and predict the results of combining, subdividing, and changing shapes; • Develop spatial sense; • Relate geometric ideas to number and measurement ideas; • Recognize and appreciate geometry in their world (p. 48).

Table 3.8 Curriculum and Evaluation Standards for School Mathematics (NCTM, 1989) Cont.

Content Standards	Pre-Kindergarten-4
10. Measurement	• Understand the attributes of length, capacity, weight, mass, area, volume, time, temperature, and angle; • Develop the process of measuring and concepts related to units of measurement; • Make and use estimates of measurement; • Make and use measurements in problem and everyday situation (p. 51)
11. Statistics and Probability	• Collect, organize, and describe data; • Construct, read, and interpret displays of data; • Formulate and solve problems that involve collecting and analyzing data; • Explore concepts of chance (p. 54).
12. Fractions and Decimals	• Develop concepts of fractions, mixed numbers, and decimals; • Develop number sense for fractions and decimals; • Use models to relate fractions to decimals and to fined equivalent fractions; • Use models to explore operations on fractions and decimals; Apply fractions and decimals to problem situations (p. 57).
13. Patterns and Relationships	• Recognize, describe, extend and create a wide variety of patterns; • Represent and describe mathematical relationships; Explore the use of variables and open sentences to express relationships (p. 60).

The data were initially analyzed using the seven frameworks using a multi-step iterative procedure. This procedure is summarized in Table 3.9. Raw data from the audiotapes and documents were used to create transcripts. These permanent data records were iteratively reviewed and the data were reduced. As the transcripts and documents were reviewed, segments within them were initially identified and coded according to the framework categories. These coded data were then examined for indications of how the framework categories were implemented in the classroom and data were then gathered and logged about implementation of the framework categories and the contextual, social, and academic factors relating to these framework categories that appear to influence kindergarten students' mathematical literacy development in a constructivist reform classroom.

Emergent themes and patterns were then identified and logged. New categories were discovered and created based on these themes and patterns and these were added to the frameworks in progress. Four of the most notable of these were student choice, student initiation, continuous assessment, and differentiated instruction (See Table 4.1). The results chapter was then drafted explicating the themes and patterns uncovered and selecting examples of the dialogue transcript and curricula supporting the results of the study. Points of incongruence were carefully explored and reported. The entire corpus of data was then reviewed to check the trustworthiness of the framework categories, themes, and patterns uncovered and any other points of incongruence were identified.

Table 3.9 Steps in Data Analysis

1. Raw data from the videotapes, audiotapes, and documents were used to create transcripts.
2. These permanent data records were iteratively reviewed and the data were reduced.
3. As the transcripts and documents were reviewed, segments within them were identified and coded according to the framework categories from the Constructivist Framework and from the NCTM Framework.
4. These coded data were examined for indications of how the framework categories were implemented in the classroom.
5. Data were then gathered and logged about implementation of the framework categories and the related contextual, social, and academic factors influencing mathematical literacy development.
6. Emergent themes and patterns were then identified and logged.
7. The results chapter was then drafted explicating the themes and patterns uncovered and selecting examples of the dialogue transcript and curricula supporting the results of the study.
8. Points of incongruence were carefully explored and reported.
9. The entire corpus of data was then reviewed to check the trustworthiness of the framework categories, themes, and patterns uncovered and any other points of incongruence were identified.

Example of analytical steps. In this next section, I provide an example of the data analysis process using data from an interview conducted as part of the pilot study (Table 3.10). The Pilot study was conducted the school year prior to the formal study and there appeared to be no major changes in the teacher-researcher's stance on the education of kindergarteners in her constructivist reform mathematics classroom. In this particular example, the data is an interview in which the teacher-researcher describes a walk in the woods with her class of kindergarten students who were collecting leaves to use in a sorting activity that addressed both mathematics and science objectives. It is a reflective piece.

Table 3.10. Transcript Excerpt of Interview on 10/30/98

Framework Sub-Categories	**Transcript Excerpt**
• Posing questions and tasks that elicit, engage, and challenge each student's thinking • Inviting students to initiate problems and questions • Invitation to participate in conversation • Encourage students to make conjectures and present solutions • Invented and conventional terms and symbols • Competence in instructional language	**Interviewer:** Mary Mather **Interviewee:** Teacher Researcher **Example 1.** V: I think the questioning is a real art form. MM: So do I, so do I. V: Because how do you have discursive kids? You know you need to have those kinds of questions that are not like how many legs does the dog have or what color but so that they're beginning to wonder about this. There's nothing neater than I remember when I had first graders and they wanted to know if 0 was an odd or even number. "What's your thinking on that?" Or the child that looks at number line and says: "I think every time you add two odd numbers do you get an even number?" MM: Wow! V: You mean there are seven year olds that can think like that?
• Listening to student ideas • Deciding what to pursue in depth from students' ideas	**Example 2.** MM: I noticed when I was in observing that you pick up on kids wondering. You come right out and mention "So and So" was wondering and then pull everyone into it. V: That comes from the kids, MM: So a lot of your questions you draw right out of the students and right out of the conversation that is going on. It's on your feet.
• Peer mediated dialogue • Conditions that sustain motivation	V: I think the kids are more interested if it comes from kids.
• Selects tasks that allow students to construct new meaning by building on and extending prior knowledge • Students initiate problems and questions • Asking students to clarify and justify their ideas • Conveys that mathematics is to be explored	V: When were out walking through the woods, usually we're looking down; cause we're into the sorting leaves and what kind of leaf is this? And look at this color and this one has lobes. One little boy says: "Not all come off the trees the same way." What do you mean Jerome? "Look! Some float, some spin, some do somersaults. (laugh) Now we are walking through the woods with our heads up. (laughs) MM: I wonder if anyone has done a study of that.
• Students listen to, respond to, and question one another • Using discourse tools-metaphors	V: Well, one of the kids said: "Look at this one! It's dive-bombing."
• Students use a variety of tools to reason, make connections, and solve problems • Respects students and their ideas and encourages curiosity and spontaneity	MM: And I wonder if some trees, a particular type of tree does one kind or another... V: the shape of the leaves. I know that like our little maple tree's got both sides on its stem it's going to spin like a helicopters. All of a sudden it's another way to think about classifying. I think a lot of it is that you take it from them, you make it because then it will be relevant; it will be real.

In example1from this interview, the teacher-researcher talks about an interchange between some first grade students and her that she had in an earlier year. They are discussing the number line that she uses when she teaches both kindergarten and first grade. Elsewhere in the interviews, Victoria indicated that she has had comparable conversations with her kindergarteners during the study year. Each school day a new number is written on a long adding tape strip above the blackboard where the students gather with her to do the morning calendar board. On the first day the number is written in red and on the second day the number is written in black so that the odd numbers are always in red and the even numbers are always in black. Other multiples are denoted by colored triangles (Multiples of three), squares (multiples of four), stars (multiples of five), etc. This routine is drawn from *Mathematics Their Way* (Barrata-Lorton, 1975, 1995), a curriculum program that the teacher-researcher has been using for at least twenty years). She continues to use this routine in addition to the reform–based curriculum package, *Investigations in Number, Data and Space* (Russell, Tierney, Mokros, & Ecnomopoulos, 1995) that the school district has adopted. During calendar time, various mathematical concepts are introduced and numbers are talked about in a way that encourages students' speculation and wonder about the patterns that they can find and observe. Mathematical language such as odd and even is also introduced during this time.

I examined the data from the interview for indications of what evidence there was that the categories from the seven frameworks were present and I also examined the related contextual, social and academic factors that might be observed in this incident. The concept of children's wondering was noted. Children often express their wonder. Parents of preschoolers use these opportunities for conveying information and instruction. This may be less common in a typical school environment. The Teacher-Researcher in this interview explains that she mentions "*So and so* was wondering and then pull(s) everyone into it." The teacher indicates that the children are the initiators in this instance. The idea of children's wondering and the idea of children's initiation are noted and these two ideas become part of the ongoing analysis of the data. They were both included in the final framework of contextual, social, and academic factors under the category of student initiation (See Table 4.1). They may also be related to the elements of social and individual motivation that may prove to be other critical elements in kindergarten children's development of mathematical language and concepts. One of the areas for analysis was whether a finding is an isolated instance or whether this approach is a pattern throughout the teacher-researcher's interaction with the children. An examination of the data for patterns or points of incongruence, such as the existence of a great many teacher initiated moments versus student initiated moments will be explored and reported. At the end of the analysis process, the corpus of data will be reviewed to check for the trustworthiness of the framework of categories, themes, and patterns uncovered.

In the second example in this interview, the teacher-researcher gives another example of a student initiation. The teacher and her students are walking in the woods behind the school (a mini-field trip) collecting leaves for a sorting activity in which the children classify leaves by different attributes such as color, lobes or points, size, etc. One student remarks that leaves do not fall in the same ways. Another student extends this academic discourse by using metaphor to describe the way one of the leaves falls from the tree. "It's dive-bombing." The teacher points out that this is a new way of classifying the leaves. The shape of the leaves affect the way that the leaves fall. She decided to pursue an area of inquiry initiated by a student in more depth. This is a form of social scaffolding.

This second example of student initiation supports the choice of student initiation as a motivating force. Another student is enthusiastic about her/his participation in a classification activity. The example also provides insight into student discourse. This is an informal discussion in the midst of a fieldtrip. The student who used the dive-bombing metaphor did not wait for his hand-raising to be acknowledged or for the teacher to initiate dialogue with a question about the different ways that leaves come down from trees. Taken together, these two examples begin to build evidence of patterns in the data that support some of the areas of inquiry in children's learning of mathematical language that were identified from the literature on constructivism and from the NCTM Professional Standards. Examples of classroom implementation of these frameworks can serve as classroom models that inform best practices in the classroom.

Summary

In this chapter, I discussed the methods used in this study of the contextual, social, and academic factors that influence kindergarten students' mathematical literacy development in a constructivist reform classroom. The design of the study as an ethnographic case study was explained, as was the setting and the participants. My relationship with the teacher researcher was examined for its potential challenges as well as its advantages in terms of an insider's perspective. I described the setting of the study in a suburban district outside of a city dependent on the automotive industry. The site and the student participants were described in general terms. I explained the choice of teacher researcher and described some of the issues of gaining entry and negotiating my role as a participant-observer. I discussed the issues of validity and reliability in qualitative or interpretive study. I described the process of data collection and analysis and gave an example of how the process was conducted. In the next chapter I will present the results of the ethnographic case study with a series of narratives and with a written analysis.

Chapter 4

Results

Introduction

In this chapter I will discuss each of the contextual, academic, and socio-cultural factors that we have identified in this kindergarten classroom. Some of these factors correspond with those that have been identified in the review of literature in Chapter 2 as important to the mathematics and language development of kindergarten children in a constructivist classroom. Each of the transcripts of classroom observation and each of the transcripts of teacher interviews was examined in order to determine if these factors were present in the classroom or were identified by the teacher as important in how she structured her classroom. As the research and the analysis of data progressed, other factors were identified during this iterative process. These appear in Table 4.1. The mathematics curricula and samples of the children's work were also examined for evidence of these contextual, academic, and socio-cultural factors and for evidence of other factors that had not yet been identified in the review of literature.

Description of Classroom and School Building from Jotted Notes

The following description of the classroom and building was written directly after my first participant observation in the classroom of the teacher-researcher, Victoria.

As I pulled into the London Elementary school, I noticed that additional parking had been opened in the grassy area at the front of the school. I pulled into the side lot where I had parked almost every school day for the ten years or so that I had been involved at this school. It is one of those modern looking yellow brick schools built all on one level in the 1960's. On the front is a huge picture of the school mascot, a buff, masculine unicorn with a rainbow horn, designed by a student in the 1970's. The exterior clock next to it was not running.

I entered one of the sets of front doors and was blocked by a repairman fixing a light fixture. Next to him were the principal, Kirk, new since my earlier involvement in the school, and the lead teacher, Mary Anne. I said hello and Mary Anne welcomed me asking why I was in the building. I explained that I was visiting Victoria's classroom. We chatted briefly about our children who had attended this school together. I was going to check in at the office when I realized that both the principal and lead teacher were already aware of my presence in the building and the secretary was not in. I turned down one of the two parallel halls that run the length of the school and passed the courtyard where trees are dedicated to former teachers and sometimes pigs or turkeys roam for show and tell. On my left I heard Mrs. Fried's third grade class talking about Sherlock Holmes. I thought about her kindergarten class in which I used to substitute and how third grade seems a better fit for her. I turned down the back hallway and noted the changes in classrooms over the years. Different teachers were in some of the classrooms and familiar ones were in different classrooms.

As I passed what had been the fourth-fifth grade pod when my children were here, I noticed that it has been renamed Cunningham Pod for the founding principal with whom I had spent many years. The building and the original open concept approach were initiated by him. The philosophy of the school has developed over the years and some of the strengths of the open concept approach are extant in the teaching for understanding and child-centered attitude of this school. Through the large windows I glimpsed the beautiful woods behind the building the Mr. Cunningham had fought to preserve so that the students would have their own nature resources on campus. How fitting that this pod should be named after him. All of the original pods were named after pioneer families of the area.

As I walked down the halls I was greeted warmly by a number of students even though none of the current students would know me. The atmosphere of this building is very child-centered and respectful of all people here. This, I feel, results in the kind of adult child relations that I have observed.

I walked toward the new addition, not knowing exactly where Victoria's class was. Tentatively I walked through the door next to a huge sign that said: "This is the Kindergarten." I felt self-conscious because this was the unknown side of a two-teacher pod. I looked across the students and tables and centers and was relieved to see Victoria sitting in the other section. I walked between children working on the floor and greeted her at a low table where a large poster announced School Jobs. Smaller versions of the poster were on the table with children's names on them. Some had shapes colored in telling in which center the child had spent the center time. Victoria was clarifying with a student what center she had been in and smiled hello at me. I've been in her classroom many times over the years and I felt immediately comfortable. She beckoned to me to join her at the table but I declined, preferring to look around and to meet some of the students first. A description of the classroom follows.

To the right of the school jobs table there was a blackboard with huge cardboard teeth on it, each labeled with a month of the year starting with January on the left. Ah, I thought, "She is once again keeping track of when students lose teeth. I'll bet she'll use them to do graphs later in the year." Two of the teeth were placed below the ones headed with months and one was labeled "loose and wobbly" and the other was named "firm and holding."

Just past the blackboard on the same wall and into the corner was a puppet center with two puppet stages. It had blue and white vertically striped curtains and a plethora of animal puppets, many of them stuffed. To the right of the puppet stage about three feet from the blackboard was a book cart with about 20 picture books. On the intersecting wall next to the puppet stage was a felt board with trees and parts of the apple cycle on it for the students to demonstrate their own apple cycle.

A tape recorder was on the floor with several science song tapes. In front of the felt board was an area with a rectangular rug with ABC's around the border and numbers in an oval inside of the ABC's. An easel was at the other end of the rug with the only adult size chair in the room. It was steel with a blue upholstered seat. This must be where Victoria does her group instruction which was called forum when my children attended this school.

During this time the students were working at centers and one of the boys showed me the animal puppets in the puppet center. He wandered off to one of the other centers, ready to begin learning in a new area. I continued checking out the centers, noticing a triangular cardboard center on the floor next to the felt board. It showed honey bees and how they visited flowers and spread the pollen. Above it on the wall were bulletin boards with bee and flower posters and a preprinted calendar for September. Next to the calendar were three “ten frames” with circles filled in denoting the number of days in September (see figure 4.4). On the bulletin board next to it was the October calendar with the numbers filled in a pattern. The odd numbers were numbered pictures of apple blossoms and the even numbers were apples. The calendar was filled in until today.

Above it was a number line with odd and even numbers with different colors and shapes surrounding the numbers. This number line counted the days since the beginning of school, I remembered. It was filled in up to day 26. I wondered if Victoria was planning on her usual day 100 celebration where students bring in collections of objects that show 100. Most of the students seemed not even aware of my presence and continued working on their center work. Victoria was circulating, stopping at every child and checking work, asking many higher level questions. Each interaction with a child was individualized. She carried a clipboard with the children’s names on it that allowed her to do constant assessment. I knew from speaking with her over the years that the assessments were always in her mind as she challenged each child to progress from where he/she was at to the next level, individualizing the use of similar materials to meet each students needs.

The next section of wall was lined with bookcases filled with various kinds of blocks. A Lego table was in use by a number of boys and several others were building with large natural colored blocks making roads and buildings. On top of the block bookcases were buckets of math manipulatives in bright reds, blues, greens, and yellows. Several large blue tubs of smaller size blocks were on the floor. In the back corner along this was a make-believe/ housekeeping center with a cabinet full of dress up clothes and a play sink, stove, pots and pans, etc.

"This is really a change for Victoria," I thought. I remember when she moved all of the toy-type kindergarten materials out of her classroom when she returned to teaching kindergarten at London Elementary about twelve years ago. Her classroom always emphasized science, math, and reading and writing skills, but especially science. I turned and to my left was her traditional science table with two parakeets, several butterfly towers, and every imaginable nature object, many of them brought in by the students. A toad was in a glass aquarium. A spider's cage was made of wood and Plexiglas with rods up the middle to help the spiders form webs. Several students came up and started talking to me about the objects on the science table. I asked them questions and they told me all about the wolf spider and the other strange spider in the web-box. I was told that the wolf spider had eaten most of the spiders as well as any insects that were put in there. They explained the difference between a frog and a toad. One of the students looked at a sunflower with seeds falling out under a very large magnifying lens.

Next to the science table was a bookcase with about twenty nature books, some of them dealing with bees and blossoms. Three computers were set up against the back wall and I noticed they weren't being used yet. The last time I visited Victoria's room she asked me to set up the computers and help get the students in a routine for using them. As I was looking at the computers I noticed two student desks with scales and materials to weigh. On the rest of the wall to the back door were hooks with 20 some odd book bags of all possible bright colors. This wall was the side of a small hall that led back to the teacher's desk. It was obvious this was only to store her books and parent notes and so on because it could not even be seen from the rest of the room. This hall was formed from the in class bathrooms that were the divider between walls of the two kindergarten rooms that were connected in an "L" shape.

Most of the children were occupied in centers in the middle of the room. There were five small child- size tables with chairs in the middle of the room and each table had a colored symbol (square, triangle, circles, etc.) just like the school job papers that Victoria had been using with students when I first arrived. A student-teacher was seated at the writing center working with four students. They were practicing writing the words from their word cards on white boards with colored markers. This was a nice change from my son's class eleven years ago when paper and blackboard were the only places available for students to practice. I thought about how motivating white boards had been for my fourth, fifth, and sixth grade central city students when I taught. Each child has time with the student teacher to read their word cards and choose a new word to learn and add to their ring of words. A very successful introduction to sight words with student choice as a motivator.

Two math tables were next to this center with a math jar with six huge plastic buttons in it. Students had taken corresponding amounts of colored tiles and counted out six tiles of two different colors and put them on paper plates with their names on them (Counting Jar figure, 4.1). There was a checklist at the tables for one of the teachers to check and mark off their counting tasks as successful. Those who had not finished this task or were not accurate were called over to recheck their jobs. The two colored tiles also reinforced number six addition family facts such as two plus four or three plus three. The other math table had October calendars on it and a check list for the teacher to assess the students' success at replicating an October calendar that was on the table. One young lady was filling in the calendar with the right sequence of numbers but they were all backwards. I asked her if she had looked at the example and she said, “No, I know how to do it without looking.” I remembered that backwards numbers are developmentally appropriate at this age. I knew that when Victoria checked the student's work she would guide her to recognize that the numbers were backwards and the student would turn them the other way.

During this entire time Victoria was circulating and challenging students, asking them what they thought about various things and checking to see that they had marked their school jobs paper. She explained that she sent these school job papers home as a conversation starter for the family and to introduce responsibility to the students. They had to do at least one school job a day and to communicate with their parents about what was going on in the room. I made a mental note to obtain one of these as an artifact. Right by the place where the “L” part of the room joined with the other kindergarten room was a white floor mat with a bag of apples at the end and sticky notes all over it. Victoria explained that the students had estimated how many apples were in the bag and had written their estimates on the sticky notes. These formed a kind of estimate graph. At this juncture there was also a listening center with tape recorded books and a tape player and headphones. Victoria mentioned that there were two more centers that the students used in the other kindergarten room during center time. It was clean up time and then the students went to the busses to be taken home.

This description of Victoria's classroom sets the overall context of her classroom while it highlights several of the contextual and socio-cultural factors that are present in that classroom. Examples include the choice time activities and the Victoria's continuous assessment of individual children during Choice Time.

Contextual and Socio-Cultural Factors

Constructivist environment. Contextual and Socio-cultural factors are very closely related in a constructivist classroom. Often the socio-cultural factors (Table 3.2) will become obvious during the discussion of the contextual factors. In this chapter they will be discussed together in reference to each passage of data examined. The following quote, drawn from an interview with the university researcher, introduces Victoria's (2000) perspectives on her kindergarten as a constructivist classroom.

Victoria:

I think of the three "C's when I think of constructivist. One, have a curriculum that will engage children's curiosity and have them love learning. Allow them choices. And the choice is not to pass on your reading, or your writing or your math but choices within those. And also to allow them to collaborate; to share their thinking, to work on a project together, to have children identify with different ways of doing things. (Realize) that there is not just one right way to do something. Often, for example, in mathematics there is one right answer but there's lots of different ways to arrive at that and celebrating the different ways that we can use our creativity to solve problems is essential.

In an earlier interview Victoria(1999) also mentioned another essential in her constructivist classroom, that of student initiation (Table 4.1) which is closely linked to student choice:

Victoria:

You take it from them. Then it will be relevant. Someone picks up on something and then you can go from there. Youngest little boy said that he knew another way to count. I said "Tell us about it." He said ten and then 11, 12, 13, 14 (counting on) and then other children piped in that you can count by fives, tens. Then we have a 100's chart right there so we did some counting by fives. Five, ten, fifteen, twenty, going down the hundreds chart. Some of the older ones are counting by twos. They figured out the number line where the even numbers are in red. Then I just will add a little bit in counting by twos. We're on four and two more and we're on six and two more we're on eight. Kids are starting to arrange the clothes pins on the t-chart in twos and counting them by twos. A child will start to put his clothes pins on indiscriminately and another child will say, "No, it has to go with a partner." The child doesn't know why but he'll go with the program.

This adaptation of a classroom task has been initiated by the students and is in addition to the curriculum that has been presented in the classroom. Victoria supports this addition but she did not introduce it or initiate it. The children began it.

As we look at the contextual factors in this kindergarten classroom, Victoria's (1999) words about a constructivist learning environment highlight a number of the areas of best practice in language development in mathematics for kindergarten children that we see in her classroom as well as two areas (choice and student initiation) that are not included in the literature as often. Victoria's (1999) three "C's" include adults' choice of curricula, children's initiation and choice within curricula, and collaboration between the children and between the children and adults in the classroom. The discourse that accompanies all of these areas will be at the center of the findings in this study.

The NCTM Professional Discourse Standards for Teachers (NCTM, 1991) includes collaboration as an essential component of the learning environment and defines important teacher and student roles in relation to this component (See Table 3.5). One of the roles of students in the mathematic classroom is to be an initiator of problems and questions while teachers are to listen to students and to decide what to pursue in depth from students' ideas. Curriculum, collaboration and student initiation are considered integral to student success in mathematics. While student choice may be considered part of social motivation, it is not prominent in the NCTM Discourse Standards.

The influence of early childhood curriculum with its emphasis on play and Victoria's (1999) study of the British Infant Schools in the 1970's are also essential contextual factors in the environment of Victoria's classroom (Table 3.4).

Interviewer:

You visited the British Infant Schools. How did that affect your teaching?

Victoria:

Oh, dramatically. I was lucky enough to be there for a summer on a project, finishing my Masters Degree. And I was also asked to write a chapter in the book that was the fruit of the labors of us going over there. And again, the British Infant Schools at that time, they were giving children choices. They had curriculum that was very interesting and engaging to children. They were letting children collaborate. And because of that experience, when I went back home, I thought – (London Elementary) was built in 1970 and it had the idea of a British Primary School. And I found that exciting, and so in 1975 I starting my teaching career at (London Elementary) where I've been ever since. And I think again, it's making school exciting for children. Giving them a love of learning, helping them to just want to learn, and to want to continue this process at home, and I love it when I get a note that says "my child is upset because they couldn't come to school they have the chicken pox." I want children to come to a calm and peaceful environment where anything is possible and where we're a team together, learning and growing. The British Primary Schools definitely had an impact on me.

Weber (1971) describes the environment of the British Infant School as one in which play was important. Curiosity was trusted as a motivating force for the child. The job of the environment and the teacher was to keep that momentum going. "It was the *child* who learned and so he had to be *allowed* to do so (Weber, 1971, p. 170)." The activities and the rich environment were support for children's curiosity and initiation.

> The idea had long roots, its present unique integration and character being an offshoot strand, woven from many such strands, of the main root of the history of education—from Montaigne, Rosseau, Owen, Pestalozzi, Froebel, Montessori,

> McMillan, Dewey…Respect for play and spontaneous activity as a child's natural way of learning, respect for natural development, came from these early roots. From Montessori came the technique of individual work, of a child's own pace and progression, and the introduction into the classroom of more concrete materials to add to the already existent influence of the Froebelian *gifts*. From Dewey came the emphasis on the experiencing of social relationships and community, on learning generated from a child's activities and his experiences. The English continued to stress individual work stemming from individual interests, but the sharing of communal functions and responsibilities in school was added to the implications of an educational method supportive of natural development. (Weber, 1971, p. 170)

This summary of the philosophical influences on the British Infant School comes very close to a description of many of the influences at play in the kindergarten classroom of Victoria.

These quotes from interviews with Victoria also highlight ways of meeting the different needs of the postindustrial society that were emphasized in the first chapter of this study. Society has a need for individuals in the United States to be independent learners (IRA & NCTE, 1996). Betts (2004) describes this concept as fostering autonomous learners—" independent self-directed life-long learner(s)" p.1. Choice and initiation within the curriculum support students becoming independent learners. A curriculum that emphasizes independent learning is one that is built upon inquiry learning rather than on the transmission of knowledge that Freire (1970) describes as the Banking Model. According to the IRA and the NCTE (1996), "Inquiry emphasizes different processes and types of knowledge than does knowledge transmission. For example, it values the ability to recognize problems and to generate multiple and diverse perspectives in trying to solve them" (p. 6). This is the perspective that Victoria (1999) highlights in describing her children as "finding different ways of doing things" in the mathematics (Table 3.2). In valuing the ability to recognize problems and to encourage use of diverse solutions, inquiry learning supports the use of choice and initiation within curriculum that Victoria (1999) suggests is essential to a constructivist classroom. Both mathematics curricula used in Victoria's classroom support the position that the teacher needs to become a facilitator of knowledge rather than a dispenser of information (Baratta-Lorton, 1995; Russell, et al. 1995).Victoria (1999) describes her vision of the inquiry process in a section taken from one of the interviews.

Victoria:

Again, I know all learning goes in a wave that first you have to be aware, and then you have to have experiences before you can ever start to question or have inquiries. And then, after that, you are able to utilize it and then something new is presented. You have to be aware of it, have experiences, the inquiry comes next, and then last, you are able to utilize it. Inquiry learning to me is an art form. The idea of questioning and not telling; getting children to think. I think that's the key to understanding. And it needs to be in all parts of the curriculum. In every subject, I find they're all integrated anyway. In science, there's math. In language, in stories, you find math. It's just, all, everything is integrated. And to try to separate it, I think is fruitless.

Magnusson, Palincsar, and Templin (2002) posit that part of the point of the national standard of inquiry is that instruction should provide students "with opportunities to learn in ways that mirror the activity of actual scientific communities" (p. 2). Initiation and choice are integral to scientific communities. With the close relationship between science and mathematics and their respective communities, it is not a stretch to suggest that the same approach would be essential for the education of children in mathematics (Table 3.3).

Inquiry learning also fits the needs of our global society in that it values cultural and epistemological diversity (Table 3.2). It supports generating multiple ways of solving problems and often produces different solutions. It supports classroom discourse that is more than recitation. Current approaches (Magnusson, Palincsar & Templin, 2002) to the cultural basis of science stress that scientific knowledge is dependent on values, beliefs, and standards about what is important to know and do in science and how students and others come to know science. Cultural and epistemological diversity should also be present in the communities that make decisions in regard to the classroom context. "In a conversation, all of the stakeholders in the educational environment (students, parents, teachers, specialists, administrators, and policy makers) have a voice at the table as curriculum, standards, and assessments are negotiated" (IRA & NCTE, 1996, p. 7). This fits with Dewey's perspective on the foundations of a democratic society with participation of all of its members in the communication of experience (Table 3.2).

Contextual factors in the learning spiral. Part of the classroom context includes the environment that has been established to foster constructivist learning. Several indicators of this type of environment have been identified in the review of literature in Chapter 2 including a balance between the social and individual aspects of constructivist learning. Magnusson, Palincsar, and Templin (2002) refer to this balance in terms of “communities of practice which provide the motivation, communication, and structure necessary to sustain individual inquiry. As such, a community is *not a* passive context for individual knowledge construction; rather, scientific communities enable (and constrain) the production of scientific knowledge” (p. 4). The Professional Standards for Teaching Mathematics (NCTM, 1991) support this position indicating that classrooms need to become mathematical communities rather than collections of individual students. These documents delineate teacher and student roles as well as characteristics of the learning environment and the discourse tools available to the students within these mathematical communities (Tables 3.3 and 3.5).

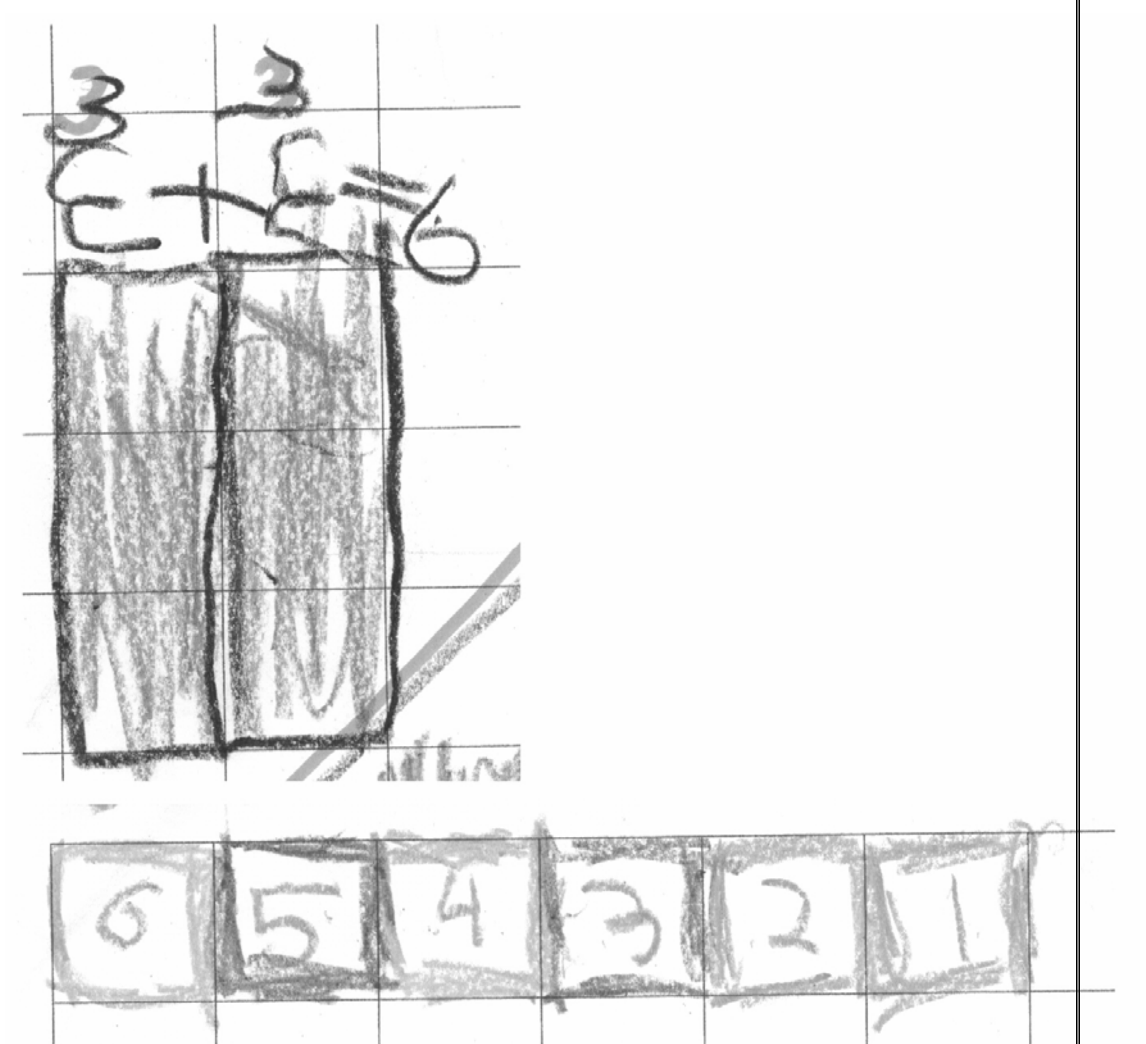
Within Victoria’s classroom every child is involved within a social context while at the same time that every child is an individual learner (Salomon & Perkins, 1998). Both aspects of the learning context are addressed in Victoria’s classroom. Students are supported by their peers as well as by their teacher in activities such as sharing their results from the morning counting jar. Victoria even uses examples from the morning kindergarten class to support students’ learning in the afternoon class. Both classes then become a scientific community as Victoria shares insights and discussions from the morning class with the students from the afternoon class and vice versa. This sharing bridges informal discourse with formal discourse. Magnusson, Palincsar, and Templin (2002) suggest that teachers enhance the bridge between informal and formal discourse by providing “a metascript, supporting the articulation of ideas, and supporting the collective memory of thinking/activity during instruction” (p. 13). All three of these bridges are present in the following example from Victoria’s classroom. These bridges are examples of supportive scaffolds (Wilkinson & Silliman, 2000) that teachers use to mediate student's acquisition of cultural tools to understand and remember in more literate ways (Table 3.3).

Metascripts "refer to teacher moves that signal what the thinking is expected to be about…A metascript does not give information about what one should be thinking or saying like a script would; rather it provides information regarding what one should be thinking or talking about" (Magnusson, Palincsar, and Templin, 2002, p.13).In this context, these metascripts provide the general rules of conversation or structure that Nelson and Gruendel (1979) propose children need in order to participate in a dialogue. In inquiry learning teachers support students' articulation on ideas through revoicing and seeding. In revoicing the teacher repeats, expands upon, or reformulates what a student has said. Seeding is the process of the teacher introducing useful ideas, vocabulary, etc. into the classroom dialogue. Teachers have information that is not shared by all members of the learning community because he/she has spoken to different students, work groups, etc. within the community and can share that information with the entire learning community. This process Magnusson, Palinscar, and Templin (2002) refer to as the teacher's role of serving as collective memory. Teachers also establish and support the norms of the larger scientific and/or mathematics communities by highlighting a certain student activity and encouraging other students to engage in that activity.

Within any learning community, collaboration supports all members of the community including the leader, facilitator, or teacher. Freire (1970) contrasts the traditional banking model of education, wherein teachers deposit knowledge in students much as a banker does with money in a bank, with problem-posing education (Table 3.2). His concept of problem-posing education fits well with the idea of a classroom as a science or mathematics learning community. "Problem-posing education, responding to the essence of consciousness --intentionality—rejects communiqués and embodies communication" (Freire, 1970, p.66). In problem-posing education, the educator and the students co-engage in critical thinking and support each other in humanization. This calls for a deep trust in people and in their creative abilities. A partnership is formed in which the teacher and student roles merge. The teacher becomes a learner as the communication with the learner transforms the relationship. "The problem-posing educator constantly re-forms his reflection in the reflection of the students. The students – no longer docile listener – are now critical co-investigators in dialogue with the teacher" (Freire, 1970, p. 68).

Figure 4.1 Counting Jar

One of the beginning class routines is called counting jar. A large jar with a certain number of huge colored plastic buttons in it is on a table near where the students enter the room. Students take corresponding amounts of colored tiles and count out the same number of tiles of each of the different colors and put them on paper plates with their names on them. They arrange them in different combinations (patterns) and record their combinations on a recording sheet.



During the following example taken from the tapes of classroom dialogue in Victoria's kindergarten classroom, the social learning aspects of the learning spiral in a learning community are demonstrated along with the scaffolds of metascript, articulation of ideas, collective memory, and the establishing of norms of learning community practice (See Tables 3.3 and 3.6). This dialogue begins in the middle of a discussion of the representation of items from the morning counting jar:

Victoria begins by setting up the expectation that the students will discuss the patterns that they have created in recording the results from their Counting Jar Activity. This signals what the thinking is expected to be about providing a metascript for the dialogue that follows. The activity itself provides the content knowledge that Nelson and Gruendel (1979) indicate is the other half of a script that children need in order to engage in real dialogue (Table 3.6).

Victoria: I have to show you one that the kids this morning did. Emily, would it be OK if I used your tiles? It was Melissa in the morning class and she said 'Mrs. Churchill, I will always remember that there is a pattern in ten. It's like a staircase. She said "Four, three, two, one."

Child speaking: That's what you did to me.

Victoria had spoken to one of the afternoon students earlier about what had gone on in the morning class with Melissa. This, as well as the current dialogue, is an example of supporting the collective memory of thinking/activity.

Victoria:

You bet! And you remember when I asked you how to move that one? You had a different shape. You had put your tiles this way where you had four, one, three, and two tiles. And I said 'Would it be OK if I moved that tile (the single one). And I showed her Melissa's way this morning because Melissa said that 'I am not going to forget about four, three, two, and one. Like counting backwards would make your ten.'

In this section Victoria supports the student articulation by revoicing what the student had said including more detail so that the other student would understand what the student was talking about. Victoria also supports the students' articulation by seeding the conversation with vocabulary (shape) and the ideas shared from the student in the morning class (Table 3.3).

Child speaking: It's like stairs.

Victoria:

Yes, it is. It looks like stairs doesn't it? Or, if you go this way, you could go one, two, three, four. And then we have that. [*revoicing*] Could I have…, Emily, would you take your plate and dump it, and Billy, thank you for letting me share this. That's neat. It made the same rectangle shape but we just talked about it a different way. [*revoicing*]

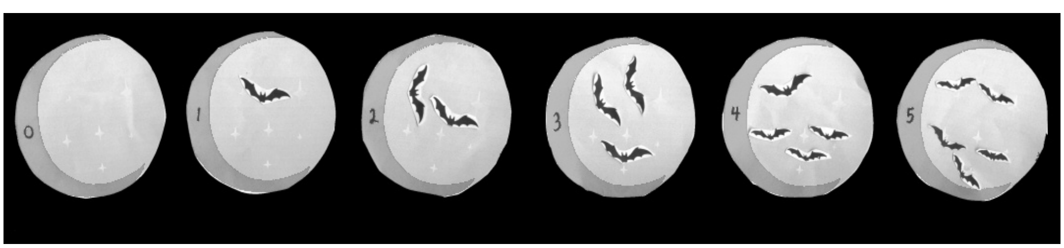
Victoria also establishes the norms of the learning community practice by privileging Melissa's work and discussion by introducing it in the afternoon's class (Table 3.3). It is her practice to highlight student's work on a regular basis when the class gathers to discuss the mathematics activities in which they have engaged during the day.

This scenario demonstrates the social scaffolding present in Victoria's classroom.

At the same time her classroom provides extensive individual scaffolding for children's learning as is obvious from the work that her students have done during center time on Math Pads.

Figure 4.2 Math Pads

Math Pads are constructed of laminated pieces of paper from note pads. The pads are usually colorful shapes such as a spider web or a basketball. The pads are numbered from zero to ten. Small objects that match the theme of the pad are included for students to use as counting manipulatives. For example, spiders might be included with the spider web math pads. The students lay out the Math Pads from zero to ten in order left to right. The next step is to count out and place the corresponding number of objects on the math pads. The zero math pad would be empty, the number one would have one object and so on until all 11 pads were covered with the corresponding number of items. With experience, the students would also learn to group the items on the pads (The objects on a number five pad might be grouped with two items and three items or with one item and four items). As the children progress in their understanding of numbers they might begin comparing two pads for more or less and later begin to work on addition and subtraction concepts. The teacher might say, "Show me the number five. Now show me the number with two more." The students would line the objects up in one to one correspondence and the teacher would check each student's work individually.



During the time that these dialogues were recorded students were working with Math Pads and other center activities that include reading and language as well as science activities. Victoria was sitting between several students and was working with each of them at the same time:

Victoria to first student: (You have) four on this side, how many on the other side? Two on the other side. Good! Can you find the number that is one more than that number?

Another student approaches with a book.

Victoria: That's a neat fox. It says a fox is a wild animal with reddish brown fur and a long bushy tail. Let's make a new word from fox. Are you ready? (She manipulates the letters in the interactive book.) Here you go. /b/ It rhymes with fox.

Child: Box!

Victoria: That's right!

She turns to the first child.

Victoria: Yes? Start from the left, here.

Child 1: One, two, three, four, (inaudible) seven, eight.

Victoria: That's right, now what would be two more?

*The student returns to working with Math Pads, looking for the amount th*at *would be two more that eight. He lines up the eight items and then lines up several other numbers in turn looking to see which one has two more than the eight. Each time he checks to see if the items match one to one. Victoria glances over as he finishes and says:*

How many do you have?

Child: Ten!

Victoria: Good thinking. You can put away your Math Pads and make another choice.

Each child works at a different level with the Math Pads depending on the level that Victoria has assessed. At the beginning of a year Victoria carries a clipboard with the assessment information (Table 4.1). She adds to it continuously. Later in the year she seems to keep much of the information in her head. She explains that she knows her students and their needs very well. Work with Math Pads is done on an individual basis. The students work on the rug to set their Math Pads up and the teacher circulates asking each child to do an activity with them that matches their individual goals for growth in learning. The teacher's interaction with each individual child exhibits the concept of individual scaffolding in constructivist learning (Table 3.3). These tasks are more Piagetian in nature than many of the other tasks and learning situations that Victoria presents in her classroom such as the group work surrounding the counting jar activity that was mentioned earlier. As indicated in the review of literature in Chapter 2, Piagetian constructivism is more child-centered with an emphasis on individual development. Students come to the classroom with pre-conceived ideas that must be altered or modified through "… tasks and questions that create dilemmas for students" (Abdal-Haqq, 1998, p.2). Victoria combines a social constructivism and Piagetian constructivism learning environment in her classroom (Table 3.3). Victoria's success with the balance between these two approaches supports the viewpoint espoused by Salomon and Perkins (1998) that the reciprocal relationship between the individual learning and the collective learning can form a learning spiral, which intensifies the learning of the individual and the collective.

Curricula, choice, and collaboration. Curricula need to include both individually supported learning and collective learning. Both curricular approaches used in Victoria's classroom, *Investigations in Number, Data, and Space* (Russell, et al., 1995) and *Math Their Way* (Baratta-Lorton, 1995), emphasize individually supported and collective learning. The following section is drawn from audio tape of one of the lessons taught by the student teacher who was also working in Victoria's classroom. This lesson is taken from the *Investigations in Number, Data, and Space* Curriculum (Russell, Tierney, Mokros, et al. 1995) and is presented essentially as written in the teacher guide. It demonstrates many of elements of constructivist classroom discourse that were present in the preceding examples (Tables 3.3, 3.5, and 3.6).

Elizabeth:

OK, seven children are riding on a bus. And the bus driver pulls up to one of the houses and opens up the door and four of them walk down the steps and go home. Who can tell me that story?"

Elizabeth is providing a metascript, a way for students to think about and discuss a mathematics problem that is presented to them (Table 3.6). She draws on their informal knowledge of story which is ordinarily reserved for language arts in typical school programs.

Child:

I will!

Elizabeth:

How many people were on the bus to start with?"

Child:

“Seven.”

Elizabeth:

“OK do you want to tell it in your words?”

Child: (inaudible)

Elizabeth:

We’ll work together on it. OK, Connor and Staci sit right here and face me. Sit side by side. You are going to be the first two kids on the bus. How many kids are on the bus?”

Expanding on her use of story as a metascript for students to use in thinking and discussing a mathematics problem, Elizabeth incorporates drama or play into the solution of the problem (Tables 3.6 and 3.4). This increases the students’ ability to visualize a story problem.

Children: (inaudible)

Elizabeth: “(inaudible) nope, how many kids all together? You start, how many kids in the story? Zoe and Austin, you two are in the next seat, OK, (inaudible) Melissa and Dustin, you are the next – how many do we have so far? We have six, that’s good. How many more do we need?

Children: “One”.

Elizabeth: “OK Alex, go sit behind the last row. Everyone else get back. There’s the bus. Show us what kids look like when they’re riding on the bus. Are you bouncing around a little bit? OK, I’ll be the bus driver. I’m gonna open the door. I’m opening the door. How many kids get off?”

Children: “Four!”

Elizabeth: "Four kids. Ok, the first four people on the bus go back to your seats. We're at your house. Yep. Sondra, Staci and Austin go back to your seats and Zoe. Hmm. What do you notice about our bus?"

Elizabeth is providing a metascript that is a signal that the children should now be thinking about and discussing both how many children are on the bus and how many children are not on the bus (Table 3.6).

Children: (inaudible)

Elizabeth: "How many kids aren't on the bus? Four aren't on the bus. How many people are on the bus?"

Children: "Three. One, two, three"

Elizabeth: "Three kids are on the bus. Did we combine things in that problem or did we separate?"

Elizabeth is seeding the dialogue with the words and concepts of combine and separate which supports the children's articulation of ideas (Table 3.3). She is bridging informal and formal discourse in the kindergarten classroom.

Children: "Separate"

Elizabeth: "How do you know we separated?"

Child: "Because me and Zoe, Staci and Connor, me and Zoe, Melissa and Dustin separated."

Elizabeth: "You separated? OK. Do we have more kids on the bus now?"

Children: "No!"

Child: "Three"

Child: "We had seven, now we have three."

Child: "Now we have less."

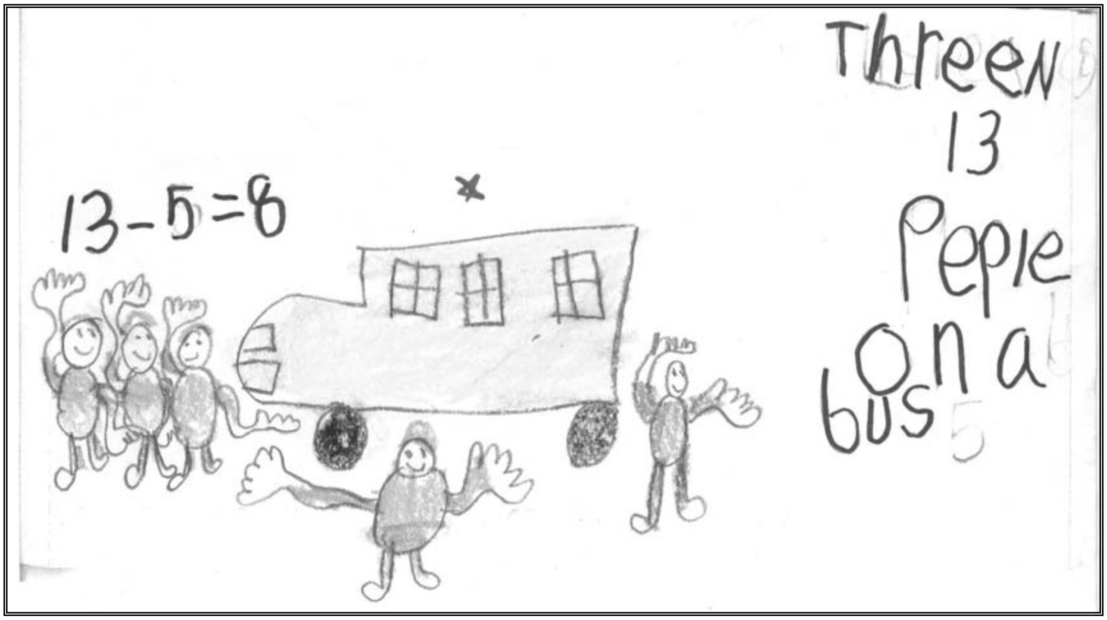
Elizabeth: "(inaudible) used a good word. She said now we have less. We have less than seven. OK! Thanks bus riders. I have one more story."

Elizabeth is revoicing what the child has said repeating, expanding, and reformulating the initiation of the child who said, "Now we have less." (See Table 3.3)

In the curriculum *Investigations in Number, Data, and Space (*Russell, et al.,1995), the first grade students revisit this problem with a traditional word problem in which the students are encouraged to use pictures and number sentences to explain their answers. These examples from separate years in the curriculum demonstrate the development of external mathematical representations that point to internal representations. These include verbal/syntactic and imaginistic (visual, spatial, kinesthetic, auditory, and rhythmic mental images) in kindergarten dramatic play progressing to formal notational representation (Tables 3.4 and 3.6) in the following first grade example from *Building Number Sense* in the Investigations in Number, Data, and Space curriculum:

"There were thirteen Children on the bus. At the next stop, five children got off. How many children were still on the bus (Russell, et al.,1995, p. 45)?"

Figure 4.3 The Bus Problem



The *Investigations in Number, Data, and Space* Curriculum (Russell, Tierney, Mokros, et al. 1995) insures that both parts of the learning spiral are present in the classroom through the use of Focus Time and Choice Time. Focus Time begins with a whole group meeting where the teacher introduces one or some times a couple of activities that highlight the important mathematical ideas of the inquiry in which the children will be engaging. After the introduction the students may work individually or with partners and then usually they return to the whole group to share or discuss the investigation. These whole group sessions may take a short period or they may stretch over several days depending on the investigation. Choice Time follows Focus Time and incorporates a series of activities that support learning in the same area that was covered in the Focus Time. Sometimes this is part of an activity or center time that is used across curricular areas in the kindergarten classroom. "During Choice Time, students work independently, at their own pace, choosing activities they prefer and often returning many times to their favorites" (Russell, Tierney, Mokros, et al. 1995, p. 3).

The other mathematics curriculum that Victoria uses in her classroom, Mathematics Their Way (Baratta-Lorton, 1995), has a similar balance of social and individual learning built into the curriculum. Students work together in a whole group at the calendar board, a class routine that Victoria uses on a daily basis in her classroom. At other times in the day, students work on activities which are individually paced according to an assessment of where the student is developmentally.

The Calendar Board Routine incorporates mathematics, science, and language arts in a group setting. In the following vignette, the students have just finished writing the date in the air with their fingers. The date is April 19, 2000. A student, Karen, is adding another red dot to the set of ten-frame cards that Victoria uses during the calendar board time to show a visual image of the number of days of the month that the current date represents (See the example of tens-frames in figure 4.4).

Figure 4.4 Tens-Frame Filled in with the Number Seven

●	●	●	●	●
●	●			

Victoria:

…Another red dot…Tell us how many dots…Joshua… Joshua, Joshua, I'm going to have to ask you to move, that's just too tempting, You're just not paying attention so I am going to sit you over here by Staci. Over on the “R” on the carpet, Joshua. Come on, over on the “R.”

Karen said nineteen. Who would like to share a way that they came up with nineteen? Zelda?

Zelda:

Ten, eleven, twelve, thirteen, fourteen, fifteen, sixteen, seventeen, eighteen, nineteen.

Victoria:

Ok, so you knew there were ten in the first frame and you counted on from ten. What about you, Staci?

Victoria is supporting student articulation by revoicing what the student had said including an explanation of how Zelda had counted on (Table 3.3).

Staci:

I did it by twos.

Victoria;

Ok, Let’s try it. Two, four, six, eight, ten, twelve, fourteen, sixteen, eighteen, and one more is nineteen.

There are many different ways to find the answer. Victoria is encouraging multiple and diverse perspectives while not accepting “any” answer to a question that has only one correct one. Acceptance of multiple and diverse perspectives supports socio-cultural inclusion (Table 3.2).

Alex:

I counted twenty. Ten and ten is twenty.

Victoria:

So you see ten in this box and ten and ten is twenty. Do we have ten and ten?

Children:

No!

Victoria:

How many are missing?

Children:

One

Victoria:

What's one lower than twenty?

Children:

Nineteen.

Victoria gently uses Alex's explanation and answer to show how the student was approaching the problem in a diverse way. This affirms and shows respect for the student's approach while maintaining the one right answer. The NCTM Professional Discourse Standards for Teachers (NCTM, 1991) emphasizes the teacher's role of deciding what to pursue in depth from student's ideas (Table 3.5). This is an excellent example of this strategy.

Victoria (1999) explains in the next quote from one of the interviews how she views the two curricula and their relationship.

Victoria:

I am very excited about investigations and I think *Math Their Way* came before *Investigations*. *Investigations,* I think, just incorporated the best of the best. Different programs whether it was *Math Their Way* or CSMP, what they did, is they…, *Investigations* just added the dialogue and also with the teacher notes, helping teachers to guide children in their mathematical thinking without telling them answers, but through the use of statements and questioning, to help them have an understanding. I see these programs as working at a higher level of thinking rather than just memorizing math. Because you can only memorize so far, and without any understanding, if you forget the rules you have no way of operating or if something is presented in a slightly different way you have no way of transferring it. I see *Investigations* doing a lot of reflective thinking. The highest level of thinking. And I think only through reflecting, do we understand and I know that is a big push in my teaching. [It] is to teach for understanding instead of doing a zillion things, to pick just some very important things and to teach for understanding.

Chosen Focus on the Contextual, Academic and Socio-Cultural Factors within the Study

As Victoria (1999) compares the two curricula that she uses in her classroom, it becomes obvious that they support the active social mediation that Salomon and Perkins (1998) consider essential to constructivist learning (Table 3.3). The teacher provides informative feed back, active guidance, and encouragement while challenging students at the optimum individual level. The teacher is a guide, facilitator, and co-explorer who encourages learners to question, challenge and formulate their own ideas, opinions and conclusions. A continuous assessment is in process with the teacher responding with a differentiation of instruction which includes student initiative and choice as essential elements of that instruction. There is a need for a balance between the child as an individual learner and the child as a learner within a social context. Peer scaffolding becomes as important as teacher scaffolding particularly in the area of language development in mathematics. Students work at collaborative problem solving, deeply thinking about their solutions and prepared to defend their positions. These positions are then refined in the interchange with their peers' attempts at solutions and explanations, deepening the reasoning skills and creativity of each member of the class. This interchange of peers mirrors the normal communications within the greater mathematics learning community.

A constructivist reform kindergarten classroom is a complex learning community. The contextual, socio-cultural and academic factors that influence students'mathematical literacy development in a constructivist reform classroom are intimately related to each other and it is difficult to discuss each in isolation, as is evident in this chapter. Several factors, however, can be highlighted in this discussion. These are chosen for a special focus because of either their centrality to the research questions or because of the need to highlight factors not often identified in the research literature.

1. The Learning Spiral in a Community of Learners (Tables 3.3 and 4.1),
2. Student Initiative and Choice (Table 4.1),
3. Mathematics as a Social Endeavor (Tables 3.3 and 4.1),
4. Transformation to Continuous Assessment (Table 4.1) and,
5. Differentiation of Instruction (Table 4.1).

Learning spiral in a community of learners.

The balance in a constructivist environment between socially constructed and individually constructed learning is essential. As learners, children are truly immersed in a learning community with all of its socio-cultural factors ranging from the effects of the mainstream culture through the influence of the greater mathematics community to the idioculture of the particular classroom. In the Chapter Two discussion of constructivism, Salomon and Perkins (1998) dilineate six meanings for socially mediated learning which they propose are each intimately involved in a learning spiral in any constructivist learning (Tables 3.3 and 4.1):

1. Active social mediation of individual learning. A teacher, parent, or peer helps an individual to learn.
2. Social mediation as participatory knowledge construction. In this version, the knowledge is constructed and held by the whole group.
3. Social mediation by cultural scaffolding. This meaning of social mediation focuses on the role of cultural artifacts such as texts, videotapes, statistical tools and socially shared symbol systems in mediating social learning.
4. The social entity as a learning system**.** Some teams and organizations should be viewed in terms of the collective itself as learners not in their role as facilitators of individual learners.
5. Learning to be a social learner. Learners learn how to learn as well as learning content information. Learners learn how to provide for themselves more of the critical conditions for learning within the social setting. This is the basis of

strategy skill learning highlighted by Pressley and Brainerd (1985) and Carr, Aldinger, and Patberg (2000).

6. Learning social content. “Social content includes such matters as how to get along with others, how to maintain reasonable assertiveness, how to collaborate in making decisions, and taking collective actions, and so on” (Salomon & Perkins, 1998, p.6).

The reciprocal relationship between the individual learning and the social learning form a learning spiral, which intensifies the learning of the individual and the group. “Students may learn more efficiently and thus reach a deeper understanding of the subject matter at hand, an achievement that they will walk away with, while the team may learn better as a team through participation in such spirals” (Salomon & Perkins, 1998, p.19). The individual remains an important and essential part of the learning spiral, sometimes resisting the collective learning while espousing an independent point of view that can then better inform the group. This valuing of resistance emphasizes the importance of student initiation and choice within the curriculum and within the classroom. An example of many of these aspects of a learning spiral can be seen in the activities and discussions around the counting jar. The first meaning for socially mediated learning (active social mediation of individual learning) is exemplified in Victoria’s interaction with Emily in showing her individually the pattern that Melissa had found in the morning class. The second meaning (social mediation as participatory knowledge construction) is evident throughout this example. The cultural scaffolding comes into play in the use of numbers and patterns in mathematical study. Victoria supports the learning to be a social learner with her use of a think aloud to relate Melissa’s thinking from the morning class. As the students are participating in dialogue, they are learning the general rules of conversation (Nelson and Gruendall,1979) and the particular rules of classroom participation such as turn-taking. (Learning social content Table 3.6).

Student choice and initiation. One of the identified needs for the 21st Century is the development of autonomous learners. According to the National Research Council (1996): "More jobs demand advanced skills, requiring people to be able to learn, reason, think creatively, make decisions, and solve problems" (p. 1). Student choice and initiation support the development of each of these areas by moving the students from a passive "banking" style of learning to an active construction of knowledge that is highly motivating and encourages life-long and autonomous learning. Students develop an *ownership* of their learning and a sense of responsibility for the learning of the community. An example from this research is the initiation of the concept of counting-on which came from the youngest student in Victoria's (2000) class. Another one is recounted in Chapter 3 with the child's description of how leaves fall in the forest. Victoria's (1998) response to each of these children supported their taking leadership in the learning community. Their initiatives were instantly accepted and pursued in the community learning activities.

Mathematics as a social endeavor. One of the most important standards in mathematics education is that of communication (NCTM 2000). Through communication in the mathematics classroom ideas are shared and understandings are clarified (Tables 3.7 and 3.8). Students reflect on mathematical ideas, refining their understandings through discussion with peers and teachers. Their misunderstandings and misperceptions are thus amended. Kamii (2000) urges teachers to help children develop number sense by creating relationships with various kinds of objects, events, and actions. Informal reasoning, problem-solving and defense of ideas is important in early childhood mathematics classrooms. Thinking, conjecturing, and attempts at validation help students to see that mathematics should make sense.

Children should be encouraged to collaborate and exchange ideas with peers. When students *talk through* their understandings of mathematics, teachers can figure out how a student is thinking and respond with scaffolding and questioning that can help the student understand the concepts and the processes involved. Assessment and subsequent planning for instruction naturally flow form this classroom dialogue. Victoria utilizes the extended community of her two classes by bridging the dialogue between the two classes. Events and conversations from the morning class are discussed in the afternoon class and vice versa. Evidence of this can be seen in the scenario around the Counting Jar and the four, three, two, one pattern.

Transformation to continuous assessment. One area in Victoria's classroom that is strikingly different than the traditional "Banking Model" is the use of continuous assessment and almost instant adjustment of the instruction to meet the scaffolding requirements of individual students and of the class. The traditional model often relies on end-of-unit tests and prescriptive assessment that is often can do no more than indicate what the students don't know. The lag time between the assessment and the implementation of changes in instruction is often considerable. The Math Pad activity is a good example of individual assessment followed by individualized scaffolding for each child which is done on a daily basis. Students move from and through recognition of number symbols to sequencing of numbers, counting, to more and less, to addition and subtraction, equalities and inequalities. Each child is at a different point on the continuum of number sense and the instruction is being continually adjusted to challenge the students just enough to stretch their knowledge without pushing them to the frustration level. Comparable class assessment is also being done simultaneously.

Differentiation of instruction. The explanation of the Math Pad activities are a good introduction to differentiated instruction in Victoria's classroom. According to Tomlinson (1995):

> A differentiated classroom offers a variety of learning options designed to tap into different readiness levels, interests, and learning profiles. In a differentiated class, the teacher uses (a) a variety of ways for students to explore curriculum content, (b) a variety of sense-making activities or processes through which students can come to understand and *own* information and ideas, (c) a variety of options through which students can demonstrate or exhibit what they have learned. (p.1)

The concept of differentiation of instruction has developed in recent years in three main areas: (a) gifted education (Cassady, Speirs, Neumeister, Adams, Cross, Dixan & Pierce, 2001; Tomlinson, 1995), (b) special education (Silliman, Bahr, Beasman, & Wilkinson, 2000), and (c) middle school (Brimijoin, Marquisse, & Tomlinson, 2003). It seems very similar to the method to that of many early childhood educators (Bredekamp & Kopple, 1997) and it harkens back to the work of Dewey (1916) in the progressive education movement. It would appear to offer a promising approach to the challenges of diversity in today's climate after the *No Child Left Behind Act of 2001.*

In Victoria's classroom students are offered a variety of ways to explore curriculum content (Tomlinson, 1995). The description of the classroom highlights the various choice time activities available to students to study bees, for instance. The puppet stage had bee puppets for the students use in dramatic play. One of the science song tapes dealt with role of bees in pollination of flowers and how they notified members of the hive about the location of nectar sources. There was a triangular center that showed how honey bees visited flowers and pollinated flowers. The felt board had a beehive and series of bees and flowers. There were bee and flower posters throughout the room. The science center contained dead bees that a students had brought in. They were looked at through a huge magnifying glass and paper was available to draw what they had observed. Many books were available on bees and other insects.

The second element, variety of sense-making activities or processes through which students can come to understand and *own* information and ideas, is apparent in dramatic play lesson that Elizabeth used with the children. Problem-solving like the first grade curriculum uses that is more traditional is presentation and more abstract is encouraged later in the year or with a student who is ready for it. The continuous individual and collective assessments direct the teacher choices for sense-making activities.

From the first day of school, students are often given an opportunity to exhibit what they have learned in whichever external representation that they choose. This is an example of third element; a variety of options through which students can demonstrate or exhibit what they have learned (Tomlinson, 1995). The recording of the students' combinations from the Counting Jar may be with numbers, pictures, tally marks, or any other representation that clearly explains their answer. Recording sheets are also explained verbally to one of the teachers.

Summary

In this chapter, I discussed some of the contextual, academic, and socio-cultural factors influencing kindergarten students'mathematical literacy development that we have identified in this kindergarten classroom. Five areas of interest were identified from the extremely complex factors that emerged from the analyses. These include: (a) the learning spiral in a community of learners, (b) student initiation and choice, (c)mathematics as a social endeavor, d) transformation to continuous assessment, and (e) differentiation of instruction.

Examples, drawn from the interviews of the teacher and from the transcripts of actual classroom observation as well as from participant-observer logs, were used to demonstrate some of the major factors identified during this research project. In Table 4.1, a final framework has been delineated fusing the seven frameworks from Chapter 3, collapsing them where the original sources overlapped and expanding them to include the additional elements observed in Victoria's classroom. Each of these elements will be discussed in Chapter 5 and the interrelationships will be clearly explained. Chapter 5 will also summarize the findings, discuss the ramifications of these findings and propose areas and types of further research that are needed in these areas.

Table 4.1 Framework of Essential Elements of a Constructivist Reform Classroom

Elements Condensed from Initial Frameworks	**Elements Observed in Victoria's Classroom**
1. Active Structuring of the Environment 1.1. Centered on: 1.1.1. Participatory Space 1.1.2. Diverse Perspectives 1.1.3. Experience 1.1.4. Process 1.1.5. Content 1.1.6. Problem-Posing	• Adult Choice of Curriculum • Direct Modeling of Cultural Tools • Differentiation of Instruction • Encouragement of Initiation • Choices of Experience and Process • Community of Learners • Collaboration Between Children • Collaboration Between Adults and Children
1.2. Spiral of Social and Individual Learning 1.2.1. Social Collaboration 1.2.1.1. Co-Investigators 1.2.1.2. Democratic Approach 1.2.1.3. Participatory Space 1.2.1.4. Scaffolding 1.2.1.5. Social 1.2.1.6. Individual 1.2.1.7. Self-Scaffolding 1.2.2. Individual Challenge 1.2.3. Motivation	• Encouragement of Initiation • Children's Choice within Curriculum • Collaboration Between Adults and Children (Dialogue Scaffolding) • Collaboration Between Children (Dialogue Scaffolding) • Continuous Assessment • Differentiation of Instruction • Direct Modeling of Higher Levels of Conceptual Competence

Table 4.1 Framework of Essential Elements of a Constructivist Reform Classroom Continued

Elements Condensed from Initial Frameworks	Elements Observed in Victoria's Classroom
2. Language and Discourse 2.1. Complexities of Language Models 2.2. Cognitive Resources 2.3. Role of Scripts 2.4. Meaning Through Social Usage 2.5. Representation 2.6. Language of the Mathematical Community	• Direct Modeling of and Support for Questioning • Encouragement of Initiation • Instructional Conversations • Collaboration Between Adults and Children • Collaboration Between Children • Discourse as Mediator of Learning • Direct Modeling of Communicative Competence • Seeding of Discussions with Concepts and Vocabulary • Complex Use of Language
3. Mathematical Process and Content 3.1. Reasoning and Proof 3.2. Problem-Solving 3.3. Communication 3.4. Connections 3.5. Representation 3.5.1. Internal 3.5.2. External 3.6. Content Standards	• Direct Modeling of Higher Levels of Conceptual Competence • Adult Choice of Curriculum • Encouragement of Initiation • Collaboration Between Adults and Children • Collaboration Between Children • Seeding of Discussions with Concepts and Vocabulary • Direct Modeling of Communicative Competence • Direct Modeling and Support for Questioning

Chapter 5

Discussion and Implications

Introduction

The literacy needs of a postindustrial society have changed dramatically from those of the industrial society. During the earlier period, shopkeeper mathematics and basic reading and writing skills were sufficient for the vast majority of members of the society. Jobs in the postindustrial period will demand more advanced literacy compentencies including the ability to learn content as well as processes, to learn to reason and make decisions, and to be able to think creatively about problem solutions (NRC, 1996). The IRA and the NCTE (1994) noted the growing need for the ability "…to recognize problems and generate multiple and diverse perspectives in trying to solve them (p.6). Centering on one area of these multiple literacies, mathematical literacy, this study looked at the contextual, social, and academic factors that influence kindergarten students' mathematical literacy development in a constructivist reform classroom. The following research questions guided this study:

1) In a constructivist reform classroom, what are the contextual, academic, and social/cultural factors that influence kindergarten students' mathematical literacy development?

2) How is disciplinary knowledge in mathematics presented through discourse in this constructivist classroom?

The chapter will be divided into three main areas: (a) a summary of the findings of this study and its relationship to the research literature, (b) implications of the results of this study , and (c) suggested areas of further research.

A key purpose of this study was to investigate the factors that show promise as essential elements for encouraging language development in a supportive mathematics learning community. In the midst of this complex learning community, development of mathematical literacy relies on the development of multiple skills for knowing, communicating, thinking and problem solving. The complexity of this learning community is affected by the nature of how students learn mathematics and how they develop habits of mind that are conducive to growth in mathematical literacy. The student's internal representations of concepts and phenomena are key components of growth in mathematical literacy but they can not be directly observed. Evidence of the development of internal representation can, however, be inferred from external representations such as the writing on the paper, drawings, geometric sketches, spoken explanations, and written equations (Cuoco, 2001; Goldin & Shteingold, 2001). The internal representations include students' natural language abilities (verbal/syntactic), their affective systems, students' visual, spatial, kinesthetic, auditory, and rhythmic images as well as the mental manipulations of formal notational representation (Goldin and Shteingold, 2001).

The reform movement in mathematics education has changed the way that many teachers are engaging their students in classroom discourse. Representation, discussion, reading, writing, and listening are strongly emphasized in the reform literature (NCTM, 2000). Little research has been conducted in the area of language development in mathematics in these classrooms. This descriptive study was undertaken in an attempt to discover what elements may be important factors in supporting this language development.

Summary of the Study

At the broadest level of support for this language development are the theoretical and curriculum decisions that inform practice in this particular classroom. These were examined in the literature review in Chapter 2. They include (a)historical/social-cultural foundations, (b) constructivism, (c) issues in the kindergarten curriculum, (d) classroom collaboration and dialogue, (e)language and discourse development in young children, and (f) informal and formal mathematics from a reform perspective.

Historical/Social-Cultural foundations. The literature review began with a discussion of the necessity of the development of multiple literacies for all citizens drawing on the work of Dewey, Freire, Delpit, hooks, and others. Some of the key issues raised by the work of these scholars include (a) a democratic approach to education wherein the voices of all members of the society are heard (Dewey,1916), (b) a problem-posing curriculum in which the teacher and student roles merge as opposed to the banking model wherein the teacher deposits knowledge into the students (Freire, 1970), (c) explicit instruction in the codes of mainstream society (Delpit,1995), and (d) a learning environment as "a participatory space for the sharing of knowledge (hooks, p 15)."

These issues were delineated in the first of seven frameworks (Tables 3.2 through 3.8) which were used to examine the data collected in this study. A final framework (See Table 4.1) was fused from the seven individual frameworks identified from the literature presented in Chapter 2. Additional elements found in this classroom were added to the framework and the relationships between the original frameworks and the additional elements were clearly marked and will be explained in depth in this chapter. This section will begin with an explanation of the key elements found in the area of historical/socio-cultural foundations.

A democratic approach to education was evident in many different ways in Victoria's classroom. Teaching for diversity is infused throughout the classroom. Each topic or area is addressed with activities, presentations, children's books, and assignments that have been carefully chosen to help children to hear the many different voices that are present in our society and in the global society. Children are encouraged to learn about, understand and value the various families and communities represented. This is supported by Dewey's (1916) second essential purpose of the environment of the schools which is the purifying and idealizing of the existing social customs, providing for the free intercourse and communication of experience. In turn, all children in this classroom see themselves represented as characters in books, as full members of society in honored professions, etc. Their family's customs, for instance, are explored on an equal basis with those of mainstream society. The use of student initiation and choice in the classroom also supports the democratic approach to education (Table 4.1). Questions, interests, and perspectives that students bring to the classroom are embraced and become core elements in the curriculum. As Victoria (1999) stated in one of her interviews: "…allow them to collaborate, to share their thinking, to work on a project together, to have children identify with different ways of doing things. (Realize) that there is not just one right way to do something."

Children's initiation and choice within this classroom are also supported by Freire's (1970) problem-posing curriculum wherein the teacher and student roles merge. "You take it from them. Then it will be relevant. Someone picks up on something and then you can go from there. Youngest little boy said that he knew another way to count. I said 'Tell us about it.'(Victoria, 1999)." hooks (1994) explains this type of interchange as engaging in dialogue, "…one of the simplest ways we can begin as teachers, scholars, and critical thinkers to cross boundaries, the barriers that may or may not be erected by race, gender, class, professional standing, and a host of differences (p.130). Experiences in our own schooling have reinforced the idea that teacher and student are distinct roles not to be shared and yet, how can there be dialogue or discussion without at least two voices? Victoria (1999) also echoes hooks' (1994) concept of participatory spaces when she says; " I want children to come to a calm and peaceful environment where anything is possible and where we're a team together, learning and growing."

The concerns of Delpit (1995) and Gee (1989) about the inclusion of all students in the dominant discourse are addressed within Victoria's classroom by the way in which she revoices and seeds mathematical concepts and vocabulary in the midst of classroom discourse (Table 3.3). Students are thus moved from informal to formal mathematical language and concepts, building on their informal knowledge and experiences and encouraging them to develop the concepts and language of the greater mathematics community. An example of this came in the transcription of Victoria's class in which she discussed the work of a student in the morning class on patterns in the number ten. Victoria supported a student's articulation by revoicing what the student had said including more detail and seeding the conversation with mathematics vocabulary (Table

3.3). Thus students are moved towards gaining the dominant mathematics discourse (Table 3.2) which will build their opportunities for success in academic mathematics.

Constructivism. The second area of support for language development in the mathematics classroom is constructivist learning theory (Tables 3.3 and 3.5). The entire spectrum of constructivist theory was briefly examined and a learning theory based in sociocultural constructivism as delineated by Salomon and Perkins (1998) and Wilkinson and Silliman (2000) was discussed as it seem to offer the most complete perspective on constructivist learning. It includes a special emphasis on the spiral of socially mediated and individual learning which these authors hold as an essential element of constructivist learning. Individual learning and collective learning form a spiral in which the individual reaches a deeper understanding of the subject matter while the team learns better by participation in the spiral. The resistance that individuals sometimes exhibit in a learning team or community can better inform the group. Peer scaffolding becomes important in team learning in a mathematics learning community. As students work at collaborative problem solving (Tables 3.7 and 3.8), they think deeply about their solutions in order to defend their positions. As the interchange between peers continues, solutions and explanations elicit deeper reasoning skills and creativity from each individual in the learning community. The value of resistance in the learning community supports the importance of student initiation and choice within the curriculum (Table 4.1).

Victoria (1999) stresses five elements within constructivist learning in a reform classroom: (a) adult choice of curriculum that supports constructivist learning, (b) encouragement of children’s initiation, (c) children’s choice within the curriculum, (d) collaboration between children and (e) collaboration between adults and children. All five areas are in place in her classroom according to the findings of this study. The two mathematics curricula, *Investigations in Number*, *Data, and Space* (Russell, Tierney, Mokros, & Ecnomopoulos,1998) and *Mathematics Their Way* (Barrata-Lorton,1995) support the six critical conditions that Salomon and Perkins(1998) propose as necessary for learning to take place well:

1. The learning entity must be able to combine, recombine, or refine the range of representations or behaviors,
2. Feedback from internal and external sources must be used in judging how well the learning process is progressing,
3. Information from many sources, ranging from text to modeled behavior, must be available,
4. Guidance in the learning process must be provided either by self-regulation or by others,
5. The challenges faced must be neither too easy nor too difficult,
6. "The learning entity will also need conditions that sustain motivation and energy." (p.3).

The encouragement of children's initiation (Table 4.1) was one of the major findings of this study. It was evident in many of the transcripts from Victoria's classroom. Students' *wondering* directs the curriculum choices that Victoria makes throughout her day. This is balanced by a constant awareness of the standards that have been established for schools in the State of Michigan (Tables 3.7 and 3.8). These standards are, in turn, directly based on the standards of the National Council of Teachers of Mathematics (NCTM, 1989). There is a balance between children's initiation and the knowledge and wisdom which the adults in the classroom bring to the learning environment.

Children's choice within the curriculum (Table 4.1) is also evident throughout the transcripts from this kindergarten classroom. Children have a range of activities from which to choose during the day. Each of these activities meets the academic content standards but each provides for a different learning style, a different children's area of interest, or a different method for demonstration of a child's knowledge.

Collaboration between children and between children and adults can be constantly observed in this classroom (Tables 3.3 and 3.5). As was noted in Chapter 4, Victoria even provides for collaboration and scaffolding to occur between children in her morning kindergarten class and the children in her afternoon class. Melissa's explanation of the patterns that she found in composing the number ten was conveyed to and discussed in the afternoon class, providing scaffolding for those children in their work on patterns.

Issues in kindergarten curriculum. The influence of the progressive school movement and the influence of the British Primary School are both readily evident in Victoria's classroom (Table 3.4). Focus on the development of the whole child is obvious in the way in which the curricula used are integrated in their presentation. Play is not a separate period in which children can relax after the rigors of school. Play is a "…a mode of thinking and a vehicle for symbolic representation…(Goffin & Wilson, 2001, p 76)" throughout the school day. During center time, the dramatic play center provides opportunities for children to engage in reading, writing, and mathematics while acting out the parts of waitress, postal worker, or store sales clerk. While fostering growth of personal and interpersonal processes, collaboration with other children and with adults within the classroom provides for the growth of cognitive functions, presenting opportunities to acquire and order information, evaluate, reason, problem-solve, and use systems of symbols (Shapiro & Biber, 1972, cited in Goffin & Wilson, 2001).

This kindergarten classroom definitely represents "…a child-centered, experience-centered, process-oriented early childhood program promoting every aspect of a child's development in the direction of optimal human functioning (Goffin & Wilson, 2001, p.83). At the same time it provides a rigorous academic program that is developmentally appropriate for the children involved. Evidence of this is presented by the fact that the curricula, content, and processes used in this classroom meet the standards of the State of Michigan for this grade level. These, in turn, are based on the National Standards of the NCTM (1989,2000)(Tables 3.7 and3.8). The issues about cultural capital and implicit teaching that Delpit (1995) raises are at least partially addressed by student initiation, by student choice, and by the use of revoicing and seeding that Victoria uses to introduce formal mathematical language (Tables 3.2, 4.1, and 3.3).

Classroom collaboration and dialogue. We can receive guidance from Vygotsky's (Wilkinson & Silliman, 2000) educational research in the area of collaboration and dialogue in the classroom (Table 3.3). This research delineated three assumptions about language and literacy learning: (a) Learning is social, (b) Oral and written language learning is integrated, and (c) Learning requires active student engagement in classroom activities and interaction. These three assumptions resonate with the critical conditions that Salomon and Perkins (1998) propose as necessary for learning to take place well.

The dialogue scaffolds of teaching and learning provide students with direct support for the learning of content and processes. Essential parts of this classroom interaction are the cultural tools and the social activities in which the dialogue and interaction is imbedded. Victoria's approach (echoed in her student teacher's presentation of the problem on the school bus) provides direct modeling in the use of cultural tools and in the development of higher levels of conceptual and communicative competence (Table 3.2). This happens in the collaboration and dialogue that takes place between adults and children and between children in her classroom. These interactions are arranged and implemented in response to the continuous assessment (Table 4.1) that Victoria uses to inform her practice. Individual differences are respected in this process because Victoria constructs "multiple zones of proximal development (Brown & Campione, 1994, p. 236). Each child is individually supported according to the results of this continuous assessment. The activity of the Math Pads is a good example of this. Several children are working on differing levels of mathematical competency using the same materials and entering into dialogues with Victoria that she supports with skillful questioning that is engineered to help students to think at higher levels. Many of her questions are opened ended which encourages more student initiation and provokes a real dialogue as opposed to initiation-response-evaluation (IRE) conversational sequences.

The four elements that Wilkinson and Silliman (2000) recommend in group discussions are each included by Victoria (Table 3.3). These essential elements are that group discussions: (a) are guided (either by the teacher or the students), (b) include open-ended tasks that can be interpreted in multiple ways that are motivated by the topic, (c) retain friendly respect for individual differences, and (d) include student topics for discussion. The inclusion of student topics for discussion is an essential part of the dialogue in Victoria's classroom. This is highlighted in the example of students' wondering that Victoria discusses in her interview. A student is fascinated with the way that seeds travel through the air and this becomes the topic for the students' discussion on their walk through the woods. Another example of student initiation of topics (Table 4.1) is the young man who suggests that he knows another way to count. This begins a collaborative interchange with several students sharing their ways of counting. Respect for individual differences is not only given by the teacher but encouraged between the children in their collaboration (Table 3.2). Discussions are carefully guided by Victoria and the open-ended tasks as well as open-ended questions are an integral part of her teaching.

Supportive scaffolding is thus used in instructional conversations, sustaining the development of new conceptual understandings (Table 3.3). According to Echevarria (1996), some of the essential elements of instructional conversations are (a) the activating background knowledge, (b) promoting more complex language, (c) asking students to explain their reasoning, (d) using open-ended questions, and (e) encouraging connected discourse.

Language and discourse in young children. Instructional conversations and dialogue in the classroom are dependent on the continuing development of more complex language (Table 3.6). In kindergarten, children move from more informal mathematical language to the beginnings of formal academic mathematical language.

Two perspectives on language development run through the literature on language development in children. The first looks at language development in relationship to cognitive growth. This centers on the referential or representational use of language. Internal representations such as: (a) the student's natural language abilities, (b) their affective systems, (c) visual, spatial, kinesthetic, auditory, and rhythmic images, and (d) mental manipulations of formal notational representation can be inferred from the observation of external representations such as spoken and written explanations, geometric drawings, and written equations. This is the area that Piaget emphasized and this area has had a strong influence on early childhood curriculum and theory.

The work of Vygotsky (1986) has emphasized the influence of social usage on the development of language. Discourse is seen as the mediator of children's learning. This perspective on the development of language is a central theme of the social constructivist research (Tables 3.3 and 3.5). Meaning is formed in the relationship between author and reader or between speaker and listener. The spiral of socially mediated and individual learning which Salomon and Perkins (1998) espouse would also apply to language learning. Researchers need to look beyond the dichotomy of the representational use of language and the social mediation of language to a theory that delineates the interrelationship between these two perspectives.

In Victoria's classroom, socially mediated language supports the growth of cognitive representational use of language. Recursive classroom contexts such as the Morning Circle that Victoria uses provide socially mediated scaffolding that supports student growth in the representational use of language. Development of internal mathematical representation, images and mental manipulations of formal notational representation for instance, is supported by the dialogue and collaboration that takes place during Morning Circle. Mental mathematics and the understandings behind mathematical concepts are essential elements in these daily routines. One of the ways that the teacher provides a scaffold for children's content understandings in Morning Circle is through the use of conversational scripts that provide the framework for the social mediation of language learning (Table 3.6). These scripts support the development of the rules of academic conversations and support the acquisition of content knowledge. A wide range of content knowledge and the rules of conversation are necessary in order for children to participate in dialogue in mathematics.

Halliday (1969) encourages teachers to broaden their definitions and descriptions of language since children come to school with a more complex understanding of the uses of language than most earlier childhood classes utilize. He identifies seven models of language of which children are aware when they enter kindergarten (Table 3.6). Many of the language tasks used in early childhood classrooms simplify these models which confuses children because the children are then required to accept a stereotype of language that ignores the insights that they have gained from their own experience. These seven models follow with some short examples of their presence in Victoria's classroom drawn from the study:

1. Instrumental-language as a means of getting things done,

    Students use language to plan activities for center time.

2. Regulatory-language is used to regulate others behavior,

    One student directs another student to put clothes pins on the T-chart in pairs. Students can regulate each other's behavior in a learning situation.

3. Interactional-language used in the interaction between people,

This is obvious in all of the collaborative work that is done in Victoria's classroom. Children are encouraged to interact with each other as well as with the teacher.

4. Personal-language as a form of individuality,

   Students have a bulletin board on which they are invited to express their emotional response to their morning. They choose various faces with expressions of frustration, happiness, surprise, etc. They often have a meeting time in which they discuss why they chose the face that they did and talk about feelings and reactions to important happenings in the classroom.

5. Heuristic-language as a means of exploring reality,

   The classroom is rich in informational text and students are encouraged to explain nature objects that they have brought into class. They are encouraged to write informational pieces as well as narratives.

6. Imaginative-language used to create one's own environment,

   Dramatic Play Centers encourage children to create their own environment and to utilize reading, writing, speaking, and listening in the midst of that creation.

7. Representational-language as a means of communicating about something.

   Their work in mathematics is filled with opportunities to represent objects, processes, and events. What is somewhat unique in this classroom is the opportunity to choose the method of representation.

> So, when recording objects from the Counting Jar on the first day of school, some students drew pictures, some used tally marks and some used numbers and symbols. Students are encouraged to represent mathematical processes by explaining how they solved problems.

Informal and formal mathematics from a reform perspective. The discussion so far has centered on the first research question; “ In a constructivist reform classroom, what are the contextual, academic, and social/cultural factors that influence kindergarten students’ mathematical literacy development.” The factors identified in the literature review have been examined and related to what has been observed in the classroom during this study. The second research question directs our attention to the disciplinary knowledge in mathematics and how it is presented through discourse in this classroom. The Michigan Curriculum Framework (Michigan Department of Education,1996) was the guiding document for the school district’s official curriculum. This was based on the National Council of Teachers of Mathematics Standards published in 1989 (Table 3.8). These Standards are widely recognized as representing the content and process knowledge that educators, scientists, and mathematicians hold as essential in student learning in the United States. The Standards were rewritten in 2000 with even more guidance from the scientific and mathematics communities (NCTM, 2000).

The breadth and depth of the curriculum standards for kindergarten, as delineated in *Curriculum and Evaluation Standards for School Mathematics*

(NCTM,1989), have been examined in relationship to the transcripts from the study of this classroom. Evidence was found that each of the standards was met in its presentation in the classroom curricula. The relationship between the classroom discourse and the presentation of disciplinary or content knowledge was also examined. As mentioned earlier, the scaffolds of dialogue in a constructivist classroom provide students with direct support for learning of mathematical content and processes. The NCTM Standards (NCTM, 1989) are organized into four process standards:

1. problem-solving,
2. communication,
3. reasoning, and
4. mathematical connections,

along with nine content standards:

5. estimation
6. number sense and numeration
7. whole number operations
8. whole number computation
9. geometry and spatial sense
10. measurement
11. statistics and probability
12. fractions and decimals
13. patterns and relationships.

Drawing on the examples from the transcripts of this study which were used in chapters three and four, we can see how the predominant modes of presentation of content knowledge are through: (a) collaboration with adults and with other children (Communication, Standard 2), (b) modeling (Communication, Standard 2), (c) continuous assessment and differentiation of learning activities, and (d) the solicitation of reasoned explanations about the problem-solving approaches that the children use in their solution of mathematical problems (Problem-Solving and Reasoning, Standards 1 and 3). Because of the integrated approach used in this classroom the four process standards of Problem-Solving, Reasoning, Communication, and Mathematical Connections are deeply imbedded in all of the mathematics in this classroom. Connections (Standard 4) between areas of mathematics will become obvious as each of the Content Standards is discussed within classroom scenarios from Chapters 3 and 4 of this study.

Numerous examples from the transcripts of this study could be used as evidence of the ways in which content knowledge is presented through the classroom discourse in the collaboration with adults and with other children, through the discourse surrounding modeling and the seeding of concepts and vocabulary, through continuous assessment and differentiation, and through the solicitation of reasoned explanations. This discussion will center on the examples from Chapters 3 and 4 of this research study with which the reader is already familiar.

Estimation (Standard 5) in Victoria's classroom is taught within the real world experiences of the children. One example is the estimation graph that the class worked on after their trip to an apple orchard. Students estimated how many apples were in a bag from the orchard and wrote their estimates on sticky notes. Some students used tally marks to represent their estimates, others drew pictures of apples and still others used numerals on their sticky notes. Multiple and diverse methods of representing data were encouraged. These were placed on a white floor mat that was arranged in form of a graph. The use of sticky notes and the floor graph introduced the children to concepts from the Probability and Statistics Content Standard (Standard 11) on how to represent and read data. The students could later check their estimates comparing how close they were to the actual number of apples as they counted the apples together as a class (Standard 6, Number Sense and Numeration). As part of this unit, students were also introduced to discussions about halves of apples (Standard 12). Many students come to kindergarten with strong informal mathematical knowledge of fair shares especially with the concept of one half. Early building on this background knowledge is essential for preparing students for the more complex third, fourth, and fifth grade standards on fractions. Measurement (Standard 10) is another standard that is introduced to students in this classroom through real world applications. Example are activities in which students cook with parent's help in the classroom. Nonstandard measurements are also used with familiar classroom and home materials.

Concepts of Whole Number Operations (Standard 7) was implemented in the Bus Problem that Victoria's student teacher, Elizabeth, introduced to the students. This was done with the simulation of a school bus ride that was very similar to their own experience on school buses in the district. In first grade, a similar problem was given as a written problem that students solved individually and they each wrote an explanation of how they had solved the problem along with a number sentence that met the Standard of Whole Number Computation (Standard 8).

Students in Victoria’s classroom develop concepts of Geometry and Spatial Sense (Standard 9) through the use of the manipulatives that are available to them during Center Time and their representations and participation in classroom discourse that follow these activities. Building projects from the Lego Center and other block centers are often represented in drawings that students later share with the class. Students use pattern blocks to match cards and later create their own for other students to produce. This helps to develop spatial sense as well as helping children to “… recognize, describe, extend, and create a wide variety of patterns” (NCTM, 1989, p.60). This is part of Standard 13.

Real world concrete experiences and simulations such as dramatic play centers form the core of the mathematics learning environment in this Constructivist classroom. Growth in content knowledge as well as growth in problem-solving, representation, discussion, reading, writing, and listening flow from these experiences and are supported by the spiral of mediated collaborative and mediated individual learning present in Victoria’s classroom. Victoria individualizes scaffolds for each child based on continuous assessments. These scaffolds utilize the dialogue between children and adults and children and their peers within the classroom. Children’s initiation and choice (Table 4.1) within the reform based curricula directly support individual and collective learning in both content and process areas while multiple and diverse methods of representation and communication are encouraged.

Implications of this Study for the Classroom Teacher

As we examine the implications of this study for teachers in mathematics classrooms, we return to Victoria's (1999) description of the essential elements in her constructivist classroom:

Victoria:

> I think of the three "C's when I think of constructivist. One, have a curriculum that will engage children's curiosity and have them love learning. Allow them choices. And the choice is not to pass on your reading, or your writing or your math but choices within those. And also to allow them to collaborate; to share their thinking, to work on a project together, to have children identify with different ways of doing things. (Realize) that there is not just one right way to do something. Often, for example, in mathematics there is one right answer but there's lots of different ways to arrive at that and celebrating the different ways that we can use our creativity to solve problems is essential.

In an earlier interview Victoria (1998) also mentioned another essential in her constructivist classroom, that of student initiation which is closely linked to student choice:

Victoria:

You take it from them. Then it will be relevant. Someone picks up on something and then you can go from there.

Curricula. Several key recommendations for best practices in mathematics education follow from the results of this research study. These recommendations flow directly from Victoria's (1999) essential elements of a constructivist classroom. First, school districts and teachers need to carefully choose mathematics curricula that engage children's curiosity and that encourage problem-posing and problem-solving as opposed to curricula that follow the banking model (Freire, 1970) wherein the teacher covers large amounts of content in order to fill the students with knowledge (Table 3.2). This recommendation is supported by an analysis of the findings of the Third International Mathematics and Science Study written by Schmidt, McKnight, and Raizen (1997).

Children's initiation and choice.The second recommendation is to plan curricula to encourage students' initiation and choice (Table 4.1). This recommendation does create a challenge for planning in the curriculum. In a similar study involving a middle school science classroom, Templin (1998) discusses this challenge: "Using this form of instruction [emerging discourse], teachers can not know in advance how or even whether any particular chunk of content will enter classroom discussion. With this in mind, planning becomes focused on activities which are likely to provoke class attention to certain issues" (p.169). Victoria seeded discussions with concepts and vocabulary that were directed at particular content and process skills. She regularly began discussions of student-generated problems and solutions. Using an example from a student in her morning kindergarten, she was able to extend students' thinking on finding patterns in mathematics problems.

Student choice also calls for careful planning to insure that each student's choices address the broad range of content and process learning that is needed. Regularly, Victoria made some of the choices for students during center time: “ Felix, you haven’t chosen the calendar activity this week. Please do that before you make any other choices.” Planning that includes children’s initiation and choice moves the teacher from the controlling position of teacher-directed learning to that of a problem-posing educator (Freire, 1970). “The problem-posing educator constantly re-forms his reflection in the reflection of the students. The students – no longer docile learners – are now critical co-investigators in dialogue with the teacher” (Freire, 1970, p.68).

Encouraging complex use of language. The third recommendation for teachers of mathematics is to develop skills in encouraging and helping to develop children’s complex use of language (Table 3.6). Children come to school expecting language to have many different purposes and expecting that it will be meaningful (Halliday, 1969). The language of mathematics, in a traditional classroom, can seem so far from students’ background knowledge and so abstract that students begin to believe that there is very little meaning beyond the process skills of doing arithmetic problems. The activities that Victoria planned around the trip to the apple orchard were grounded in the children’s experience. Encouraging various types of representations of the number of apples in the bag allowed each child to use language (pictures, tallies, numbers, etc.) in a way that was meaningful to each one of them.

Collaboration between adults and children and between children. Planning for collaboration between adults and children and between children is the fourth essential recommendation of this research study for the classroom teacher (Tables 3.3 and 3.5). NCTM (1991) discusses collaboration and the discourse roles of teachers and students in *Professional Standards for Teaching Mathematics.* In a traditional mathematics classroom "…the flow of ideas and knowledge is primarily from teacher to student. When students make public conjectures and reason with others about mathematics, ideas and knowledge are developed collaboratively, revealing mathematics as constructed by human beings within an intellectual community" (p.34). Teachers can encourage this discourse through the questions that they ask and through the activities that they plan in the classroom. These activities should engage each student and challenge him/her to develop higher level mathematical thinking. Opportunities for students to conjecture, to present mathematical reasoning based on evidence, and to clarify their ideas should be essential elements in the classroom planning process. This research study has shown that all of this can exist in a kindergarten mathematics classroom.

Continuous assessment and differentiated instruction. Continuous assessment that informs a differentiation of instruction for each child in the classroom is the fifth recommendation of this study (Table 4.1). Within the learning spiral in a community of learners, continuous individual assessment allows the teacher to respond to the unique learning strengths and challenges of each child who constructs knowledge through interactions within socially mediated contexts. "Emphasizing tasks that focus on thinking and reasoning serves to provide the teacher with ongoing assessment information" (NCTM, 1991, p.35). Our exploration of Victoria's classroom has allowed us to see how a differentiated curriculum might be implemented in response to that ongoing assessment (Table 4.1).

Implications for Research

Teaching methods. Research in the area of development of language in the reform mathematics classroom has been limited. The relatively few studies in the literature indicate that our knowledge in this very important area is limited. Teaching methods that encourage discourse in the classroom offer promise for more engaged learning but little research has been done with some of the more promising methods such as the use of instructional conversations. As Echeverria (1996) indicates: “Until recently approaches such as instructional conversations have been largely theoretical, and lacked empirical evidence for their effectiveness, although advocated in the literature” (p. 360). This leaves us with many unanswered questions such as:

1. What are the most effective classroom methods that encourage classroom discourse?
2. How can teachers best implement these methods?
3. Do these methods improve student motivation and inspire student engagement in learning?
4. Do students learn better in classrooms that utilize these methods?
5. Can methods and approaches such as those described in this study be used by teachers of older students?
6. Will these methods work well in content areas that are more complex than the kindergarten curriculum?
7. Will the elements observed be different in a classroom for older students?

Student motivation. Another research area to explore is student motivation and its relationship to student initiation and student choice. Although there has been much research in the area of motivation and learning, it has been my experience that many classroom teachers are unaware of the research or of the importance of these issues. The following questions follow from the current research:

1. Do environments that support and encourage student initiation of problems and questions motivate students to pursue deeper understandings of key content and processes in mathematics?
2. Can all of the expectations of standards-based curricula be met in a classroom that encourages student choice?
3. Is student choice motivating for deeper learning or will students simply take the easier way to finishing the work?

Differentiation of instruction. It is very difficult for teachers to meet the needs of every child in the increasingly diverse classrooms of today. Echevarria (1996) indicates that many teachers of language minority students are drawing guidance from special education. He discusses the inherent problem in this approach:

> Many special education programs promote a reductionistic approach, emphasizing task-analysis and highly structured drill and practice for mastery of discrete skills. Critics suggest that such reductionism takes the task too far out of context so that it becomes a meaningless, even trivial, exercise that does not encourage concept development or allow students to use language in a meaningful way (Ortiz & Wilkinson, 1991, cited in Echevarria, 1996, p.340).

Differentiation of instruction may provide a successful approach to this problem but how the instruction is actually structured is at least as important as the differentiation. So while some of the questions for further research will flow from the concept of differentiation and continuous assessment, these must be combined with research on what methods of differentiation foster meaningful language use and avoid reductionist approaches to teaching and learning in the classroom. The following research questions arise from this discussion:

1. Is differentiation a viable approach to this problem?
2. What are the most efficient methods for a teacher to use in differentiation of instruction that preserve the context and meaningful language support?
3. Does continuous or ongoing assessment provide a better method to inform practice in the classroom than the criterion and norm-referenced standardized tests that are proliferating across the country?
4. Will these continuous assessment approaches provide time for more powerful instructional time?
5. Do these continuous assessment approaches provide adequate guidance for the differentiation of instruction?

Pre-Service teachers. Finally, as a pre-service teacher educator, I am concerned with how future teachers will be able to benefit from research into these practices. We know that the movement towards more accountability for teachers will include the need for teachers to develop skills in research within their classroom and to develop the ability to use evidence-based methods for justifying their choice of teaching methods. Several question flow from this:

1. If subsequent research does support the value of these methods and approaches, how will teachers learn to implement these practices?
2. What are the most effective ways of teaching best practice approaches to in-service and pre-service teachers who probably have not experienced these methods themselves?

Chapter Summary

In this chapter, I summarized this study of the contextual, academic, and socio-cultural factors influencing kindergarten students' mathematical literacy development using the categories from the review of literature and demonstrating where each of these elements could be found. I then discussed the complexity of the learning environment and the new findings and new emphases that were revealed by this study. These included (a) choice of curriculum, (b) children's choice and initiation within the curriculum, (c) the necessity of encouraging complex use of language and discourse within the classroom, (d) the importance of collaboration between adults and children and between children within this environment, and (e) the interrelationship of continuous assessment and differentiated instruction The implications of this study for the classroom teacher were delineated and implications for research were suggested in the areas of: (a) teaching methods, (b) student motivation, (c) differentiation of instruction, and (d) in the development of curricula for the teaching of pre-service teachers.

References

Abdal-Haqq, I. (1998). *Constructivism in teacher education: Considerations for those who would link practice to theory*. Washington, DC: ERIC Clearinghouse on Teaching and Teacher Education. (ERIC Document Reproduction Service No. ED426986)

Atwell, N. (1991). *Side by side: Essays on teaching to learn*. Portsmouth, NH: Heinemann.

Bakhtin, M. (Ed.). (1986). *Speech genres and other late essays*. Austin, TX: University of Texas Press.

Ballew, H., & Cunningham, J. (1982). Diagnosing strengths and weaknesses of sixth grade students in solving word problems. *Journal for Research in Mathematics Education, 13*, 202-210.

Baratta-Lorton, M. (1995). *Mathematics their way*. Menlo Park, CA: Addison-Wesley.

Baroody, A. (1987). *Children's mathematical thinking: A developmental framework for preschool, primary, and special education.* New York: Teachers College Press.

Billow, R. (1981). Observing spontaneous metaphor in children. *Journal of Experimental Child Psychology, 31*, 430-445.

Bowerman, M. (1981). The child's expression of meaning. In Winitz (Ed.), *Native language and foreign language acquisition* (pp. 172-189). New York: New York Academy of Sciences.

Bredekamp, S., & Copple, C. (Eds.). (1997). *Developmentally appropriate practice for the education of young children*. Washington, DC: National Association for the Education of Young Children.

Brimijoin, K., Marquiesee, E., & Tomlinson, C. (2003). Using data to differentiate instruction. *Educational Leadership, 60*(5), 70-73.

Brown, A., & Campione, J. (Eds.). (1994). *Guided discovery in a community of learners*. Cambridge, MA: MIT Press.

Brown, R. (1991). The one-literacy schoolhouse in the age of multiple literacies. *Educational Horizons, 36*(3), 141-145.

Bullock, J. (1994). Literacy in the language of mathematics. *American Mathematical Monthly, 101*(8), 735-743.

Calkins, L. (1986). *The art of teaching writing*. Portsmouth, NH: Heinemann.

Carr, E., Aldinger, L., & Patberg, J. (2000). *Thinking Works*. Toledo, OH: Thinking Works.

Cassady, J., Neumeister, K., Adams, C., Cross, T., Dixon, F., & Pierce, R. (2004). The differentiated classroom observation scale. *Roeper Review, 26*(3), 139-147.

Chase, C. (1961). Formal analysis as a diagnostic technique in arithmetic. *Elementary School Journal, 13*(3), 282-286.

Churchill, V. (1998). Interview with teacher-researcher. Toledo, OH: University of Toledo.

Churchill, V. (1999). Interview with teacher -researcher. Toledo, OH: University of Toledo.

Churchill, V. (2000). Interview with teacher-researcher. Toledo, OH: University of Toledo.

Cobb, P., Boufi, A., McClain, K., & Whiteneck, J. (1997). Reflective discourse and collective reflection. *Journal for Research in Mathematics Education, 28,* 258-277.

Cox, J., & Wiebe, J. (1984). Measuring reading vocabulary and concepts in mathematics in the primary grades. *The Reading Teacher, 37*, 402-410.

Creswell, J. (1998). *Qualitative inquiry and research design: Choosing among five traditions.* Thousands Oaks, CA: Sage Publications.

Cunningham, P., & Hall, D. (1996). *Guided reading the four blocks way: With building blocks and big blocks.* Greensboro, NC: Carson Dellosa.

Cuoco, A., & Curcio, F. (Eds.). (2001). *The roles of representation in school mathematics: 2001 yearbook*. Reston, VA: National Council Teachers of Mathematics.

Delpit, L. (1995). The silenced dialogue: Power and pedagogy in educating other people's children. In L. Delpit (Ed.), *Other people's children* (pp. 21-47). New York: The New Press.

DeVries, R., & Kohlberg, L. (1987). *Programs of early education: The constructivist view*. New York: Longman.

Dewey, J. (1916). *Democracy and education*. New York: The Free Press.

Earle, R. (1976). *Teaching reading and mathematics*. Newark, DE: International Reading Association.

Echevarria, J. (1996). The effects of instructional conversations on the language and concept development of Latino students with learning disabilities. *The Bilingual Research Journal*, *20*(2), 339-363.

Eisenhart, M., Borko, H., Underhill, R., Brown, C., Jones, D., & Agard, P. (1993). Conceptual knowledge falls through the cracks: Complexities of learning to teach mathematics for understanding. *Journal for Research in Mathematics Education, 24*, 8-40.

Eisner, E. (1991). Rethinking literacy. *Educational Horizons*, *69*(3), 120-128.

Erickson, F. (1986). Qualitative methods in research on teaching. In M. Wittrock (Ed.), *Handbook on research on teaching* (3rd ed.). New York: Macmillan Publishing Co.

Fountas, I., & Pinnell, G. (1996). *Guided reading: Good first teaching for all children*. Portsmouth, NH: Heinemann.

Franklin, M., & Barten, S. (1988). *Child language: A reader*. New York: Oxford University Press.

Freire, P. (1970). *Pedagogy of the oppressed*. New York: Continuum Publishing Company.

Gee, J. (1989a). Literacy, discourse, and linguistics: Introduction. *Journal of Education, 171*(1), 5-17.

Gee, J. (1989b). What is literacy? *Journal of education, 171*(1), 18-25.

Giroux, H. (1997). Pedagogy and the politics of hope: Theory, culture, and schooling. Boulder, CO: Westview Press.

Glesne, C. & Peshkin, A. (1992). Becoming qualitative researchers. White Plains, New York: Longman.

Goffin, S., & Wilson, C. (2001). *Curriculum models and early childhood education: Appraising the relationship*. Upper Saddle River, New Jersey: Merrill Prentice Hall.

Goldenberg, C., & Gallimore, R. (1991). Changing teaching takes more than a one-shot workshop. *Educational Leadership, 49* (3), 69-72.

Goldin, G., & Shteingold, N. (2001). Systems of representation and the development of mathematical concepts. In A. Cuoco & F. Curcio (Eds.), *The roles of representation in school mathematics: 2001 yearbook* (pp. 1-23). Reston, VA: National Council Teachers of Mathematics.

Hale-Benson, J. (1986). *Black children: Their roots, culture and learning styles*. Baltimore, MD: Johns Hopkins.

Halliday, M. (1969). Relevant models of language. *Educational Review, 22*, 26-37.

Heath, S. (1982). What no bedtime story means: Narrative skills at home and school. *Language in Society, 11*(1), 49-76.

Heinrichs, M., & Sisson, T. (1980). Mathematics and the reading process: A practical application of theory. *Mathematics Teacher, 73*, 253-257.

Hicks, D. (1995). Discourse, learning, and teaching. In M. Apple (Ed.), *Review of research in education* (Vol. 21, pp. 49-95). Washington, DC: American Educational Research Association.

hooks, b. (1994). *Teaching to transgress: Education as the practice of freedom*. New York: Routledge.

Jackson, M., & Phillips, E. (1983). Vocabulary instruction in ratio and proportion for seventh graders. *Journal for Research in Mathematics Education, 14*, 337-343.

Kamii, C. (2000). *Young children continue to reinvent arithmetic: Implications of Piaget's theory*. New York: Teachers College Press.

Kamii, C. (1989). *Young children reinvent arithmetic: Implications of Piaget's theory*. New York: Teachers College Press.

Kamii, C. (Ed.). (1991). *Early literacy: A constructivist foundation for whole language*. Washington, DC: National Education Association.

Kessler, S., & Swadener, B. (Eds.). (1992). *Reconceptualizing the early childhood curriculum: Beginning the dialogue.* New York: Teachers College Press.

Kouba, V., Brown, C., Carpenter, T., Lindquist, M., Silver, E., & Swafford, J. (1988). Results of the fourth NAEP assessment of mathematics: Measurement, geometry, data interpretation, attitudes, and other topics. *Arithmetic Teacher*, *35*, 10-16.

Lubeck, S. (1998). Is developmentally appropriate practice for everyone? *Childhood Education, 74*, 283-298.

Magnusson, S., Palincsar, A., & Templin, M. (2004). Community, culture, and conversation in inquiry-based science instruction. In L. Flick & N. Lederman (Eds.), *Scientific inquiry and the nature of science: Implications for teaching, learning, and teacher education* (pp. 131-155): Kluwer Press.

Markman, E., & Hutchinson, J. (1984). Children's sensitivity to constraints on word meaning: Taxonomic vs. thematic relations. *Cognitive Psychology, 16*, 1-27.

Marshall, C., & Rossman, G. (1995). *Designing qualitative research* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Martin, M., & Kelley, D. (Eds.). (1996). *Third international mathematics and science study (TIMSS) technical report*. Chestnut Hill, MA: Boston College.

McLaughlin. (1989). Power and the politics of knowledge: Transformative leadership and curriculum development for minority language learners. *Peabody Journal of Education, 66*(3), 41-60.

Michigan Department of Education. (1997). *Michigan curriculum framework*. Lansing, MI: Author.

Muth, K. (1984). Solving arithmetic word problems: The role of reading and computational skills. *Journal of Educational Psychology, 76*, 205-210.

Muth, K. (1988). Research and practice: Comprehension monitoring: A reading-mathematics connection. *Reading Research and Instruction, 27*(3), 60-67.

Nager, N., & Shapiro, E. (2000). The developmental-interaction approach to education: Retrospect and prospect. In N. Nager & E. Shapiro (Eds.), *Revisiting a progressive pedagogy*. Albany, NY: State University of New York Press.

National Association for the Education of Young Children, & International Reading Association. (1998*). Learning to read and write: Developmentally appropriate practice for young children*: Washington, DC: Authors.

National Council for Social Studies. (1994). *Curriculum studies for social studies*. Washington, DC: Author.

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

National Council of Teachers of Mathematics. (1991). *Professional standards for teaching mathematics.* Reston, VA: Author.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Reston, VA: Author.

National Council Teachers of English & International Reading Association. (1996). *Standards for the English language arts*. Urbana, IL: National Council of Teachers of English.

National Research Council. (1989). Everyone counts: A report to the nation on the future of mathematics education. Washington, DC: National Academy Press.

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

Nel, J. (1993). Preventing school failure: The Native American child. *Preventing School Failure, 37*(3), 19-24.

Nelson, K., & Gruendel, J. (1979). At morning it's lunchtime: A scriptal view of children's dialogues. *Discourse Processes, 2,* 73-94.

No child left behind act of 2001, Pub. L. No. 107-110, (2001).

Nolan, J. (1984). Reading in the content area of math. In M. Dupuis (Ed.), *Reading in the content areas: Research for teachers* (pp. 28-40). Newark, DE: International Reading Association.

O'Brien, D., Stewart, R., & Moje, E. (1995). Why content literacy is difficult to infuse into the secondary school: Complexities of curriculum, pedagogy, and school culture. *Reading Research Quarterly*, *30*(3), 442-463.

Oakes, J. (1985). *Keeping track: How schools structure inequality*. New Haven, CT: Yale University Press.

Oldfather, P., & Dahl, K. (1994). Toward a social constructivist reconceptualization of intrinsic motivation for literacy learning. *Journal of Reading Behavior, 26,* 139-158.

Pallas, A., Entwisle, D., Alexamder, K., & Stluka, M. (1994). Ability group effects: Instructional, social, or institutional? *Sociology of Education*, *67*, 27-46.

Payne, J. (Ed.). (1990). *Mathematics for the young child*. Reston, VA: National Council of Teachers of Mathematics.

Plank, G. (1994). What silence means for educators of American Indian children. *Journal of Indian Education, 34*(1), 20-34.

Pressley, M., & Brainerd, C. (Eds.). (1985). *Cognitive learning and memory in children: Progress in cognitive development research.* New York: Springer-Verlag.

Reehm, S., & Long, S. (1996). Reading in the mathematics classroom. *Middle School Journal*, 402-410.

Reys, B. (1992). *Developing number sense in the middle grades*. Reston, VA: National Council of Teachers of Mathematics.

Romberg, T., & Carpenter, T. (1986). Research on teaching and learning mathematics: Two disciplines of scientific enquiry. In M. Wittrock (Ed.), *Handbook of research on teaching*. New York: McMillan.

Routman, R. (1991). *Invitations: Changing as teachers and learners k-12*.

Russell, S., Tierney, C., Mokros, J., & Economopoulos, K. (1995). *Investigations in number, data, and space*. White Plains, NY: Dale Seymour.

Salomon, G., & Perkins, D. (1998). Individual and social aspects of learning. In R. Pearson & A. Iran-Nejad (Eds.), *Review of research in education* (Vol. 23). Washington, DC: American Educational Research Association.

Schell, V. (1982). Learning partners: Reading and mathematics. *The Reading Teacher, 35*, 544-548.

Schmidt, W., McKnight, C., & Raizen, S. (1997). *A splintered vision: An investigation of U.S. science and mathematics education.* Boston: Kluwer.

Schulte, P. (1996). A definition of constructivism. *Science Scope, 20*(3), 25-27.

Secada, W. (1992). Race, ethnicity, social class, language, and achievement in mathematics. In D. Grouws (Ed.), *Handbook of research on mathematics teaching and learning*. Reston, VA: National Council Teachers of Mathematics.

Silliman, E., Bahr, R., Beasman, J., & Wilkinson, L. (2000). Scaffolds for learning to read in an inclusion classroom. *Language, Speech, and Hearing Services in the School, 31*, 265-279.

Simon, M. (1995). Constructing mathematics pedagogy from a constructivist perspective. *Journal for Research in Mathematics Education, 26*, 114-145.

Skemp, R. (1978). Relational understanding and instrumental understanding. *Arithmetic Teacher*, *26(3), 9-15.*

Sowder, J., & Schappelle, B. (1994). Research into practice: Number sense-making. *Arithmetic Teacher, 41*(6), 342-345.

Taylor, H. (1991). Ambivalence toward Black English: Some tentative solutions. *The Writing Instructor, 10*(3), 121-135.

Templin, M. (1998). Science discourse in a middle grade classroom attempting learning community-centered science instruction. (Doctoral dissertation, University of Michigan, 1990). Dissertation Abstracts International, 59/07 p. 2432.

Tomlinson, C. (1995). *Differentiating instruction for advanced learners in the mixed-ability middle school classroom* (No. E536). Reston, VA: ERIC Clearinghouse on Disabilities and Gifted Education. (ERIC Document Reproduction Service No. ED386832).

von Glaserfeld, E. (1979). Cybernetics, experience and the concept of self. In M. Ozer (Ed.), *A cybernetic approach to the assessment of children: Toward a more humane use of human beings* (pp. 67-113). Boulder, CO: Westview Press.

von Glaserfeld, E. (1995). *Radical constructivism: A way of knowing and learning.* London: Farmer Press.

Vosniadou, S., Ortony, A., Reynolds, R., & Wilson, P. (1984). Sources of difficulty in the young child’s understanding of metaphorical language. *Child Development, 55*, 1588-1606.

Vygotsky, L. (1978). *Mind in society: The development of higher mental processes*. Cambridge, MA: Harvard University Press.

Vygotsky, L. (1981). The genesis of higher mental functions. In J. Wertsch (Ed.), *The concept of activity in soviet psychology*. Armonk, NY: Sharpe.

Vygotsky, L. (1986). *Thought and language*. Cambridge, MA: MIT Press.

Weber, L. (1971). *The British infant school and informal education*. London: Prentice-Hall International.

Whitin, D., Mills, H., & O'Keefe, T. (1990). *Living and learning mathematics: Stories and strategies for supporting mathematical literacy*. Portsmouth, NH: Heinemann.

Whitin, D., & Whitin, P. (1996). Fostering metaphorical thinking through children's literature. In P. Elliott & M. Kenney (Eds.), *Communication in Mathematics, K-12 and Beyond*. Reston, VA: National Council Teachers of Mathematics.

Wiersma, W. (2000). *Research methods in education*. Needham Heights, MA: Allyn and Bacon.

Wilkinson, L., & Silliman, E. (2000). Classroom language and literacy learning. In M. Kamil, P. Mosenthal, P. Pearson & R. Barr (Eds.), *Handbook of reading research* (Vol. 3, pp. 337-360). Mahwah, New Jersey: Lawrence Erlbaum Associates.

Winner, E., Rosenstiel, A., & Gardner, H. (1976). The development of metaphorical understanding. *Developmental Psychology, 12*, 289-297.

Yaden, D., Rowe, D., & MacGillivray, L. (Eds.). (2000). *Emergent literacy: A matter (polypony) of perspectives* (Vol. 3): Mahwah, NJ: Erlbaum.