INTEGRATING ART AND MATH: TEACHING PLACE VALUE IN THIRD GRADE

By

NANCY GREER

Bachelor of Science
Oklahoma State University
Stillwater, Oklahoma
1968

Master of Science
Oklahoma State University
Stillwater, Oklahoma
1983

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Thesis Approved:

Margaret M. Scott

Thesis Adviser

Kay Reinke

Chris Moseley

Pamela J. Fry

Wayne B. Powell

Dean of the Graduate College

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CHAPTER I

INTRODUCTION

The *Professional Teaching Standards for School Mathematics* states as one of its undergirding goals that "all students can learn to think mathematically" (National Council of Teachers of Mathematics [NCTM] 1991, p. 21). By "all students" the NCTM includes: students who have access to educational opportunities and those who do not, minorities, students who are female and those who are male, and students who have been successful in mathematics and those who have not. This is a powerful assumption on the part of the NCTM, and it has not yet been realized (Sadker & Sadker, 1994).

According to the NCTM, 1991, the study of mathematics has had negative connotations associated with it by many students, parents, and teachers. In many ways the study of mathematics has been a sorting mechanism in that those few children identified as mathematically talented were encouraged to pursue higher arenas of mathematics, while those judged—often by teachers—as mathematically challenged, were discouraged from choosing careers in mathematically-related fields of study (NCTM, 1991). In recent decades this type of sorting system has shown its inadequacy. More and more citizens—most of whom would not be identified as "mathematically talented"—are experiencing an increased need to understand the quantitative complexities of mathematics to be able to survive in today's society (NCTM, 1991). For example, new technological advances such as the self-service ATM banking system, important consumer reports, and an increased use of the Internet are incentives to produce quantitatively competent citizens. Where does this competency begin?

This competency finds its roots in school mathematics' programs all over our country. Our schools must begin to nurture the development of students at an early age so they will be successful in mathematics and embrace a life-long learning approach to mathematics. Promoting the belief system that all children can learn number concepts and calculations is the critical first step to increasing the number of children who do well in mathematics because they will have the confidence and attitude it takes to succeed in mathematics' programs (NCTM, 1991). This belief can be a powerful influence in the type of school system we embrace with specific reference to what curriculum we provide and who will teach it. However, more is needed than merely promoting a belief system.

Eisner (1998) suggests that the programs we provide in schools, what we include and what we exclude, what we emphasize and what we minimize, what we assign prime time and what we assign to the remainder reflect the directions in which we believe children should grow. Educators help shape minds, and the curriculum we provide is one of the most important tools we use in the process. Eisner believes that the mind is a form of cultural achievement, and the school programs we develop and implement help define the kinds of minds that children will be given the opportunity to own. The curriculum also represents, symbolically, the cognitive virtues that we value (Eisner, 1998). Applied to the assumptions of the NCTM, this would appear to indicate that if the council is serious about implementing a nation-wide effort to ensure the success of children in learning mathematics, articulating those assumptions is not enough. We must look to the schools, their curricula, their teachers, and, most importantly, the needs of the children in order to implement math programs in which all children can learn to think mathematically.

When considering what types of math programs to implement, educators must first understand that children acquire knowledge in different ways. One manner of teaching does not work for all children. According to Gardner (1993), to be successful in reaching and teaching all children, we must incorporate into our teaching methods a multiplicity of teaching styles. Gardner (1993) states that school is difficult for many children because the curriculum is often presented in frameworks that emphasize the linguistic and logical-mathematical intelligences not easily understood or mastered by children whose intellectual strengths lie in other areas. He notes that in addition to the linguistic and logical-mathematical intelligences, children may possess at least five other intelligences. Though Gardner's theories have gained recognition by educators, more must be done to help teachers understand how to utilize and implement classroom instruction that includes strategies for all of the seven intelligences.

Background Information

Though I did not realize it at the time, I think this study has been taking shape since I was a child studying mathematics more decades ago than I wish to acknowledge. It began in childhood with my experiences in number construction in the classroom and continues in my professional life as a teacher and as a student. I decided at some point in my student career that I did not like math because I was not successful in my attempts to master it. Positive math memories were few. A long absence from school when the concepts of multiplication and division were taught, difficulties with decoding and understanding story problems, a failing notice in high school geometry, and the pressure of trying to live up to family scholarly standards were sources that produced anxiety about mathematics. I felt this anxiety every time I entered a math classroom.

By the time I reached college, I knew I had experienced as much math as I ever wanted or needed. I was dismayed to find that requirements to obtain a degree in teaching included two math courses explicitly designed for elementary teachers and a course in testing and measurements. As each class rolled around on my course schedule, I enrolled, took tests, and made Cs in each course. Let's face it—I was a "dummy" in math; but, then, girls weren't expected to be good in math anyway (Sadker & Sadker, 1994).

Thirteen years later I was employed to teach third grade in a departmentalized school situation—meaning, of the three teachers hired to teach third grade, one would teach science, one would teach social studies, and I would teach math. I felt a bit overwhelmed, to say the least, but to my surprise, I found I enjoyed teaching math, and many of the concepts taught in the designed-for-teachers math courses that I had failed to comprehend as a student I now understood.

It made sense to me now, except for one thing. Some of the math concepts I taught the children were understood quickly while others I would teach, reteach, and stand on my head to teach and children "just didn't get it." I found it fascinating but extremely frustrating to go through math problems with children (especially those who appeared mathematically talented) feeling confident that this time the conceptual seed was securely planted in the student's head only to find out the next day the concept was gone. I needed to know why this happened because I felt it reflected poorly upon my ability to teach third grade math.

These frustrating feelings subsequently urged me to instigate a career-long quest to determine how children construct mathematical concepts. An ultimate goal of this quest was to acquire a clearer understanding of what mathematical experiences should be for all children. I knew it was my responsibility to find ways children could experience success in math—a key component of mathematical understanding. This pathway led to the acquisition of a master's degree that included a creative component focused on mathematical manipulatives, a discovery that children enjoy multiple means of learning math, and about as many unanswered questions about children's ability to construct mathematical concepts as I had when I first set foot upon this pathway.

My experiences as a student broadened my understandings of how children constructed knowledge and piqued my interest in pursing a multifaceted approach to teaching mathematics in the classroom. Theories that stressed the integration of subject areas—especially in the areas of math and art—and the benefits that children derived from classroom instruction that was not always segmented into subject areas were other learning interests I wanted to pursue. All of these background considerations led to the following statement of the problem.

Statement of the Problem

Children continue to have difficulties constructing mathematical concepts of an abstract nature. The abstract nature of the place value concept creates frustration for children when they are expected to deal with problems at an abstract, symbolic level (Labinowicz, 1980). Yet, it is imperative for children to possess a sound understanding of the place value concept to understand the numeration system and its basic operations—addition, subtraction, multiplication, and division. It is critical for this concept to be developed in third grade to serve as a foundation for more advanced concepts and skills.

The focus of this study was to determine how third grade students construct their knowledge of place value when this concept was approached from a different direction than that traditionally incorporated in the classroom. This study sought an alternative way help children construct meaning about the abstract concept of place value by engaging the children in different art experiences. If an integrative approach to this abstract concept utilizing art as a linking mechanism could eliminate some of the mystery surrounding the concept, children would more easily grasp the concept, improve their attitudes, and be better able to construct other mathematical concepts.

Research Questions

The following questions guide this study:

1. What role does the inclusion of integrated art experiences play in helping children understand the abstract concept of place value?
2. What role does the integration of art experiences play in changing children's attitudes toward math?

The following section provides an overview of the experts to whom I turned to expand my understanding of how children construct knowledge, the significance of art in a child's life, and the integrative attributes of art and math.

Cognitive Themes

Bruner wrote that since the seventeenth century the ideal of how to understand anything is to *explain* it causally by a theory—the ideal science. He wrote that a theory that works is altogether a miracle: it idealizes our varying observations of the world in a form so stripped down as to be kept easily in mind, permitting us to see the grubby particulars as examples of a general case (Bruner, 1996, p. 88). Bruner's definition of theory seemed to direct attention to what the experts had to say about learning mathematics. It appeared to suggest that if one sought out theories on children's thinking, one might find the answers to questions pertaining to the development of children's cognitive skills. Therefore, this study reviewed the theories of several noted researchers in the field of education.

In a third grade math curriculum, it is necessary to teach many abstract concepts. To understand more completely when children are developmentally ready for abstract mathematical reasoning necessitates knowing how and when this occurs for children. An extensive review of Swiss psychologist Jean Piaget's contributions to the field of developmental psychology is pursued in more detail in the second chapter to understand how children progress developmentally in their way of thinking. Though there are criticisms of his theories, even the critics acknowledge his name as the dominant psychological resource for professionals who want to know how children think (Burman, 1994). Labinowicz writes that he owes a special debt to Piaget and his co-workers for their ingenious methods of exploring children's thinking and their theory of intellectual development (Labinowicz, 1980). Bruner refers to Piaget as an intellectual giant and states that his genius was to recognize the fundamental role of logic-like operations in human mental activity (Bruner, 1997). Clearly, this was a good starting place in the attempt to understand how children construct knowledge.

Attention was paid to the learning theory of Russian psychologist Lev Vygotsky who dedicated his life to the study of how human beings grow to construct and exchange theories about the world and about each other. Bruner wrote that Vygotsky's respect for the growing mind changed the study of human development, indeed, the intellectual climate of our times (Bruner, 1997). Though Vygotsky agreed with some of Piaget's conclusions about the manner in which children construct knowledge, he did not agree with all of Piaget's theories. Vygotsky proposed alternative explanations for several of Piaget's early works concerning the development of language in young children (Bodrova & Leong, 1996). It was of some interest to note that these two tremendously important theorists—Vygostky and Piaget—were contemporaries born in the same year, 1896.

The Multiple Intelligence Theory proposed by Howard Gardner contributed some enlightening thoughts as to how children construct knowledge (Gardner, 1983). Eisner wrote that in recent years psychologists such as Howard Gardner have re-emphasized the multiple nature of human intelligence, argued the case for a multiple theory of intelligence, and made a place for the arts within the seven modes of intelligence he describes (Eisner, 1998). Gardner's theory proposes that not all children construct knowledge in the same way, and perhaps this theory could be used to explain the relationship between logical-mathematical intelligence and spatial intelligence that addresses the representational characteristics of art (Eisner, Sternberg, Levin, & Gardner, 1994). Spatial intelligence is frequently referred to in research as the visual/spatial intelligence (Armstrong, 1994).

Gardner's theory of multiple intelligences would appear to provide clues important to the understanding of individual learning styles or preferences exhibited by each child.

A study that included art could not be complete without the inclusion of the theories of Elliot Eisner who is currently Professor of Education and Art at Stanford University. Eisner wrote that for centuries the arts have been regarded as marginal to the central mission of schooling, which has been considered to be the development of intellect. He added that arts are thought to be matters of play rather than work, matters of body rather than mind; they are thought to trade in emotion rather than in the cool rationality that is supposed to characterize mature, rational beings (Eisner, 1998). Eisner furnished ideas about the cognitive skills students employ as they focused on a particular art activity.

These theorists provided the informational scaffolding for the study of how children construct knowledge—both the logical-mathematical and the spatial/visual connection to art (Eisner, Sternberg, Levin & Gardner, 1994)—and contributed valuable pieces to this intricately complicated "coming to know" process. Each piece studied separately failed to describe the thinking process adequately; but studied as a whole, the picture was more complete.

Utilizing the scaffolding and context of the theories presented by Piaget, Vygotsky, Eisner, and Gardner, the review of literature investigated current research regarding the importance of providing art experiences for children, and it identified the important role art plays in children's cognitive development. From the research a poignant question emerged: if art does, indeed, affect the souls of children, shouldn't art be included as a more integral part of the classroom ("Art education boosts," 1996)? Could the integration of art and math provide the impetus needed for educators to acknowledge the role of the arts in the curriculum?

Together, art and math conveyed an engaging blend—an intersection of the qualitative nature of art and the quantitative nature of mathematics. It was interesting to compare and contrast the unique characteristics of each of these disciplines. Due to financial constraints and dominant ideology, art was often the first subject area denigrated to whatever a self-taught art teacher can deliver (Goodlad, 1984) as opposed to math whose supporters are numerous and whose importance is recognized by educators (Copeland, 1984).

While investigating the various roles art can play in a mathematics program, the review of the literature includes qualitative studies that reveal different ways in which art and math have been integrated to achieve academic growth in both areas (Stix, 1990; Shigematsu, 1994; Unsworth, 1996; Catterall, 1998; etc.). More instructional materials are beginning to appear on the market for teachers of elementary children that include strategies for integrating math and art. Apparently, there are many teachers interested in the theory of art and mathematics integration (Brunetto, 1997; Ritter, 1995; Williams, 1995). Yet, many questions persist.

Therefore, the guiding questions remain centered around the issue of integrating the subjects of art and math to help third grade students understand the mathematical concept of place value. They ask what role does the integration of art experiences play in helping third graders understand the mathematical concept of place value. What role does art play in changing children's attitudes toward math? What is the importance of art in the curriculum? These are the questions driving this study.

Qualitative Versus Quantitative

There were two philosophical approaches from which to choose when deciding what kind of inquiry would be initiated—a positivistic research orientation or a post positivistic one. Through the coursework I had completed, I understood that quantitative methods were supported by a positivist paradigm that is characteristic of researchers who view the world as made up of observable, measurable facts. Researchers who do this type of research assume that a fixed, measurable reality exists. Qualitative methods are generally supported by the interpretivists'—sometimes referred to as constructivists—paradigm that portrays a world in which reality is socially constructed, complex, and ever changing (Glesne, 1998). Glesne used the term "construct" to describe the ideas behind a qualitative inquiry and suggested that an interpretivist or constructivist paradigm portrays a world in which reality is socially constructed, complex, and ever changing—an apt description of my little part of the world called the classroom. The idea of my constructing qualitative research at the same time the children were constructing knowledge seemed to appeal to my sense of practicing what I preached.

In the initial stages of my thinking, I had always assumed that since mathematics was a quantitative subject my research would lead me in that direction. In actuality, I had minimal knowledge of the existence of any other form or type of research. This lack of understanding of research methods was always the difficulty—the roadblock to what direction my inquiry would take. I knew I wanted to study the relationship between art and math because I had witnessed in my classroom the light in children's eyes, the enthusiasm in their voices, and the motivation to learn when we pulled out the art supplies to do math. Still, I did not have the vaguest idea about a method to employ to make this desire—this interpretation of interaction with my children—a trustworthy study about children and how they learned to do math.

Glesne (1998) wrote that the research methods you choose say something about your views on what qualifies as valuable knowledge and your perspective on the nature of reality. I wanted my research to reflect my views concerning how I teach children, the curriculum choices that I make, and how this affects the learning that takes place in the classroom.

The heart of qualitative research centers on the integral elements of observation, interviews, theme generation, and analysis. A researcher doing a qualitative study observes the participants, writes detailed field notes as the observation takes place that "exude thick description," and records these observations in a journal over the period of time that the research is taking place. Thick description is essential to good theory building (Glesne, 1998). Interviews are conducted with the participants and use a set of questions constructed and transcribed by the researcher. The data gathered from these interviews are then coded for analysis. I knew that I could apply all of these elements to my classroom during the time it took to do the study and, hopefully, produce some insightful understanding relative to learning as it occurred for these children. Therefore, I chose to conduct a qualitative study.

I liked the qualitative approach because I wanted the children's voices to be heard throughout the research process. Interviewing the children in a one-to-one setting gave me additional information into how they processed information and at the same time encouraged the children to participate in the inquiry. I felt my children could truly be active participants in this study by recording their conversations as they worked in groups—perhaps even leaving a tape recorder at their work areas (Nespor, 1997). These recorded responses provided valuable, freely-elicited information that might not have been heard in one-on-one interviews.

My approach to the study of the integration of math and art and the learning produced in the classroom—my way of recording the excitement and enthusiasm children exhibited as they went about the process of learning—was as an active participant in the study. McKernan describes this type of research as action inquiry and explains it as a form of research that takes place within the classroom and is enacted by practitioners—teachers (McKernan, 1991). I felt strongly that each day the classroom environment produced valuable research and insights into how children construct and process information, but seldom was this research reflected upon and recorded. This was a lost opportunity to share important teacher knowledge with other teachers.

Speaking to the downside of this type of research, Lareau cautioned that using qualitative methods meant learning to live with uncertainty, ambiguity, and confusion, sometimes for weeks at a time (Lareau, 1989), and those are not nouns I enjoy experiencing. But I was eager to begin this research to find out what the children had to share with me. It was exciting to think of doing research in my classroom and looking for themes reflecting how my children learned!

Subjectivity Issues

Choosing a research site and children to study who are near and dear to my heart would seem to some an implausible choice because of the element of subjectivity involved.

I wondered if it would be possible to generate useful data about children I taught on a daily basis? Historically, subjectivity has been considered something to keep out of one's research, something to control through a variety of methods, to establish validity. Current thought recognizes that subjectivity is always a part of any research from the point a research topic is decided upon until the final analysis has been recorded (Glesne, 1998). Understanding that subjectivity is a natural part of the research process is the first step towards recognizing the positive role it can take in inquiry. Emotions such as anger, irritability, gleefulness, excitability, and sadness may be signals of subjectivity that could be used to help a researcher generate new themes in the research material (Glesne, 1998).

Glesne suggests that a way to become aware of subjectivities that may creep into research is to note how the research topic intersects with your life. In my case this intersection was easy to identify. It was those math experiences I encountered as a child, college student, and teacher (Glesne, 1998). I thought that I could use those same anxious feelings in a positive way to understand the frustration children in my classroom face in their attempts to understand math concepts.

Heshusious (1994) suggests that if we want to free ourselves from the focus of objectivity in research, we need to rethink our understanding of the relationship between self and other and turn toward a participatory mode of consciousness. Participatory consciousness is defined as the awareness of a deeper level of kinship between the knower and the known. She sees the management of both subjectivity and objectivity as sharing the same mode of consciousness. We should let go of the focus on self. Heshusius sums up her position on the issue of subjectivity by writing that any concept of rigor (validity) related to participatory consciousness must not override the recognition of kinship and the centrality of tacit and somatic ways of knowing (Heshusious, 1994). I think that the kinship or empathy I brought into my research broadened and intensified my interpretation and insights and provided authentic and valid research for analysis.

Trustworthiness Issues

The final issue that this chapter addresses centers on the area of trustworthiness in qualitative research. Lincoln and Guba (1985) suggested that to add truth and value to research, it must be credible, and they provided methods about how this can be accomplished. For a qualitative researcher to achieve credibility, they recommended prolonged observations written with thick description, a constant analysis of the research for themes and generalizations, and sharing research analysis with a colleague for the purpose of receiving input. They also recommended frequent revisitation with the participants in the study to determine if the researcher had accurately recorded or interpreted what happened during the observations and interviews. These are the methods that I employed with my research to make it trustworthy.

Lincoln and Guba (1985) also suggested that to be a trustworthy inquiry the characteristics of the study should be transferable or applicable to other educators, exhibit dependability, and provide some means of confirmability whereby the biases, motivations, interests, and perspectives of the inquirer can be shown not to be a part of the inquiry. Keeping an audit trail—a detailed paper trail—of all of the pieces of research acquired through documentation, observations, and interviews assisted in my attempts to produce a trustworthy study.

Denizen (1989) advocated triangulation, or the combination of methodologies to overcome any inherent weaknesses in the study. To understand triangulation, he suggested that methods could be thought of as a kaleidoscope: depending upon how methods are approached, held, and acted toward, different observations will be revealed. I liked the kaleidoscope idea as I could visualize all the different experiences gained from this study shifting into different designs as I began to interpret the interviews and observations of a study of art and math activities.

Curriculum Framework

To begin this qualitative inquiry necessitated the development of a unit of study that focused on art and math activities to introduce the concept of place value into a third grade curriculum. The challenge to restructure existing curriculum written by a host of "experts" in the field of mathematics and art was daunting, but exciting at the same time. Working from the philosophy that the teacher is the pinnacle of the education process and that good teaching comes before good learning afforded me the confidence to try (Williams, 1990). My 20 years of experience teaching math to children enabled me to feel qualified to design a unique study that focused on integrating art and math in the classroom. Williams (1990) theorizes that the difference between good art teaching and good mathematics teaching is not as great as one might think. Both subjects are based upon foundations of shared language between the child and teacher and child to child, and both should adopt a problem-solving approach to constructing knowledge. These thoughts supplied me with the incentive to plunge ahead.

The foundation for designing and developing the activities to be used in this study was created in alignment with the NCTM Standards and Oklahoma Priority Academic Student Skills (PASS) for math and art recommended for third graders in the school district involved in this study. Using each standard, I created several math and art activities that would integrate both the logical and mathematical intelligence with that of the spatial intelligence (Gardner, 1993). Each standard was supported through art experiences designed specifically to connect visually with the mathematical concept to be taught. Some of the NCTM Standards lend themselves more readily to art activities such as geometry and fractions, while standards dealing with place value prove more challenging. It was the challenging standard of place value to which this study was applied because this concept is often the most difficult and elusive mathematical concept for children to master (Copeland, 1984).

Significance of the Study

Facilitating the successful acquisition of knowledge is the main purpose of the classroom teacher. If the integration of art experiences with the mathematical concept of place value helps children succeed in the acquisition of this abstract concept, the children will be better prepared to master additional mathematical concepts. Art experiences could play a key role in promoting positive attitudes toward math, thereby increasing the chances of mathematical achievement. This integration may make teachers more successful in their main objective—the acquisition of knowledge by children. In addition, if the integration is successful with the place value concept, it may point to a need for a similar approach with other mathematical concepts and with other disciplines.

Limitations

1. The population of children in the study was atypical as the group was homogenous in ethnic and socioeconomic make-up.
2. Parents, as a whole, exhibited an enthusiastic interest in their children's learning experiences.
3. When exploring how children construct mathematical concepts when art is integrated, more time is needed to validate the study. Additional time observing the children's learning styles might provide pertinent data of a consequential nature.
4. This particular action research addressed only the mathematical concept of place value and drew conclusions based on the data from a selected area of math. Pertinent to the conclusions would be data obtained from art integrated with other mathematical concepts; for example, a unit on addition and multiplication.
5. Conclusions from this study indicated that children's behavior improved when art experiences were integrated into the math instruction. Once again, data of a more conclusive nature as to the permanence of this improved behavior could be better established by increasing the length of the study and integrating art experiences into all of the mathematical concepts taught to third graders.
6. Another limitation of the study addresses a personal dissatisfaction with the prior-knowledge, pencil-and-paper assessment given to the children both

before the instruction on place value took place and at the conclusion of the unit. The prior knowledge assessment produced frustrated tears from the children. However, to derive some sense of what the children had learned, I felt it was necessary to give it again at the close of the study. The results were not particularly helpful in that some children required assistance in reading and interpreting the assessment.

Definition of Terms

Art Experiences – are used to describe a multiplicity of art activities. Sometimes, the art experiences involved arts and crafts mediums while at times they incorporated the use of famous artists and their artwork.

Place Value – refers to the numeration value of each place in a number. For example, when numerals are written in combination such as 27, not only does each numeral represent a number itself, but their positions also take on a value that is some multiple of ten. This coding system is very efficient for communication among mathematicians, but most confusing to children in initial stages of understanding (Labinowicz, 1980)

Integration – for the purposes of this study, had as its reference the position statement issued by the National Council of Teachers of Mathematics (1995) that states that k-4 teaching should center on interdisciplinary instruction obtained from a curriculum organized around questions, themes, problems, or projects to capitalize on the connections across content areas. Integrating subject matter content is not only understandable but has greater relevancy (Foss & Pinchback, 1998). For this study, place value math concepts were taught and related art experiences were included for the purpose of assisting the children's understanding of these concepts.

Summary

The National Council of Teachers of Mathematics has issued the challenge that all children can learn to think mathematically. Gardner's (1993) research indicates that not all children learn to think in the same manner. Therefore, I have conducted a qualitative inquiry that addressed questions about how children learn mathematics—specifically, how they learn the concept of place value by integrating diverse art experiences with the place value unit for third graders. In addition, the research sought to discern what role art experiences might play in changing children's attitudes toward math. Could the introduction of art as an integrated medium help all children become better math students by changing children's attitudes toward math and enhancing their understanding of this concept? Would the results of this study prove that art should play a more integral part in classroom curriculum? As a teacher, I was anxious to pursue this qualitative inquiry in a familiar environment with participants whose success in school is my responsibility. I thought I could conclude that this newly designed integrated art/math curriculum had been successful if, when I got the art supplies out, the children asked, "Are we going to do math?"

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

This chapter focuses on a review of educational research that attempts to provide an answer to the question: Does the use of teacher-designed art experiences in a third grade classroom during math instructional periods enhance a child's construction of mathematical concepts? In the search for answers to this question, the literature review branches out into three strands: (1) how children construct knowledge—with an emphasis on mathematics, (2) the significance and impact of art on children—a subject often considered less significant in a child's intellectual development than other subjects, and (3) the utilization of an integrated-curricula approach to art and math within the classroom for the dual purposes of teaching mathematical concepts and introducing children to art activities.

Strand 1: How Children Construct Mathematical Knowledge

As a classroom teacher, a major concern of mine has always been how children construct mathematical concepts so that I could better guide my teaching strategies down pathways that would enhance this understanding. There is a wide array of theories and some dissension among theorists about how children learn mathematical concepts. There appears to be some agreement about the importance of the following questions: does the level of children's thinking pass through stages, and if so what happens to cause developmental changes to occur; how can cognitive development best be studied; and finally, what relationship exists between children's and adults' thinking (Siegler, 1986). The teacher provides directions, gives explanations, and raises questions through words, but to what extent do teachers communicate with their children? Teachers realize that all children bring to mathematical situations some point of reference derived from their own experiences which may or may not be the same ones with which the teacher arrives. However, it is the teacher who has the ability to understand not only her own point of reference, but the child's as well. With this understanding, a teacher will be better able to recognize and meet the child's needs (Siegler, 1986).

It is frustrating and discouraging for teachers to feel they have failed in their attempts to guide children through explorations of mathematical objectives. It is equally disappointing for teachers to feel a lack of accomplishment in helping children master crucial concepts needed for a positive, confident attitude so necessary for successful mathematical endeavors throughout their school careers. Why does this mathematical telling and exploring not effectively accomplish its purpose? Perhaps, in part, it is a teacher's inability to remember what it was like to be a child and process new information. Teachers are often too busy telling children how things should be to observe what they say and do (Labinowitz, 1980). In order to understand the multitude of reasons why children frequently fail to find success in math, this part of the literature review explores the cognitive theories of recognized experts in the field of education, both past and present: Jean Piaget, Lev Vygotsky, Howard Gardner, and Elliot Eisner.

Piaget's Theory

Jean Piaget, a world-renowned Swiss psychologist, is highly regarded for his studies on the development of children's thinking processes. Piaget spent much of his professional life listening to children, watching children, and poring over reports of researchers around the world who were doing the same thing (Papert, 1999). His natural rapport with children became the catalyst for much of his research which was based upon observations and conversations with children about how they derive mathematical knowledge (Labinowitz, 1980).

Piaget's ideas on the development of children's thinking argue the position that intellectual development is a process in which ideas are restructured and improved as a result of an individual's interaction with the environment (Labinowitz, 1980). Furthermore, it is his contention that a child bends reality to the way things are organized in the child's mind—children don't think like adults (Papert, 1999). Piaget believed that children have a few basic structures available to them at birth, and as they begin interacting with their environment, reorganization of the existing structures progresses leading to the development of new structures.

In Piaget's view, knowledge is not absorbed passively from the environment but is being performed in the child's mind and emerges as the child matures and constructs knowledge through interactions of their mental structures with the environment. Piaget made three distinctions among the kinds of knowledge according to their ultimate sources and modes of structure: physical, logico-mathematical, and social (conventional) knowledge (Kamii, 1994).

Physical knowledge is knowledge of objects in external reality and their physical properties. Logico-mathematical knowledge consists of relationships created by each individual as they react with the environment. Social knowledge implies conventions worked out by people—it is the kind of knowledge that must be transmitted from one person or generation to another. A logico-mathematical framework is present for both physical and social knowledge as well (Kamii, 1994).

Piaget's theory is a stage theory that consists of four stages through which children consecutively pass. The stages, in the order of their passage, are called the sensorimotor period, the preoperational period, the concrete operational period, and finally, the formal operational period. The sensorimotor period typically spans the period from birth to roughly the second birthday, the preoperational period lasts from about age 2 to age 6 or 7, the concrete operational period extends from about age 6 or 7 to 11 or 12, and the formal operational period continues from approximately age 11 or 12 through adulthood (Piaget, 1973).

Since Piaget has labeled his stages according to levels of thinking that are generally characteristic of them, one might incorrectly assume that each stage progresses in a stair-step model, but these stages do not begin and end overnight. Children's intellectual development cannot be represented as abrupt changes that result immediately in stable and ordered stages. On the contrary, they are overlapping stages of continuous development (Labinowicz, 1980). This would mean that a child might demonstrate preoperational thinking on one task while at the same time demonstrate concrete operational thinking on a less challenging task. There are no static changes as such. Each is a fulfillment of something begun in the preceding one and the beginning of something that will lead to the next (Labinowicz, 1980).

A brief description of the stages involves a look at the sensorimotor period first. At birth, a child's cognitive system is limited to motor reflexes, but within a few months children build on these reflexes to develop more sophisticated procedures. The children's physical interactions with objects provide the impetus for this development (Seigler, 1986). By the end of the first year, the children have altered their views of the world as they recognize the permanency of objects outside their own perception. Other signs of intelligence include the initiation of goal-directed behavior and the invention of new solutions (Labinowicz, 1980).

The preoperational period from age 2 to 6 highlights the acquisition of representational skills such as language, mental imagery, and drawing. From Piaget's view, however, preoperational children can use these representational skills only to view the world from their own perspective and experience (Piaget, 1973). Despite tremendous gains in symbolic functioning, the child's ability to think logically is marked by certain limitations. These include the inability to reverse mentally a physical action when returned to its original state, to hold mentally these changes in two dimensions at the same time, and the inability to consider another's viewpoint (Labinowicz, 1980). For example, if shown two balls of clay the same size, the child would acknowledge the equivalency of the two balls until one is rolled out. When asked if the balls are still the same size, the child will respond that the longer one is larger. The child tends to focus on the actual act of transformation of the clay and is unable to take a mental round trip back to the original shape of the clay (Labinowicz, 1980).

The ages of 6 or 7 years herald the concrete operation stage that lasts to roughly 11 to 12 years of age. This stage signifies growth indicating that children can take other points of view, can simultaneously take into account more than one perspective, and can accurately represent transformations as well as static situations. This growth stage allows children to solve many problems involving concrete objects, but they are still unable to consider all of the logical possible outcomes and do not understand highly abstract concepts (Seigler, 1986). These new mental capacities benchmark the child's ability to perform conservation tasks which demonstrate their capability to establish equivalence of materials, witness the transformation or rearrangement of equivalent objects, judge that two materials are equivalent though the appearance is different, and justify conclusions with reasons (Labinowicz, 1980). The understanding of conservation develops gradually, but one knows it is in place when the logic of children's responses show they can use identity, reversibility, and compensation with their answers. For example, the child is shown two balls of clay equal in size and acknowledges that both are equal. When one of the balls is rolled into a sausage shape, the child now understands that the balls are still the same size and can explain and justify why the balls, though in different shapes, retain the same size (Labinowicz, 1980).

Formal operations attained at roughly age 11 or 12 are an indication that children have reached the highest level of stage development. At this level children are purported to be able to reason on the basis of theoretical possibilities as well as concrete realities. This new perspective brings with it the potential for solving many types of problems that to date, children have been unable to solve. Piaget likened formal operational reasoners to scientists who devise experiments on the basis of theoretical considerations and interpret them within a logical framework. Children responding to the examples of the clay balls at this state give serious consideration to the question in the absence of clay balls showing they are no longer restricted to the immediate, testable environment. Children who reach this stage, and not all do, will posses a basic mode of thinking that will last them a lifetime (Siegler, 1986).

According to Piaget, there are four factors affecting mental development as the child proceeds through the developmental stages—organic growth (maturation), experience, social interaction or transmission, and equilibration. The first of these factors, organic growth, refers to maturation, especially maturation of the nervous and endocrine systems. With reference to the experience factor, there are two types of experience that are different from a psychological standpoint and important from a pedagogical standpoint (Piaget, 1973). The first one implies a physical experience, such as the child's actual experience of weighing two objects to determine if they have the same weight. The second refers to a logical mathematical experience, which comes not from the object or objects but rather from the action of the learner on the objects. For example, the child can be asked to weigh three objects: A, B, and C—which is a physical experience—but if B is heavier than A and C is heavier than B, can the child predict which is heavier, C or A, or will the objects have to be weighed again before an answer can be given (Copeland, 1984)? It becomes a logical mathematical experience if the question can be answered without having to reweigh the objects. Social transmission, the third factor, involves the imparting of knowledge by language. This factor is most important for children to possess in order to understand language being used by classmates and the teacher. It is here that children often become lost because they don't understand the context of the concept the teacher is trying to explain (Copeland, 1984). The fourth factor, equilibration or self-regulation, is the fundamental one, according to Piaget. One form of equilibration is the coordination of the first three factors, but there is also another form. This form of equilibration or self-regulation refers back to the example of the clay balls and the development of the child's logical capacities of compensation, identity, and reversibility. Piaget would agree with Dewey that children must experience things for themselves, and a good pedagogy will provide children a learning environment in which they have the opportunity to try things out for themselves (Copeland, 1984).

In order to determine the passage of children from one stage to another, it is important to view three of Piaget's processes he called assimilation, accommodation, and equilibration. Accommodation and assimilation work together for the purpose of achieving the equilibration factor mentioned in the previous paragraph. Assimilation is the process of incorporating perceptions of new experiences into an existing framework (Labinowicz, 1989). Assimilation involves treating, filtering, or modifying data from the physical world in such a way as to incorporate it into the mental structures of the individual (Copeland, 1984). A child may resist change even to the extent that he/she tries to bend the new information to work into the old scaffolding. For example, a child may know cat and upon seeing a butterfly for the first time, may try to assimilate butterfly into what is known about cats. This resistance to change insures that intellectual development is deliberate and continuous. As a child faces a basically familiar world, this process allows time to connect structures to those that have previously been constructed internally. If this process of assimilation was totally dominant, the mind would have only a few large and very stable categories for processing incoming information. Being unable to differentiate between inputs would severely limit what the child could learn (Labinowitz, 1980).

The process of accommodation allows the child to enrich the mind's framework by modifying the scaffolding in place to process the new information. On the opposite side of assimilation, accommodation of new input insures that change and extension of knowledge occur. This modification of existing structures may involve reorganization of existing structures or construction of new ones, thus allowing more information to fit. This accommodation of environmental events forces the child to move beyond present understandings by testing new ideas in different situations. If the process of accommodation was totally dominant, it would greatly increase the number of categories for handling input (Labinowitz, 1980).

Obviously, some balance between these processes is essential if the child's interactions with the environment are to lead to progressively higher levels of understanding. Piaget calls this active intellectual balance with the environment equilibrium; thus, the process of reaching the state of balance is referred to as equilibration which consists of complementary processes operating simultaneously (Labinowitz, 1980). The opposite of equilibrium is disequilibrium, which defines the discomforting inner conflict between contrasting interpretations of data, thereby providing the motivation to find a solution. Once the solution is discovered, the intellectual balance and inner contentment of equilibrium are restored.

A more detailed description of equilibration suggests that it takes place in three phases. First, children are satisfied with their mode of thought and, therefore, are in a state of equilibrium. Then they become aware of shortcomings in their existing thinking and are dissatisfied. This constitutes a state of disequilibrium. Learning begins when a child recognizes a problem (disequilibrium), uses structures that do not initially solve the problem, and then finds solutions by testing other thinking strategies that will correctly restore equilibrium. The demands of the task must match the child's framework if there is to be a problem and a solution. In a state of disequilibrium, what a child says and does may not always agree, but a child's errors are actually natural steps to understanding (Labinowicz, 1980).

A stable equilibrium is reached when a child adopts a more sophisticated mode of thought that eliminates the shortcomings of the old one (Siegler, 1986). According to Piaget's theory, the equilibration process of experiencing discrepancies among ideas, predictions, and outcomes, whether compressed and sequenced as in those explored or randomly experienced in real life, are important factors in the acquisition of knowledge and become the basis of lifelong learning. In other words, teaching involves more than merely telling or even guiding experiences (Labinowicz, 1980). Teachers should not be misled by what appears to be permanent acquisition of new knowledge for children; rather, adults who teach would do well to remember that mathematical concepts are developed slowly, and concepts which might appear to be mastered one day may not, in fact, be stable.

Piaget had very definite ideas about children's concepts of numbers. He felt that once logical ideas had been developed, the child could deal with number operations as part of a system of related operations. Rote memory recitation of number names in order had about the same relation to mathematics that reciting the alphabet had to reading. Reciting number names in order seldom meant that children actually understood their meaning (Labinowicz, 1980).

The theory of conservation is perhaps the key that unlocks the mystery as to "why" children just are just not "getting it." This unlocking usually occurs during the third stage referred to as the concrete operational stage. To achieve a better understanding of the abstract theory of conservation, consider the following concrete example. A child might be shown two glasses containing the same amount of water. The water in one glass is then poured into a taller glass with a smaller diameter. If the child understands that the amount of water is still the same in both classes, it can be concluded that the child understands that the amount of water has been conserved or remains invariant after the pouring operation (Copeland, 1984). Conservation of number can occur in a child from age 5-7, but not all types of conservation occur at the same time in children's thinking. Conservation usually occurs in the same order: first, conservation of number; then quantity; then weight; and, finally, volume which occurs at around 10 to 11 years of age. It seems reasonable to conclude that children with higher intellect can pass through the stages more quickly than children of average intellect can pass (Copeland, 1984).

Seriation is another of Piaget's conclusions. It derives its concept from the idea that ordering builds on comparing—which puts objects in relationship to each other. Between the ages of 7 and 8, most children can systematically name a series of objects from smallest to largest in an ordered series with each object being larger than the one before it while at the same time realizing that the object is smaller than the object following it. Once children begin to grasp the notion of ordering in the physical world, they can begin to look at the order of abstract numbers, realizing that each member of the counting series is one more than the one before; conversely, the member is one less than the one following it.

Piaget's theory of class inclusion is a difficult concept for seven-year-olds. They have difficulty in considering the idea that all of one group can be an included as part of another group at the same time, yet this concept is necessary for children to realize number relationships as being more than a name. Once children are able to place numbers into a mental relationship at around age 7, they have more flexibility in dealing with number problems (Labinowicz, 1980).

Thus, Piaget's concept of number includes the synthesis of related ideas such as serial order and class inclusion into an integrated framework (Labinowicz, 1980). This concept of number further implies the notions of addition and multiplication as offshoots of class inclusion and one-to-one correspondence. As children gain a mobility in their thinking that allows them mentally to reverse physical operations, this reversibility gives access to subtraction as the inverse of addition and to division as the inverse of multiplication. Thus, no number operation exists alone—every operation is related to a system of operations and logical ideas (Labinowicz, 1980).

Piaget's influence on education has been pervasive through the last few decades. He has been revered by generations of teachers inspired by the belief that children are not empty vessels to be filled with knowledge but active builders of knowledge—little scientists who are constantly creating and testing their own theories of the world (Papert, 1999). Papert (1999) contends that Piaget found the secrets of human learning and knowledge hidden behind the cute and seemingly illogical notions of children. Bruner (1997) describes Piaget as a genius who recognized the fundamental role of logic-like operations in human mental activity. Piaget's theories must be a force with which to be reckoned by teachers in order to understand how their children are constructing knowledge.

Vygotsky's Approach

The background of Lev Vygotsky's, a Russian psychologist, is an interesting one. His educational theories emerge from a history that include acceptance at the medical school at Moscow University, switching to the law school, and simultaneously enrolling in a private university to study literature. At the age of 28 he became interested in psychology while teaching literature at a provincial school. During this period he gave his first lectures on psychology and published his first large research project, *The Psychology of Art.* He later used this research as his Ph.D. thesis in psychology at Moscow Institute of Psychology. Though Vygotsky never had formal training in psychology, he, with the assistance of collaborators such as Alexander Luria and Alexei Leontive, created the body of research now referred to as the Vygotskian approach.

Vygotsky's theory of development is unique and distinct from those of his contemporaries and is often called the *Cultural-Historical Theory* (Bodrova & Leong, 1996). The major theme of Vygotsky's theoretical framework is that social interaction plays a fundamental role in the development of cognition. Vygotsky (Bodrova & Leong, 1996) believed that every function in the child's cultural development appeared twice: first, on the social level, and later, on the individual level; first, between people (interpsycological), and then inside the child (intrapsychological). This applied equally to voluntary attention, to logical memory, and to the formation of concepts. All the higher functions originated as actual relationships between individuals. Though most of Vygotsky's original work is done within the context of language learning in children, later applications of the framework have been broadened to include other cognitive thinking areas as is shown in the research found in *Tools of the Mind* (Bodrova & Leong, 1996).

The basic principals underlying the Vygotskian framework, according to Bodrova and Leong (1996), can be summarized as: children construct knowledge, development cannot be separated from it social context, learning can lead development, and language plays a central role in mental development. Vygotsky believed that children construct their own understandings and do not passively reproduce what is "taught" to them, and their construction is always socially mediated. It was his belief that social context influences learning more than attitudes and beliefs, ultimately having a profound influence on how and what children think. The idea that culture influences cognition was, in Vygotsky's opinion, crucial because a child's entire social world shapes not just what is known but also what is thought. Vygotsky's theory insists that we must consider the child's development level and also present information at a level that will lead the child into further development. In some cases, a child must accumulate a great deal of learning before development or qualitative change can occur. He felt teachers must constantly adjust their methods to accommodate the learning and teaching process for each child. Language, Vygotsky felt, had dual roles. First, language is instrumental in the development of cognition, and secondly, language is also part of the cognitive process. Language is the important tool for appropriating other mental tools (Bodrova & Leong, 1996). Although many of Vygotsky's theories are formulated within the context of language, it is interesting to apply his general theory to situations involving logico-mathematical thinking.

The book *Tools of the Mind* (Bodrova & Leong, 1996) is a report about a project in Denver, Colorado, that has promised to improve dramatically the acquisition of knowledge with elementary-school students, most significantly, those at risk. *Tools of the Mind* is not just a method, but a body of teaching and learning practices based on Vygotskian theories that enable children to become self-regulating, self-directed learners.

Vygotsky thought the purpose of learning, development, and teaching was more than just acquiring and transmitting a body of knowledge—it required the acquisition of tools. According to Vygotsky language was the universal tool—a cultural tool because it's created and shared by all members of a specific culture.

Lower and higher mental functions were attributes of mental tools. Vygotsky thought mental processes could be divided into lower mental functions and higher mental functions. The distinction between the two is that lower mental functions would apply to both higher animals and some human beings dependent upon the level of maturation they developed. Examples of lower mental functions are cognitive processes such as sensation, reactive attention, spontaneous memory, and sensorimotor intelligence.

Higher mental functions are unique to humans and are acquired through learning and teaching (Bodrova & Leong, 1996). Vygotsky believed that higher mental functions developed in a specific way: they were dependent upon lower mental functions, determined by the cultural context, developed from a shared function with an individual, and involved the internalization of a tool (Bodrova & Leong, 1996). Higher metal functions were evident when a child could demonstrate deliberate behavior—being focused, and not easily distracted in addition to having the ability to understand signs or symbols. He felt if teachers taught with the purpose of arming children with these tools, then children could become masters of their own leaning. Vygosky felt that the difference between humans and lower animals was that humans possessed tools (Bodrova & Leong, 1996).

The zone of proximal development, or ZPD, is a way of defining the relationship between learning and development. Vygotsky chose the word "zone" because he visualized development not as point on a scale, but as a continuum of behaviors or degrees of maturation. By describing the zone as "proximal," he intended his readers to understand that the zone is limited by those behaviors that will develop in the near future, and proximal refers to the fact that not all behaviors will emerge. According to Vygotsky, the development of a behavior occurs on two levels that form the boundaries of the ZPD. The lower level is the child's independent performance—what the child knows and can do alone. The higher level is the utmost the child can reach with help and is called assisted performance. The ZPD is not static but involves a sequence of constantly changing zones as the child attains a higher level of thinking (Bodrova & Leong, 1996).

<u>Comparison of Piaget and Vygotsky</u>

Both Piaget's and Vygotsky's theories are best known for their insights into the development of thought processes. Tryphon and Voneche (1996) label Piaget and Vygotsky as the two most pivotal figures in psychology. After a week-long advanced course held at the Jean Piaget Archives in Geneva, they wrote that despite the differences of action versus praxis and Swiss capitalism versus Soviet communism, both men reached a similar conclusion about learning and thinking.

Both men felt that knowledge is constructed within a specific material and social context. Both Piaget and Vygotsky believed that children are active in their acquisition of knowledge, and instead of seeing the child as a passive participant, a vessel waiting to be filled with knowledge, both stressed the active intellectual efforts that children make in order to learn. Each acknowledged that a child's development is a series of qualitative changes, though for Piaget the changes occur in distinct stages while Vygotsky proposed a set of less defined periods. While Piaget emphasizes the role of the child's interactions with physical objects, Vygotsky focuses on the child's interaction with people. For Piaget language is a by-product of intellectual development, but language plays a major role in cognitive development and forms the very core of the child's mental functions according to Vygotsky (Bodrova & Leong, 1996). Perhaps Bruner (1997) summarizes the contributions of Vygotsky and Piaget best when he writes that it was a great and good fortune for us, as students of human development, to have had two such giants inspiring our quest. He continues that it is not just their intellectual power that we celebrate but their greatness of spirit and courage and their willingness to admit the baffling complexities of the growing mind. By teaching us not to oversimplify, Bruner (1997) adds they have bequeathed us a heritage free of reductionism—one truly to be treasured.

Howard Gardner's Multiple Intelligences

It's a long leap from the theories of Jean Piaget and Lev Vygosky to those of Howard Gardner, but an appropriate one, I feel. Having read and pursued the cognitive theories of both giants, one wonders who will be the next candidate for "gianthood" in the approaching millennium. According to Armstrong, (1990) Gardner is a likely candidate for this mantle. He describes Gardner as being like the archeologist who discovered the Rosetta stone of learning. Armstrong states that the Gardner model can be used to teach anything from the "schwa" sound to the rain forest and back. Perhaps the contributions of Howard Gardner will indeed qualify him for that rank and title of educational giant in this coming millennium. Certainly, it is difficult to pick up current research on cognition without locating some reference to Multiple Intelligences and its author, Howard Gardner.

Gardner wrote *Art Mind and Brain* in 1982. He describes his life at this time as an educator who has spent the last 15 years studying human creative processes, particularly as they are manifest in the arts. His theories originally stem from a perspective of cognitive psychology that he defines as an aspiring discipline that seeks to uncover the basic laws of thought. He notes that when he first began to study developmental psychology, he was struck by certain limitations in the field. Notably, he felt that children were seen by nearly all researchers almost exclusively as rational creatures, problem-solvers—in fact, little scientists in knickers—a theory which emanated from Piaget and Vygotsky. A second limitation Gardner (1982) believed was the focus within the cognitive arena on certain forms of logical-rational thought.

Gardner (1982) acknowledges that there is little doubt that Piagetian theory defines the major psychological issues concerning the child and cognition, but it neglects other central aspects of human cognition. Gardner believes that while science and mathematics address sophisticated forms of thinking, so do literature, art, and music.

Piaget had little to say about these subject areas. Gardner (1982) writes that in Piaget's zeal for capturing the operation of the mind, he consistently neglected the realm of feeling.

Garner trained as a developmental psychologist and later as a neuropsychologist. It was through his efforts to synthesize research conducted on normal and gifted children with that done on brain-damaged adults that led him to develop the theory of Multiple Intelligences. In 1983 Gardner published *Frames of Mind* that explains in detail the theory of Multiple Intelligences (MI). This theory, in a nutshell, is a pluralized understanding of intelligence as opposed to focusing singularly on the logical-mathematical aspect of cognition (Gardner, 1993).

As the name indicates, Gardner believes that human cognitive competence is better described in terms of a set of abilities, talents, or mental skills, which he calls "intelligences." He feels that all normal individuals possess each of these skills to some extent but individuals differ in the degree of each skill they possess and in the nature of their combination (Gardner, 1993). Traditionally, intelligence is defined as the ability to answer items on tests of intelligence. Gardner (1993) defines intelligence as the ability to solve problems or fashion products that are of consequence in a particular setting. Examples of problems to solve are the completion of a story, anticipating the next move in a chess game, or the repair of a quilt. Products might range from scientific theories to musical compositions to successful political campaign strategies.

In order to define an intelligence, Gardner consulted data from several different sources: knowledge about normal development and development in gifted individuals; information about the breakdown of cognitive skills under conditions of brain damage; studies of exceptional populations, including prodigies, idiot savants, and autistic children;

evolution of cognition over the millennia: cross-cultural accounts of cognition; psychometric studies; and psychological training studies; and particularly, measures of transfer and generalization across tasks. Intelligences must also have an identifiable core operation or set of operations and must be susceptible to encoding in a symbol system—or a type of language system. There are seven original intelligences that meet these criteria, though recently he has added an eighth intelligence and is considering a ninth one.

A list of the original seven intelligences includes: musical intelligence, bodily-kinesthetic intelligence, linguistic intelligence, spatial intelligence, logical-mathematical intelligence, interpersonal intelligence, and intrapersonal intelligence. While Gardner feels that all people possess a certain degree of each intelligence when he speaks of learners who learn best from a musical intelligence, he is referring to that intelligence as being a strength for that child (Gardner, 1983, 1993). Musical intelligence refers to children who enjoy activities involving music, rhythm, melody, and sounds. Bodily-kinesthetic learners are those children who take pleasure from activities of movement, touching, and doing. The area of linguistic intelligence includes learners who delight in activities that involve speaking, reading, and writing. Spatial learners like to learn through visualizing, diagrams, and visual media. Children who think becoming involved with numbers, searching for patterns, experimenting with things, and ask a lot of questions provides a fun way to spend their time are often logical-mathematical learners. Interpersonal learners are the "talkers" in the classroom who communicate and work cooperatively with other children while intrapersonal learners enjoy personal, self-directed, and individualized learning.

According to Gardner (1983, 1993), the most popularly understood cognitive faculty is that of logical-mathematical intelligence. This intelligence often does not require verbal articulation because it can be solved in the head and articulated once the answer is derived. Gardner calls this the "Aha!" phenomenon. These are also the children who do best on the usual intelligence tests of the Western culture. All children do not thrive educationally when teachers exclusively use a logical-mathematical teaching approach in the classroom. Understanding there are more intelligences than logical-mathematical enables teachers to orchestrate other ways of providing information for children which address their learning strengths. The end result of different teaching strategies is a larger population of children feeling successful—more children acquiring an education.

Elliot Eisner's Thoughts on Cognition

Elliot Eisner is a professor of education and art at Stanford University, an award-winning author, and an internationally renowned authority on how arts can be used to improve education. Eisner feels that education without the arts would be an impoverished enterprise. Though he has no single theory as does Gardner, he has given eloquent voice to the concerns of those who feel the arts have been marginalized in the school curriculum. With reference to Gardner's Multiple Intelligence Theory, Eisner (1998) regards Gardner's work as among the most influential that have appeared in the field of education in the last decade.

Eisner (1998) writes that for many people "to cognize" is to think in language—thinking and the use of language are synonymous, but for Eisner cognition is more than words. He believes that his work in the arts as a painter made it clear that cognition is not limited to linguistically mediated thought. Eisner (1998) writes that the business of making a picture that works is an awesome cognitive challenge, and that those who limit knowing to science are naïve about the arts. Teachers who lack understanding about the cognitive nature of art can, in the long run, be injurious to this area of children's cognitive development.

Eisner (1998) writes that we are all born with brains, but our minds are developed, and the shape they take is influenced by the culture (school) in which that development occurs. This would indicate that Eisner thinks schools and the priorities they make with regard to curriculum can influence how children think. He feels that there are five widely held but fundamentally flawed beliefs about mind, knowledge, and intelligence that give direction to schools.

The first of these flaws is that human conceptual thinking requires the use of language. He gives the example of a child who has not yet developed speech, but who is still inquisitive and capable of solving many problems even before being able to verbalize answers. Eisner (1998) also thinks that before there was speech there were images—that speech was derived to describe the images that were observed first.

The second flaw Eisner (1998) mentions is the fact that sensory experience is usually regarded as low on the hierarchy of intellectual functioning. He points out that an indifference to the refinement of perception and inattention to the development of imagination can limit children's cognitive growth. Since no teacher has direct access to a child's mind, it is up the child's ability to think by analogy in order to be able to grasp what the teacher intends for the child to understand, and children often require perception and imagination to foster these analogies for understanding.

Eisner's third flaw refers to the fact that people often think that intelligence requires the use of logic. He notes that to regard logic as a necessary condition for the exercise of intelligence is to restrict intelligence to those forms of representation that require its use (Eisner, 1998). He gives the example of poetry as being an intellectual domain that doesn't require logic to understand the meaning.

The fourth flaw relates to the degree emotion plays with regard to intelligence. Eisner thinks detachment and distance from emotions are not necessary for true understanding. He writes that not to be able to feel a human relationship is to miss what may very well be its most critical feature. Eisner gives the example of the difference of knowing that Christopher Columbus stood on the deck of the *Santa Maria* as opposed to being able to experience the pounding of the vessel by the relentless sea and the excitement of the first sighting of land (Eisner, 1998).

The last flaw deals with the issue of the scientific method being the only legitimate way to generalize about the world. Eisner (1998) states that the traditional, flawed conception of the arts claims that, when they are about anything, the arts are only about particulars—they yield no generalizations. Eisner believes that the need to generalize is fundamental, and human beings generalized long before either science or statistics were invented.

Eisner (1998) contends that these five flawed beliefs create an intellectual climate that marginalizes the arts because what these beliefs celebrate is not what the arts provide. Marginalizing arts leads to marginalizing curriculum choices. How, then, do these curriculum choices affect the children who rely on Gardner's spatial/visual intelligence to gain access to knowledge?

Summary

The first section of the literature review explored the views of four noted researchers in the area of how children learn to think. It included theories by two researchers who had thinking down to a science and two who observe that thinking scientifically is not the only way children think. The message here is that each has made a contribution to education. Each has a message to share with teachers concerned with how well children are learning within the classroom.

Piaget reminds teachers to slow down and let children have the opportunity to mature and grow physically while exploring the world around them. This allows children the gift of time to make connections and constructions that for them acquire personal meaning. Vygotsky prompts teachers to provide opportunities for children to work together, talk together, and make meaning together in collaborative groups. Gardner advises teachers that children learn through pluralistic styles. He cautions us to use a variety of approaches and strategies so that all children have an equal opportunity to learn—not just those who think in a logical-mathematical or linguistic style. Eisner informs us that the cognitive decisions made while doing art projects are important and should not be reduced to two hours per week in elementary schools, nor should art in the secondary schools be for just the fortunate few who choose it as electives. Each researcher has provided teachers the means to understand better how children construct knowledge not only about mathematics but about the entire curriculum spectrum. With this background, it is appropriate to investigate how art influences the development of children's learning.

Strand 2: The Significance and Impact of Art in Child Development

Why should art be included in a literature review most directly concerned with how children construct math concepts? The answer, in part, lies in my responsibilities as an art teacher as well as math teacher. My enthusiasm for teaching art stems from the necessity that I must be an art teacher. I have always assumed that teaching art requires someone with both talent and art training but having the services of a qualified art teacher is not an option in our school district. This absence speaks, I feel, to our school district's cavalier attitude toward art, though their excuse for this situation is one of funding. Art is a subject often relegated to whatever left-over time can be found during the day and is not ever really taught as a subject by untrained teachers such as myself. This gave me pause for thought. Was I neglecting an important dimension of a child's life at school? I began to search for answers. Consider the following discussion on the merits of art and what the presence of art can mean to teachers and children.

Lowenfeld (1987) describes art as a fundamental process with which every society, regardless of how primitive, expresses itself. Children use art as a means of learning through the development of concepts that take visible form, and through the making of symbols that capture and are an abstraction of the environment. He feels that art is a dynamic and unifying activity with great potential for children.

John Dewey, in *Art As Experience* (1934), referred to art as a live creature. He thought the common conception of art is to identify it with a building, book, painting, or statue in its existence apart from human experience. A more accurate way to view art, he thought, should be through our actual experience of art—experience being the most important ingredient in understanding it. He saw artistic activity as a continuum from the common, everyday world of aesthetic feeling and concern to that which results in products exhibited in museums and performed in concert halls. Dewey provides us with an unusual image of an artist as he described the intelligent mechanic, engaged in his job, interested in doing it well, finding satisfaction in his handiwork, and caring for his materials and tools with genuine affection, as being artistically engaged. The mechanic, thus engaged, was experiencing art.

Depree and Mackinnon (1994) compare art to literature when they write that art is language based on line, pattern, shape, color, form, and texture. The end result is a composition in the same way that a combination of words and punctuation makes up written composition. They further note that art skills need to be taught in the same way as grammar and punctuation in a meaningful setting, not as endless, formal exercises, but as and when needed.

Art is a complex study, and one that cannot be easily defined due to the many aspects of its nature. Some art enthusiasts place emphasis on the end product, but most art teachers feel the self-expression that unfolds during the process of art is the essential element of art. Art can mean different things to different people, but how important is it in the role it plays in the development of a child.

Is Art a Necessary Component in the Classroom?

A holistic model of child development includes five basic areas in which children develop according to Schirrmacher (1988):

1. Physical—including large and small muscle control, perceptual-motor control, and sensory development;
2. Social—including a development of self and relations with others;
3. Emotional—including feelings about self and emotional expression, personality, and temperament;
4. Cognitive—including thinking, problem solving, reasoning, and learning; and,
5. Creative—including original thinking, imagination, and verbal and nonverbal expression.

Art activities provide children with experience and practice in all of these areas of development. The physical and manipulative activities of holding paintbrushes or molding clay as they "consult" with friends, learning about taking turns and sharing, learning to feel good about themselves and their work as they think and construct their masterpieces can be accomplished through art. Still, art activities are often shortchanged when it comes to cognitive development.

In terms of cognitive development, Eisner (1976) makes one of the strongest cases for the relationship between art and thinking, learning, and other academic performance. He suggests that art reflects what a child knows about the world, and the more experiences a child has had with people and places, the larger will be a personal array of things from which to choose when doing art. He explains that one must know about something before one can recreate it through art.

Eisner (1976) further suggests that translating ideas, concepts, and experiences into art activities involves many thinking skills. Children actively involved in an art project are planning, organizing, making choices, concentrating, and problem solving—all thinking skills. It is impossible to document all of the thinking that is occurring at such moments in a child's head. Eisner suggests that art is a means of communication for the child. Art is language concur Depree and Mackinnon (1994). Through art a child can communicate with symbols the ideas for which he may not have words. Art can serve as an index of a child's thinking. Observing children's artwork is an indication to the teacher of what they know about their world, what they consider important, and how they choose to represent it.

According to Schirrmacher (1988) teachers can also observe stages of children's development through their artwork. Schirrmacher (1988) attempted to combine stages identified by Kellogg, Lowenfeld, and Brittain into one general sequence. Though the stages are overlapping and the ages are approximate, the following characteristics emerge:

1. Stage I was called the scribbling and mark-making stage (birth to two and up). Schirrmacher described this stage of scribbling and mark-making as forms of nonverbal self-expression that set the stage for later art. Scribbling and mark making are to drawing as babbling is to speech and crawling is to walking.
2. Stage II he referred to as the very personal symbol and design stage (two to four and up). At this stage the child has some concerns for the placement of lines, and geometric shapes are built into very personal symbols and designs.
3. Stage III attempts at public representation (approximately four to seven) and designates older pre-schoolers' efforts to customize and individualize

their personal symbols and schemas. At this stage the children's symbols become recognizable to others, and a greater concern for detail, planning, and realistic rendering is evident.

4. Stage IV is named realism (primary grades and up) due to the efforts which primary and elementary grades make to produce photographic realism in their art. In this stage children are very concerned with size, placement, shape, color, perspective, proportion, depth, shading, and the use of details to approximate reality. It is also at this stage when children, due to their inability to replicate photographic-like pictures, become frustrated and may decide they are not artists and become reluctant to pursue future art activities.

Schirrmacher (1988) also tries to integrate these stages into those of Piaget's and his stages of cognitive development. He points out that art expression is, at least in part, a cognitive activity; therefore, it should progress in developmental stages and follow, to some degree, Piaget's developmental theory to explain in more detail how children's art develops. However, he acknowledges the task is a difficult one because general intellectual development is one of progression, whereas artistic development is one of retrogression. In other words, the artwork of the young child appears more creative than that of the older child. However, he does conclude that the scribbling and placement stages relate to the sensory and preoperational stages of Piaget and the schematic stages of Lowenfeld relate to Piaget's concrete operation stage. Piaget's formal operation stage would then assume that, artistically, children would be in the pseudo-realism stage or as Lowenfeld refers to it, the artistic decision stage.

Understanding some art theories and stages children pass through on the their way to adulthood is to understand the importance—even necessity—for teachers to provide an exemplary art program as part of the curriculum. Merryl Goldberg (1997) lists seven general principles outlining the connections of multicultural education in the arts, but her seven principles add emphasis and reiterate the importance art plays in classrooms everywhere. The seven principles state:

1. The arts expand expressive outlets and provide a range of learning styles available to children.
2. The arts enable freedom of expression.
3. The arts provide an opportunity to build self-esteem.
4. The arts encourage collaboration.
5. The arts empower students and teachers.
6. The arts deepen teachers' awareness of children's abilities and provide alternative methods of assessment.
7. The arts provide complexity to teaching and learning.

Viktor Lowenfeld (1987) wrote that humankind will not be saved by merely developing a good creative art program in public schools; but the values that are important in an art program are those which may be basic to the development of a new image, a new philosophy, even a totally new structure for our educational system. Furthermore, he argues that art encourages students to develop the capacity to think critically and communicate effectively. Experiences central to an art activity require self-direction, regardless of the age of the child, creating a relationship between the arts and the environment.

Art education, as described by Lowenfeld (1987), is a fundamental part of the educational process, possibly providing the difference between a flexible, creative human and one who will not be able to apply learning because of the lack of inner resources to relate to the environment. Art reflects the feeling, the intellectual capacities, the physical development, the perceptual awareness, the creative involvement, the aesthetic consciousness, and the social development of the individual child (Lowefeld,1987). Of what importance is a "drawing" one might ask?

- A drawing can provide the opportunity for emotional growth as is evidenced by the intensity with which the creator identifies with the work.
- A drawing can provide the means to witness the intellectual development of a child first hand.
- A drawing can afford the observer insight into the physical growth of a child as seen in the visual and motor coordination exhibited by the creator.
- A drawing can provide the child the opportunity to show his enjoyment of life by projecting his sensory experiences onto paper with an eye to the space they occupy in his mind thereby recording the pleasures perceived by the child.
- A drawing can reflect the degree of social identification a child has with peers, and can afford the opportunity to interact cooperatively with them in the artistic process.
- A drawing can offer a child the most basic of life's skills—that of learning to organize thinking, feeling, and perceiving into an expression that aesthetically communicates these thoughts and feelings to someone else.

- A drawing allows a child to make marks, invent forms, and put down something that is unique.
- Drawing is fun!

Summary

Art is a cognitive activity that requires many decisions to be made by children in order to complete a picture or project. Though it is not a logical-mathematical cognitive skill, it is what Gardner and Eisner think to be a spatial/visual cognitive skill and one of equal importance.

Most scholars agree that art satisfies a number of human needs. It provides a means to express the personal feelings of the mind and soul. Children and adults can communicate the joy and sorrow of life and death by expressing their most personal feelings through recording their experience of the glories and tragedies of society and the world around them (Golstein, Katz, Kowalchuk, Saunders, 1992). This particular statement brings to mind the remembrances left on the fence that at one time surrounded the site of the Oklahoma City bombing. A more personal expression of feelings would be difficult to find elsewhere. With the issue of violence in the school system rearing its ugly head so frequently in society, perhaps this fence addresses the need for children to find appropriate ways of expressing their feelings through art—not the barrel of a gun. With a child's basic need to represent the parts of the environment with which that child has contact, art would seem to be one of the most viable ways to fulfill this need.

Strand 3: The Utilization of an Integrated Curricula Approach to Art and Math

> In the old days pictures went forward toward completion by stages. Every day brought something new. A picture used to be a sum of additions. I do a picture—then I destroy it. In the end, though, nothing is lost . . . But there is one very odd thing—to notice that basically a picture doesn't change, that the first "vision" remains almost intact, in spite of appearance. Picasso (Gasner & Thomas, 1964, p. 234)

In an attempt to try to squeeze art into an already full curriculum, I began to look for ways to integrate this subject with other subjects that I taught. Math was an unlikely place to use art, but I began to find ways to do it that the children seemed to enjoy. There were many aspects of a union between art and math that I found to be of interest, perhaps because of the somewhat paradoxical characteristics the two seemingly different subject areas enjoyed. Both art and math are considered to be universal languages. Paintings, art, sculptures, numbers, and number operations rarely need an interpreter for their meaning to be understood. However, some, including well-meaning and concerned educators, consider the similarities to stop right there. Acquisition of mathematical concepts and standardized achievement scores in math are always hot subjects of intense interest to school boards and school districts, while art often remains the subject with stepchild status. The significance of art and the role it plays in children's cognitive development is often overlooked.

Another aspect I found to be of interest with regard to these two subjects had to do with children's attitudes toward each discipline. Having taught for two decades, I have, from time to time, encountered children who were hesitant to engage in mathematical activities for one reason or another. To put it simply, they didn't like math. Rarely have I ever encountered a child who didn't enjoy a good art activity. I was aware that some educators felt math could be taught through means of art activities, and this interested me, too. I wondered if enjoyment for one subject could be "used" to foster enjoyment of another, less-cared-for subject. Could a good picture or two enhance mathematical proficiency and if so, how?

One other side to this unlikely pair of subjects caught my attention as well. Both subjects are cognitively developmental in nature, and this development of children's thought processes is well defined by very definite stages according to Jean Piaget and Viktor Lowenfeld (1987), leaders in their respective fields of math and art. I thought the comparison of these developmental stages was interesting. Is it possible that the stages in art signaled a corresponding stage in math? Could these stages be interchangeable in predicting the developmental levels at which children were working?

This section of the art/math issue will focus on a shared relationship of these two disciplines. The literature review will continue to investigate art and math, but not as separate entities, but rather as integrated, linking, and connecting. Does this relationship support a natural alliance of two dynamic disciplines in an attempt to make learning meaningful and purposeful, or must it be contrived in order to encourage and promote effective learning? What, if any, are the merits of integrating these two disciplines, thereby diminishing the isolationist approach of each discipline in the classroom? Can a determination be made and supported that one subject can assist in the transfer of knowledge in such a way that cognition proceeds from that of a concrete nature to an abstract one? What are some attempts teachers have used to enable this transfer to occur?

What is art, and what is math? They both employ the use of lines, dots, and squiggles to represent deeper symbolic meanings. Great works of art rendered by famous artists all began with lines, dots, and squiggles that were inspired from some internal motivation to communicate with an audience. According to Rhoda Kellogg (1970) in her book, *Analyzing Children's Art*, there are 20 basic scribbles, and these basic scribbles are the building blocks of art. Certainly, this is an overly simplistic view of art, but the point to be made is that math problems begin in much the same manner. They begin with a symbolic representation of lines, dots, and squiggles in an attempt to communicate pertinent information to an audience. Both disciplines rely on the artist's or mathematician's ability to use symbolic representation for communication to occur. As a teacher of mathematics, I find it intriguing that every math problem has the potential of becoming a famous painting.

Stressed-out teachers are looking for ways to compact the curriculum, teach math in the most effective way possible, and, realizing its unique importance to children, restore art to the fulcrum of educational learning. The process of including art, often times in a school system where art teachers are noticeably absent due to district monetary crunches, adds an extra dimension to the word stress. If each subject can enhance the performance of the other through the subtle weaving and blending of disciplines, then can it not be concluded that this union must be beneficial for the acquisition of learning for children? Exploration of the term integration might enhance an understanding of how it can occur within the classroom for teaching young minds and fostering a sympathetic appeal to educators to incorporate integration techniques in learning situations.

Making the Connection

The position statement issued by the National Council of Teachers of Mathematics (1995), states that K-4 teaching should center on interdisciplinary instruction obtained from a curriculum organized around questions, themes, problems, or projects to capitalize on the connections across content areas. They also concluded that children need curricula that are more authentic—meaning it reflects real life. Research indicates that a focus on technical content diminishes understanding and that by integrating the topics, subject matter content is not only understandable but has greater relevancy (Foss & Pinchback, 1998).

According to research done by Ulbright (1998), the concept of interdisciplinary education is not a new one, but one that can be traced historically, though it has not always been addressed by the same terms. Often, the words integrated, related, and correlated are used interchangeably to describe this blending together of different disciplines. Parsons (1998) suggests that there are a number of phrases associated with recognition of this same interest: integrated curriculum, interdisciplinary study, cross-disciplinary study, art-centered curriculum, and integrated learning. He speculates that these phrases represent a significant shift of emphasis in art education, away from the preoccupation with the integrity of disciplines and the differences between the arts and other subjects toward making connections between them. Though Parsons makes his comment in reference to an art program, this same statement could be made to apply to mathematics as well. Parsons feels this change is propelled by the renewed desire to make school learning meaningful which echoes the current constructivist trend in education today.

Reviewing the cyclical nature that the arts' discipline has experienced in its attempts to integrate with other disciplines throughout history often parallels that of other interdisciplinary journeys. According to Ulbright (1998), John Dewey's Laboratory School at the University of Chicago in the early 1900s was based on Dewey's belief that education should follow the natural development of the child and social life of the community. Dewey believed in an integrated, child-centered curriculum that was expected to occur naturally as teachers designed activities to explore important problems. Historically, art developed in concert with evolving scientific discoveries and social concerns, but after World War II, the disciplines of knowledge became more specialized, and modern art appeared to distance itself from previous art styles and common, every-day problems (Ulbricht, 1998).

What constitutes an integrated curriculum? A multi-faceted definition attached to integrating disciplines is the notion of "making connections." Ulbright cited Fogarty's (1991) connection theory as: (a) sequential integration within the discipline as one lesson relates to the next, (b) across several disciplines via sequential and thematic comparisons and connections, and (c) within and across learners through relating personal experiences and points of view to course content.

In contrast to a focus on integrated subjects, Viktor Lowenfeld (1987) felt the focus should be on integration of children's emotional, intellectual, perceptual, and aesthetic experiences. He cautioned that the isolation of subjects occurrs when subjects are not correlated but slotted into specific time periods during the day thus promoting an artificial, fragmented situation. He felt this term was often misunderstood by teachers to mean equal emphasis on two subjects as when students were asked to illustrate a history report. Lowenfeld felt that an integrated experience could develop in a school setting, but the separate parts must totally lose their identity so that the individual child would feel that there was a meaningful whole with which to identify.

Though there appears to be wide acceptance, as well as historical background, to point to the value of integrated subject areas, there are those within the art community who warn of its misuse. About the time the merits of integration of subject areas were becoming well recognized, there were art teachers who began to think that art was becoming a servant to other subjects—not valued as important in its own. Because art is usually looked upon by the child as an attractive experience and some of the social studies, arithmetic, or writing exercises are sometimes less favorably viewed, the correlation of these subject matter areas with art may have a negative value for the art experience (Lowenfeld, 1989). In other words, as Mary Poppins once sang, "A spoon full of sugar helps the medicine go down in a most delightful way."

Understanding, the different meanings attached to the integration of subjects, how can integration be accomplished effectively in educational systems where unique structures of disciplines are advocated? How could integration of art take place in school systems that have qualified art teachers and qualified math teachers? Aren't art teachers hired to give the classroom teacher a planning period? Jean Morman Unsworth (1996) challenges readers to dare to think differently. She states that too often classroom teachers are not present to see the arts program, let alone integrate it or extend it. In systems such as these, the arts are valued not as subjects to enrich curricula but as convenient babysitters hired to fulfill union contracts. Unsworth (1996) suggests that with acknowledgement of integration, art teachers can take the role of resource persons to classroom teachers, giving them ideas, thereby helping them to teach visually and creatively.

This is the premise of a program called Connecting: Integrating Art Across the Curriculum. Unsworth (1996) suggests that perceptual drawing, which should be a basic mode of expression in all subject areas, can be effectively taught with the direction and encouragement of the classroom teacher. She adds,

> Art has always been interwoven with mathematics, science, history, religion—with all areas of human knowledge. Just as artists have needed to know these disciplines, so our students need to learn them in juxtaposition to the arts. (Unsworth, 1996 p.3)

The fact that art is an essential, complementary mode of learning across the entire curriculum in no way diminishes the information content of the visual arts or the skills proper to the discipline.

Can Art Experience Boost Math Achievement?

Now the issue becomes, if art is integrated, does it enhance learning in other subjects—with the emphasis on math for the purpose of this study? "Those of us in arts education are apparently 'faster than a speeding bullet, more powerful than a locomotive, able to leap tall buildings in a single bound" (Eisner, 1998, p.1). Eisner remarks are aimed at educators who think that the arts can be "used" to boost academic achievement in math, reading, or any other academic area. While he understands the desperation educators feel as they hotly pursue ways to upgrade our educational system and to improve the performance of our children, Eisner feels that using art as a vehicle to accomplish these lofty goals is to marginalize the contributions art can make to society. Furthermore, he downplays the research done in these areas as inconclusive and ineffective, with exception to influencing, positively, attitudes with regard to mathematics as was found in the Forseth, (1980) study.

Catterall (1998) disagrees with Eisner's assessment and chooses to focus on the amount of attention given these days to notions that engagements with the arts do help children succeed in school. He agrees with some educators in the art field that most of this notoriety is an attempt to get local school boards to acknowledge the importance of art in the public school system and replace long-ago-dropped art programs with bona fide art programs in all school systems. Still, this does not lessen his feelings as to the role that the arts can play in education. He responds to Eisner's (1998) comments about the lack of research supporting the theory that art does, indeed, influence the acquisition of information in other disciplines in positive ways by citing research not included in Eisner's article that points to links between the arts and academic learning. Catterall concludes his article with the thought that there is too much active interest in possible connections between education involving the arts and developments bearing on success in school to hold back the emerging tide of new studies. This renewed interest in the possible connections between respective disciplines involving the arts is at an all-time high; therefore, these new studies must be an indication of the success teachers are having with this integration process.

Can Art Assist in the Transfer of Information?

It is at this juncture one might wonder what the word transfer means and how it applies to art and other disciplines. Referring back to the research done by both Piaget (Labinowicz, 1980) and Schirrmacher (1988) is to be reminded that children progress through stages in the development of their thinking skills, so what benefit would integrating art with other disciplines provide? Certainly, a tooth cannot be forced to grow back as a replacement to the lost one until maturation–the stages of "snaggletoothedness" have run their course. It is here that the clarification of just what art can and cannot do for the world must be identified.

It would seem to be safest to establish that art can be an enhancing agent to all curricula through the following processes. First, the visual arts may enhance a child's ability to move from working in a concrete stage to that of a more abstract nature—when maturation determines they are ready to make this move. Secondly, review of the research done by Howard Gardner (1983) suggests that children work from multiple intelligences, and cognition derived through art experiences differs from that of the logical-mathematical cognition providing another avenue of learning. Thirdly, attention to motivation and attitude children experience when working through an art medium to learn a new concept must be considered as a potential boost to children's learning.

The following ideas and quotes came from the Getty Education Institute for the Arts' National Conference (De Bevoise, 1996).

1. We are in a new age where the image can now be central, thanks to technology in large part. Images are around us. Today, they have the potential to be as fundamental to education as words and numbers, adding significantly to the excitement, depth and relevance of what and how

children learn. (J. Carter Brown, director emeritus of the National Gallery of Art and selected by technology guru Bill Gates as advisor and consultant to his Seattle-based enterprise) Brown believes in the centrality of the visual image to education.

2. Children need tools with which to contextualize these images . . . art making, art criticism, and art history and aesthetics are critical tools for today's educators. These tools must translate to skills, critical skills which developing human beings must have to navigate their ways through the new media universe. (Cecily Truett award–winning children's television producer)

3. Images actualize the variety of the capacities of mind. Our human cognitive ability is extraordinarily diverse. Images are at the core of education because the imaginative exploration of the image makes worlds possible. Imagination traffics in image construction. (Dr. Elliot Eisner, Stanford University Professor of Education and Art)

These quotes are powerful testaments to the contributions visual images can have in the classroom, and, to take these thoughts one step further, the effects these images can elicit in assisting with the transfer of a child's movement from that of a concrete stage to an abstract one. Ramon Cortines, speaking at a meeting in 1996 of the Getty Institute for the Arts, credits art as the "Fourth R" in education citing that teachers want materials and activities that are hands-on, challenging students to move from concrete to the abstract. He told of a recent visit to a middle school in New York City where the lesson centered on the Brooklyn Bridge. He reported he had never seen so much math, science, physics, history, reading, writing, listening, speaking, researching, comparing, contrasting, predicting, and presenting going on in a classroom, all through the prism of the arts.

Art experiences have often been used in elementary mathematics classes to enhance the concrete-to-abstract experiences children encounter while learning mathematics (Forseth, 1980). Art activities have also been used to develop problem-solving skills in children and to provide pleasant experiences for them in mathematics (Swartz, 1968). Carolyn Ford Brunetto (1997), in the introduction to her book *MathART*, states that there is more to the math and art connection than just tapping into students' innate creativity. She contends that many children are simply better at understanding and retaining abstract mathematical concepts through physical experiences than through the typical pencil-and-paper drill. She cites the National Council of Teachers of Mathematics, in their K-4 Curriculum Standards, as recommending active, hands-on learning, using concrete materials as one of the major directives in math education for the 21st century.

Research done by Erna Yackel and Grayson Wheatley (1990) addressed the issue of the increasing attention of mathematics educators to spatial imagery and spatial thinking. The purpose of the article was to describe instructional activities that were used successfully to facilitate development of visual imagery in elementary school pupils and to describe pupils' responses to these activities in a second grade classroom. The activities asked the children to use line drawings to express their understanding of tangram drawings that they had previously seen. Then these pupils participated in a discussion in which they were so anxious to report "how they saw" the line drawings that the teacher frequently had to curtail the discussion to be able to include four or five drawings during one 30 minute period.

The authors of the study felt that such drawing activities helped pupils learn to recognize and draw basic geometric shapes, develop geometric concepts and learn geometric vocabulary, find geometric shapes in complex drawings, and develop such abstract spatial operations as rotating images. Their conclusions spoke to what they felt was the powerful nature of the pupils' conceptual activity and the dramatic improvements in their spatial imagery over the course of one school year. This led them to believe that activities such as the ones they had used in the study should be a significant part of the elementary school mathematics curriculum at all grade levels. Clearly, the implied message for educators is that when children create their own visual images, they construct their own bridge from concrete to abstract.

Sketching, drawing, and constructing models can be important tools used to make abstract concepts realistic. This can be evidenced by another study that addressed building math skills by visualizing problems and was reported in the *Christian Science Monitor* (1997). It involved third-graders in Verona, Wisconsin, who were part of a three-year experiment to make math something children could see and feel. This program is frequently referred to as cognitively guided instruction (CGI). Researchers from the University of Wisconsin-Madison were working with the school system to develop students' spatial skills at the same time they were learning about numbers. Though some parents were skeptical of another "new math," they were quickly won over when they saw what their children were doing and realized they couldn't solve the problems themselves. In the previous year, a group of second-graders in the program performed as well or better than college honors students on an exercise to create two-dimensional representations of three-dimensional objects.

Elizabeth Miller (1996), a first-grade teacher for many years and currently a second grade teacher developed a program called "Learning to Think through Reading and Math" with the key ingredient being the children's ability to express themselves artistically. She found that when students were able to visualize mathematical problems through their own artistic devices their enthusiastic responses were "I get it!" Students were able to enjoy mathematics while expressing themselves artistically—not to mention the celebration of creativity as no two pictures were alike. This would appear to be another indication of art bridging the gap between concrete and abstract.

The study of the mystical world of Escher, the Dutch-born artist, is an example of how a celebrated artist and his work can be used in math classrooms across the grade levels to enhance students visual learning (Watson-Newlin, 1995). Art teacher Karen Watson-Newlin used tessellation—a pattern of shapes that completely covers a flat surface with no gaps and overlapping—to enhance visually her students' geometric understanding.

Other reported citings of improved math performance of elementary students exposed to the visual arts when drawing was the primary tool include a study focusing on the practices in the United States and Japan for promoting the use of drawings in helping students to solve mathematical "story" problems (Shigematsu, 1994). Although the author does not claim that the use of line-segment drawing is the Japanese "secret to success," he does encourage teachers to try some action research in the classroom, or join with others to carry out a more controlled study on the effectiveness of using drawings in solving problems.

A somewhat similar study conducted by Andi Stix (1994) investigates the use of pictorial journal writing in mathematics, including pictures, numbers, symbols, and manipulatives to help students in grades 3-8 to understand mathematical concepts and make them truly their own. The results, she writes, are a better understanding and retention of mathematics, a decrease in "math anxiety," and a heightened confidence level among students who have really made a lesson "their own."

The literature is extensive in the area of visual arts being incorporated in the classroom to give students who are assimilating new mathematical constructs the opportunity to visualize them in such a manner, and that the accommodation of such new constructs may be realized more readily.

Art and Math Cognition Styles

Art is once again referred to as the Fourth R in a paper written by Darby and Catterall (1994). They explore the central ideas of the prominent thinkers in arts and education and the roles played by the arts in cognition, cultural representation, and student motivation. While their study is one which expresses reasons for the inclusion and promotion of arts in curriculum, it also addresses art as a cognitive thinking skill which should take its place with logical mathematical thinking skills. This segment of the paper will focus on references pertaining to cognition and Howard Gardner's (1983) Multiple Intelligences theory in an attempt to show the importance of responding to every child's right to obtain an education in the most appropriate manner. It is at this point that the emphasis changes from that of connecting, or bridging, to the pursuit of different learning or thinking styles children use in their efforts to learn.

In the past half century, art has often taken a back seat to other disciplines in the role it plays in the development of children's cognitive skills (Eisner, 1982). John Dewey and Sir Herbert Read both promoted the idea that the arts involved cognition. The view of the arts as an important way of knowing and constructing knowledge involving the use of symbol systems finds its roots most notably in the philosophical work of Ernst Cassirer, Susanne Langer, and Nelson Goodman. Attributed to these scholars is much of the credit for challenging the philosophical and psychological thinking of the early half of the twentieth century (Darby & Cattarall, 1994). Recent decades have brought a growing interest in the arts as a form of cognition, based on the idea that, like language with its inherent set of symbols, the arts also have their own symbol systems that involve cognitive processing (Darby & Catterall, 1994). This form of cognition has to do with the symbol-making capacities of the mind, as it perceives and produces art.

Gross (1974) suggests that there are five thinking modes. Two of the modes are the iconic mode which is found in art making and the logico-mathematical mode associated with mathematics. The iconic mode is represented by images emerging from the manipulation of concrete media in image making, while the logico-mathematical mode is represented by abstract symbols emerging from abstractions of mathematical operations, such as addition or multiplication which operate on a number system. Gross recognizes that both modes are types of mental coding systems for retaining knowledge, but the logico-mathematical mode is the one most likely to be used to teach mathematical concepts.

Forseth (1980) cites the research done by Rohwer (1972) and Salomon (1972) which postulated that the acquisition of new or different modes or coding systems increased a child's mental capacity for new knowledge at the same time it increased the various systems of communication the child used to learn. Rohwer theorizes that as children acquire knowledge in each mode, they become better able to handle more domains of information associated with that mode. Salomon adds that as children internalize these skills, the skills serve as mental tools in the acquisition of new information. This research suggests that a variety of learning experiences normally associated with one mode, such as iconic, might be beneficial for children. It also sends a strong message that art activities normally associated with the iconic mode but used in a mathematics class may increase knowledge in both thinking modes, thereby enabling a child to communicate acquired knowledge in the logico-mathematical mode more effectively.

Howard Gardner, author of *Frames of Mind: The Theory of Multiple Intelligence* (!983) has provided a major contribution to discussions of the mind and to the content and aims of education (Eisner, 1994). Gardner's basic premise is that intelligence is a biologically given capacity that manifests itself in many forms. Strand 1 of the review of literature addressed in more detail Gardner's theory, but to reiterate, Gardner works with the theory that instead of the commonly held belief that human beings possess one general intelligence, there may exist as many as seven or more basic intelligences.

Gardner feels that failure at school can be averted if educators will utilize five different ways to approach a topic in an effort to synthesize children's several forms of knowing (1991). Names given to these approaches are: a narrational entry point, a logical-quantitative entry point, an esthetic approach, a foundational entry point, and an experiential approach. It is here that the arts can play a crucial role in improving children's ability to learn because the arts draw on a range of intelligences and approaches. With regard to this research review, Gardner's theories provide additional reinforcement to the idea that instruction steeped in a blending of the logico-mathematical and spatial intelligences should offer children an excellent way to boost mathematical skills.

Motivating Minds with Good Attitudes

This section has addressed the potential that art and related art activities can play in helping children construct mathematical concepts. First, it reviewed information about the possible support that art, in the form of visual arts, can provide in bridging concrete and abstract concepts. Next, it looked at different ways children think, with emphasis on the fact that there is more than one way to think, and by understanding that there is more than one way to approach thinking, better instruction can be utilized for those children who don't think through a logico-mathematical mode. The last topic to be discussed is motivation and its connection to attitude. It is the intent in this section to discuss art when it is used as the spice for a mathematics curriculum.

Forseth (1980) concludes in her research that the use of art activities that are designed to reinforce mathematical concepts seem to affect children's attitudes toward mathematics. She goes on to report her findings that attitudes tend to be more favorable when art activities are used in the mathematics class as part of or as a supplement to the regular lesson. Forseth hastens to add that her study did not imply that the use of an art activity will alleviate learning difficulties a child may have in mathematics, but it does suggest that art may improve the child's attitude toward learning. This, in turn, may affect achievement in a positive manner by creating a favorable predisposition toward learning mathematics. A final note offers the idea that learning mathematics need not be restricted to pencil and paper or ditto sheets or mathematical games, but can include art projects as well.

Doug William's book, *Teaching Mathematics Through Children's Art* (1995), is a product of Williams' teaching career. In his introduction he speaks to the fact that he had spent many years specializing in mathematics and many other years specializing in art/crafts teaching and still more years as classroom teacher. He reports that as he sought to draw upon his many years of experience to create the framework for this book, and three generalizations came to mind. They were:

1. most children enjoy art activities,
2. too many children learn to dislike mathematics, and
3. teachers enjoy working across curriculum areas when they feel good teaching is proceeding in each area.

He feels that the differences between good art teaching and good mathematics teaching are not as great as one would think. Williams lists the following thoughts on teaching math and art:

1. Shared language (teacher/child, child/child) is the foundation for learning.
2. Problem solving is used to stimulate and challenge.
3. Planned experiences with many materials are provided to
    a. develop concepts, and
    b. practice skills.

Williams's book then seeks to combine his experiences from classroom to art-room to develop activities that are both mathematically sound and motivating.

Martin Gardiner, research director and faculty member at the Music School and Kodaly Center of America, was involved with a program called The Start With Arts program (Art Education Boosts, 1996). The intention of this program was to show that teaching pupils about art and music can improve their reading and math skills. The program was administered in two Pawtucket, Rhode Island, elementary schools.

Gardiner believes that the data indicate that when students discover that participating in the arts is pleasurable, they become motivated to acquire skills in the arts. This, in turn, seemed to affect the pupils' general attitude toward other school subjects and helped them improve in other areas. He strongly felt that some skills learned in arts instruction were transferable to other branches of learning.

The two-year study of the Start With Arts program at two of the elementary schools found a "significant percentage" of children who had been below grade level in kindergarten were performing above grade level in first grade after being in the program. After seven months in the program, 77 percent of the pupils were performing at or above grade level in math, compared with 55 percent of other pupils who were given traditional courses in music and art for smaller amounts of time.

Gardiner concludes his study with these quotes,

> You don't teach music and you don't teach visual arts in order to teach kids math. We're not saying that. We're saying there are wonderful reasons for the kids to get the arts training...there are deep effects on their personalities, on their behavior, on their emotional development, on their souls. (Arts Education Boosts, 1996, p.2)

Summary

Does the integration of math and art boost academic achievement? There are claims from teachers across the country that it can and does, even if Eisner is reluctant to see art used in this manner. There are also those who are not enthusiastic about this union, primarily because they do not wish to see art used as a means to an end. Perhaps, at times, the art aspect of the art/math connection is contrived and doesn't occur naturally, but one might ask . . . So what? Is there anything unethical about setting out to provide students with an opportunity to learn sometimes difficult math concepts disguised as art? I personally don't think so as long as art is given its full measure of respect. I must confess that I began this paper with a rather cavalier attitude about how teachers could just throw a little art into the different mathematical objectives they were required to teach in a given year, and the results would be just what the doctor ordered. After attending art classes with wonderfully gifted and talented colleagues and reading books and articles written by experts in the role art plays in cognition, I have gained an incredible respect for the arts.

On the other hand, if a teacher could find an interesting art project that provides children with the opportunity to make decisions regarding painting, drawing, or sculpting and at the same time "see" the answer to what appeared to be an unsolvable math problem, well, it sounds like Utopia to me. To use a little tact here would probably be important, and by that I mean, art is not "just a little project" to enhance logico-mathematical thinking, but rather an attitude—as Gardiner says, "It affects the soul." (Art Education Boosts, 1996, p. 2)

The bottom line is art and math are cognitive "naturals" that should be taught together as much as possible. They compliment each other by the very nature of the complexities each brings to the table. If, indeed, our brain functions in various ways as Gardner (1983, 1993) contends, then that is all the more reason to proceed full steam ahead, with reckless abandon, into the mathematical experiences of our lives presented through living Technicolor and boosted in such a fashion as only art can achieve.

CHAPTER III

METHODOLOGY

Introduction

According to Eisner (1998), the conventional role for research is built upon the paradigm that assigns to the specialist the job of studying teaching and learning in order to identify variables that will have predictable effects on students. This chapter describes a different paradigm used to conduct research based on actual teaching practices in the classroom. It will disclose how such research can have a positive impact on curriculum that has been designed and sculpted by an experienced expert—the teacher—to meet the needs of third grade children in the classroom. Chapter III discusses and describes in detail the components of this research study. It includes information about qualitative inquiry, action research, the teacher as researcher, the participants, site information, curriculum design, data collection, analysis procedures, assurances of rigor, and summary.

Qualitative Inquiry

Qualitative inquiry is defined as the subjective process of understanding and interpreting educational phenomena. The word "qualitative" implies a direct concern with experience as it is lived or felt or undergone—in contrast to "quantitative" research that is indirect, abstract, and treats experiences as similar, adding or multiplying them together, or "quantifying" them. The aim of qualitative research is to understand experience as nearly as possible as its participants feel it or live it (Sherman & Webb, 1998). Glesne (1998) describes this understanding as becoming immersed in the setting, its people, and the research questions. Greene (1998) writes that qualitative research is concerned with meanings as they appear to, or are achieved by, persons in lived social situations. The purpose of qualitative research is to construct meaning through gathered information and interpret it in an attempt to gain understanding of a particular issue (Edson, 1997).

Qualitative inquiry plays an important role in educational research because it consistently raises new questions. It does not focus on the idea that researchers might miss some of the answers. Rather, it focuses on the idea that researchers do not know all of the questions (Edson, 1997). Furthermore, Edson contends that qualitative inquiry also expands our understanding of research by making us conscious of our assumptions and by fostering an appreciation for the complexity of the phenomena being studied. For example, most educators possess assumptions or theories of how children in their classrooms learn math. Qualitative research acknowledges the fact that teachers make assumptions and construct learning theories that provide information that is trustworthy and valuable for other educators.

Edson (1997) writes that qualitative inquiry increases our understanding of educational research by expanding the traditionally logical-positivist frames of reference that encourage searching for universal and external generalizations. Eisner (1988) agrees referring to qualitative research as an alternative paradigm that rejects the idea that there is only one single epistemology and that there is an epistemological supreme court with which to appeal in order to settle all issues concerning truth.

Although there are different qualitative methods (e.g. case studies, ethnography, narrative, and action research) there are similar qualitative concerns in each genre (Sherman & Webb, 1998). Four hallmarks are proposed by Edson (1998) that allow different approaches to be grouped under the qualitative heading. He defines the first hallmark as that of being context-specific. By this he means that ideas, people, and events cannot be understood if isolated from the context in which the research takes place. Sherman and Webb (1998) add that the contexts of inquiry are not to be contrived or constructed or modified; they must be natural and taken as they are found. That is why qualitative research is sometimes called naturalistic inquiry (Lincoln & Guba, 1985). This leads to Edson's second hallmark that all qualitative research should take place in natural settings as opposed to those that are abstract or theoretical. The translation here is that researchers learn more about how children acquire knowledge when the study takes place within the natural setting of the classroom. Edson's third hallmark of a qualitative approach to research is that experience is studied as a whole, not in isolation from the past or present—researchers seek to understand a possible experience as it is actually experienced in relation to both the past and present. Expressed in another way, the experience is to be taken and studied as a whole, or holistically, and one must attend to all features of the experience (Sherman & Webb, 1999). The last hallmark to which Edson refers is the researcher's concern for *interpreting* experience and explaining its significance—experiences do not speak for themselves. It is qualitative researchers who must employ an interpretive frame of reference in order to bring meaning to the experience. It is one thing to observe what is going on in a classroom but quite another to interpret correctly the meaning of the experience. This is what qualitative researchers do.

Though there are different types of qualitative research, Edson feels that any research that claims to be qualitative will share these attributes.

Action Research

Included under the umbrella of qualitative research is action research. In 1946 the theory behind action research originated with social psychologist, Kurt Lewin—often referred to as "the father of action research" (Dickens & Watkins, 1999). Lewin strongly believed that social problems should be addressed by those individuals who were most affected by the social problem, and he understood that the reason for failure to address these needs adequately was the gap between theory and practice. Lewin and his colleagues studied numerous social issues with the intent to improve the quality of human relations. Early action researchers attempted to employ the scientific method to affect change in social issues, but Lewin felt the scientific method was often ineffective in resolving social issue problems. Though Lewin understood the difficulties experienced in resolving social issues and the need for people to be involved in solving their own problems, his model of action research was grounded in the positivist paradigm with clear separation between the researcher and the researched. It was later used in industry research to study ways to make businesses more efficient (Glesne, 1998).

Currently, action research is referred to and defined in a variety of ways. Elliot (1981, p.1) defines action inquiry as "the study of a social situation with a view to improving the quality of action within it." Miller and Bench (1996) state that action research is not like university research. In university research, teachers are typically the subjects of the research, or they gather data for someone else to analyze. With action research, teachers become the initiators; they develop and lead the studies of issues important in their classrooms and schools. Action research concerns itself with the processes that are

> rigorously empirical and reflective; engage people who have traditionally been called "subjects" as active participants in the research process; and result in some practical outcome related to the lives or work of the participants

adds Stringer (in Kuzel, 1997). Calhoun (1998) writes that action research is learning to inquire together in order to generate knowledge and action simultaneously. Though action research can be couched in many descriptions and can assume different guises, its two main goals are always improvement of the situation and involvement of the participants experiencing the problem (Dickens & Watkins, 1999).

In recent years action research has experienced a renewal of popularity (particularly in education as a way to improve practice), and more teachers have shown an interest in becoming researchers. Researchers who identify themselves as action researchers attempt to clarify and modify Lewin's theories in many areas. Educational action researchers argue that curriculum inquiry and theory should be relevant to what is practiced within classrooms and other curricular settings and should be accomplished by practitioners (McKernan, 1991). McKernan explains action inquiry as a form of practical reflection related to curriculum choice that takes into account the teacher's personal interpretive account of what occurs in the classroom. In the classroom the teacher is a participant observer in a naturalistic setting in which observation and research opportunities present themselves (McKernan, 1991). Teachers are natural participant observers who reflect upon curriculum practice daily.

Eisner (1998) adds that although there is a place in research for conventional approaches, there is a difference between the kind of knowledge a teacher needs in a particular context and the abstracted generalizations found in learned journals or provided by in-service programs for teachers. He suggests that teachers need to conduct research themselves—action research. Furthermore, what action research yields is not to be regarded as dependable prescriptions for action but as interpretations to increase the quality of teachers' deliberations. Eisner (1998) feels that is important to conduct this type of research because the kind of knowledge gathered on the inside differs in fundamental ways from the findings that will ultimately be published in a professional journal. He believes that this type of research expands teaching rather than reducing it to a rule and, in the process, confers professional status to the teacher.

Lewin is credited with having developed a spiral theory for addressing social issues that involved interlocking cycles of planning, acting, observing, and reflecting (Dickens & Watkins, 1999). To address current social concerns in the classroom, such as curriculum change, the cycles of research have evolved to encompass observing, reflecting, and acting according to Kemmis and McTaggart (1988). Though the words for the cycles tend to vary by author, the common denominator appears to be some form of looking, thinking, and acting.

My action research inquiry used the philosophical theory provided by the qualitative umbrella term "action research" and applied the evolved research cycles of observation, reflection, and action. I observed over the past two decades that children have problems understanding the mathematical concept of place value. I recognized the importance and need for third graders to acquire a basic understanding of the mathematical concept of place value in order to achieve success in mathematics. The extent of this understanding of place value and the study of how number placements define value influence the future success third graders experience in mathematics (Copeland, 1984). I reflected upon how this educational practice could be improved, and I designed a new method to teach place value by integrating art experiences into the mathematical concept. This new plan of action was implemented in my classroom this fall. Implementing some of the ideas of Lewin's social action theory, I became the researcher, my students became the subjects of curriculum change, and the classroom became the setting for this action inquiry.

The Teacher as Researcher

Though the role of researcher was a new one for me, the role of third grade teacher was not. I have enjoyed renewing and redesigning that role every August for the past 21 years. This teaching opportunity first presented itself when the principal of the local elementary school offered me the choice of teaching either third or fourth grade in the fall of 1978. I chose third, and third grade it has been since that impulsive initial choice. Though some might think teaching only one grade a limiting experience, I do not. Third grade is just a convenient descriptive name coming between second and fourth in ordinal order. I have taught children performing anywhere from kindergarten through, in some cases, fifth grade in the same room at the same time. It might be said that it has been a regular one-room schoolhouse affair.

For most of my tenure, I team taught with two other teachers in a departmentalized teaching situation. I taught the math: that meant I was often responsible for teaching math to 75 or more third graders in one school year. As the educational pendulum began to shift in the '80s to embrace theories of whole language and integrated learning, I realized a need to make some adjustments in my teaching pedagogy. I sought ways of integrating social studies, science, and art into the math and language arts curricula that I was responsible for teaching. Through this context, I was able to expand my teaching expertise to include other subjects. At present, I team teach with one of the teachers with whom I began this saga. She is still mainly responsible for the science area and I for the math, but we currently enjoy sharing, planning, and integrating our math and science programs.

Though there are few who embrace departmentalization of subjects today, I do not regret the opportunities it afforded me. As a novice teacher, I could focus on math preparations—making all of the hands-on manipulatives needed to teach math the next day. Departmentalization afforded the time and opportunity to become more confident and proficient in teaching third grade math. My personal need to feel more competent provided the stimulus to return to the university setting to expand my current teaching skills. The goal always has been to become a more effective teacher by improving upon my teaching techniques and understanding the ways in which children acquire knowledge.

I experienced many reservations about conducting research with my own students. The participants in this study would be the third graders I work with on a daily basis. I had my doubts as to what the results of the research would uncover. Would any significant information emerge from a study designed to integrate diverse art experiences with the mathematical concept of place value? Would noteworthy theories emerge that would provide assistance to colleagues as they endeavored to teach their students the concept of place value? Could I be objective and not judgmental while trying to conduct this inquiry? Could I carefully observe the children's art/math experiences, conscientiously record in detail the many dimensions of the learning encounter, and correctly analyze what was going on in these surroundings? Would I still have time to be a classroom teacher?

Defining the Participants and Site

Once the topic for the research and the type of inquiry to be conducted had been determined and the review of relevant literature and theories pursued, the issue became where to conduct this study and who the study's participants would be (Glesne, 1998). The site chosen for this research was the elementary school where I have been employed as a teacher for the entirety of my 21-year teaching career. The most obvious reason for this decision was the site's accessibility, my two decades of personal history within the four walls of this building, and the pride and loyalty I felt with regard to the school's accomplishments. In order to conduct a trustworthy inquiry, I knew it would be important to make the strange familiar and the familiar strange in an attempt to gain new insight from these familiar surroundings (Glesne, 1999).

Acknowledging there were definite pitfalls in conducting research within my classroom, I still found myself eager to give this research a try. I began to familiarize myself with the subjects of this inquiry—the children—through documentation; namely, enrollment cards. This class is composed of 20 children—12 boys and 8 girls. Information from these "green cards" indicated that the parents of the participants in the study checked the box marked Caucasian for race for all children with the exception of one black male and one black female. English was the language spoken in all 20 homes. Only two male children were born out of the state in which they currently reside, and ten of the children, half of the class, were born in the city of which they live. This group of children is neither ethnically nor geographically diverse. Fifteen children still live with the original parents who brought them home from the hospital. Of the remaining five students, only one male and one female live with a single parent—the mother in each case. One male and one female live with the birth father and stepmother, and one male lives with the birth mother and stepfather. This is a significantly higher percentage of children living with two parents than I have observed in classes in the past decade. Those classes tended to show just the opposite parental background with one-parent homes or stepparents figuring more into the configuration of the class. The fact that all parents attended open house and the first parent conference indicates a strong interest in their children's education.

A brief look at the socioeconomic status of the parents of this group of children revealed a lack of unemployment—apparently those parents who wished to be employed outside of the home had jobs. This fact speaks to the current economy in the state and the nation (1999 Oklahoma Economic Outlook, 1999). Unemployment in this county is at an all-time low. Occupations ranged from professors at the local university to blue-collar workers employed at various construction and factory sites located in town. Four parents, three male and one female, listed their occupations as self-employed, and six mothers listed themselves as housewives or homemakers. For the most part, the children come to school clean and appropriately dressed for school and the weather. There does not appear to be a reason for concern regarding financial assistance to supplement the families' incomes to meet the basic needs of their children. At a glance, this background information seems to indicate a group of children whose parents are sufficiently able to take care of their children's basic needs and appear to be interested in the quality of education their children receive at school.

This class of 20 children is typical in comparison to other third grade classes in the building, but it does have some "special needs" children. The behavior of these children is important to note as they presented potentially disruptive factors in the study. The behavior of the participants had the capability to affect their ability to pay attention to the teacher, to concentrate, and to process new information. These behaviors could also have a negative affect on other children in the classroom when the teacher's time was directed to the interruptions these behaviors created.

One child in the classroom had been recommended for placement in an emotionally disabled class due to behavior and academic performance. Another member of this class was a child diagnosed as autistic, though the autistic mannerisms manifested by this child are mild and usually do not present handicaps for learning. For example, the reading level of this child, according to the reading specialists and multiple reading tests, is above that of the average third grader.

Included in the classroom composition is a child with diabetes. Although this child was very responsible about remembering to eat snacks during the day, there was always the potential that the learning environment could be changed at a moment's notice if this child required the teacher's assistance. The other children understood the seriousness of this health issue and were sensitive to the fact that this child's needs came first.

These were the identified problems, but other emotional areas of concern stemmed from issues of anger, attitude, and behavior. For instance, one child found comfort from hair twirling and thumb sucking at frequent intervals during the day, another child's frustration often led to angry outbursts that included breaking pencils, crayons, rulers, etc. and hurling them at classmates. For two children, just the hint that something was incorrect about their work or fear that they did not understand a new concept was reason for tears—at which point one of the children began vomiting. There were serious issues surrounding the fear of failure, defiance, anger, and insecurity observed among the children in this classroom to such an extent that several of the parents have sought professional counseling.

Five of these 20 children were identified in previous grades as learning disabled in one or more content areas. Therefore they spend from 30 to 90 minutes daily, depending on the child's individualized educational plan, under the tutelage of a teacher designated for this instruction. Four of these children also spent 30 minutes daily with the reading specialist, and two attended speech therapy sessions with the speech therapist for 30 minutes twice a week. It was difficult to find significant times during the day when the entire class could work together—a definite downside to "pullout" programs. This "typical" group of third grade children made up my class.

The school—the site for this research—was located in the northeast section of town in what used to be thought of as the "edge of town"—in fact, it is believed that this site was once the town's landfill. Recent years have evidenced housing developments springing up in directions to the north, west, and east of the school. These houses are built with young families in mind and contribute to the always-increasing population of the school. This site provided the participants and the opportunity to write about children and their learning experiences.

Curriculum Design

The purpose of this study was to determine how the integration of diverse art experiences with a mathematical unit on place value helped third graders understand the mathematical concept of place value and what role the art experiences played in changing the children's attitude toward math. Inspired by the books, *Teaching Mathematics Though Children's Art* (Williams, 1995), *Math Art* (Brunetto, 1997), and *Math Art* (Ritter, 1995), I designed a math curriculum infused with art experiences to integrate with every third grade math PASS objective on place value and NCTM Standard addressing the mathematical concept of place value (Appendix B).

For purposes of the research, the unit on place value was selected for a variety of reasons. The foremost reason was the fact that it is an abstract concept that is difficult for third graders to understand. Third grade is a time when most children are just grasping the concept of number, yet the scope-and-sequence chart in a mathematics curriculum requires an understanding of place value concepts (Copeland, 1980). If a teacher follows the scope and sequence of a state-adopted textbook, children are allowed little time or opportunity to construct a personal meaning for place value. Place value is the key component on which understanding the number system is built (Copeland, 1984, Labinowicz, 1980).

From past teaching experience, there is never enough time for the children to experience fully and explore thoroughly the place value concept. While many children can memorize the steps for adding and subtracting, they are unable to grasp the actual meaning of those steps due to their misconceptions of the base ten number system. Place value is an essential concept to be understood if children are to be successful in their pursuit of higher-level thinking in mathematics (Labinowicz, 1980).

The place value unit that I developed was conducted over a four-week period of time during the fall of 1999. Art experiences (Appendix C) designed to be integrated with each math concept taught during the unit on place value (Appendix F) were central to this study. The art experience was created to extend and visually expand upon the math concepts taught in an effort to strengthen the children's understanding. In addition, these art experiences provided children the opportunity to use diverse art mediums at the same time they were learning math concepts and skills. The artwork produced by the children throughout the month's study were displayed on bulletin boards in the class or kept in a math portfolio for future reference depending on the child's preference.

Data Collection

Data for this research were gathered through several means: enrollment documents, conservation activities, initial and final interviews with the children, written questions relating to the children's prior knowledge of place value and their understanding at the end of the study, participant observations made by the teacher as researcher that took place during math and art experiences, Field Notes Journal reflections recorded daily by the children participating in the study, and parent surveys that were filled out before the study began and at the study's conclusion.

Enrollment Cards

The enrollment cards provided background information for the research by asking for specific information about the child—name of the child, date and place of birth, address, employment of the parents, siblings, teachers in past years, medical problems of which the teacher should be aware, and who to contact in the case of emergency. These green cards, as they are often called, provided very concrete information about third graders—a literal understanding of the children who participated in the study.

Conservation Insights

Before beginning the research on the place value unit, a quick and informal one-on-one conservation assessment with each child was performed to determine if the children were able to conserve numbers, equivalency, grouped numbers, and quantity (Appendix E). Being able to conserve numbers is an essential prelude to the understanding of the place value concept. Included in this brief oral assessment was a place value activity using lima beans and one using base ten blocks (Appendix F & G). The purpose of each of these activities was to expand my understanding of the children's ability to work with numbers and to become better informed as to the levels of concrete and abstract cognitive reasoning each child possessed. A basic check-off list with each conservation activity, the base ten activity, and the lima bean activity was listed in columns across the top of the page, and a place for each child's name down the left side of the check-off sheet was used to record the answers given by each child. If the child was able to perform the conservation activities, a check was placed by the name under the activity.

For the base ten and lima bean activities, the numbers 1, 2, and 3 were used to designate the level of competency.

Interviews with the Children

The purpose of an individual interview was to provide the researcher with the opportunity to sit down with the children in the study in an effort to understand better how school "worked" for them (Glesne, 1999). Prior to the beginning of this unit, each child was interviewed. The children loved this special time alone with the teacher and a tape recorder and were very eager to hear their voice on tape. Though this was a time-consuming endeavor—much more so than had been anticipated—it was an interesting one. School had just begun, and I did not know these children very well. I had a cursory understanding of their skills—both academically and socially—but really did not know who they were or what they thought about school, their teacher and classmates, and the subjects they studied. The interviews were a way of "coming to know" each child better.

Each interview consisted of nine questions (Appendix G) designed to learn about the children in my classroom and—important to this research—their attitudes about art and math. Some interviews were more successful due to how well these children could express themselves orally and, perhaps, the comfort level they felt with the interviewer. There were times during the day when the opportunity to interview the children was better suited for this activity than other times. The best time occurred while other class members were seated at their desks, quietly engaged in learning activities that did not require my attention. The interviews were then conducted in a corner of the room while within eyesight of the other children. The novelty of this experience soon became a routine procedure for all of the children as each child realized they would have a turn with the teacher and the tape recorder. Time periods before recess, their special classes at the end of the day, and prior to getting ready to go home were not prime interviewing times. The interviews did provide a better understanding of these children and their attitudes about school preferences—especially in the areas of art and math.

The children's final comments were recorded on tape in the last interview sessions. The children were excited about another interview, but they suggested that these taped interviews consist of small groups. It was agreed that this might be an interesting way to conduct the interview—the interviews would take place over the lunch hour, and the group participating in the interview would bring their lunches back to the classroom and eat while being interviewed on tape. Though I chose the first group of children, from that point on one person volunteered to select a group of four children for the next day. The ground rules for these groups included the requirements that all participants take turns speaking and take turns listening while others were speaking.

Written Questions

Assessing prior knowledge with written questions that pertained to the unit on place value was one aspect of collecting data for this research. This assessment required handing the children a piece of paper with 19 math problems pertaining to place value concepts that were going to be taught during the next few weeks. The purpose of these questions was to determine how much information the children possessed about this mathematical concept in order to understand how better to teach the unit. Questions were designed to ask for specific knowledge of different ways numbers could be written, the use of the < > symbols, rounding concepts, writing money amounts, and story problems. The story problems were included for the purpose of finding out if children knew how to employ the strategy of "draw a picture" to solve the problem (Appendix H).

Although the interviews with the children had been an enjoyable experience for the children and the interviewer, the paper and pencil prior knowledge activity was not! This activity was presented to the children from the calm and rational standpoint that this was just a way for their teacher to understand how much they knew about the subject of place value. They were told that this activity would not count as a grade and that they were not expected to be able to answer all of the questions. The children were not impressed with efforts to help them relax and work through this activity. Many of the children became very agitated and distressed—to the point of tears in more than one instance. The children were asked to solve problems for which they had no prior knowledge, nor did they understand the math vocabulary. This activity appeared to be written in a foreign language, and they did not like it.

While the activity did give an understanding of prior knowledge, the downside to this activity was the stress the children felt as they tried to please their teacher. It leads reflecting teachers to wonder if the pencil-and-paper activity could have been written in a more user-friendly manner for the children or if they could have been better prepared mentally in advance of being asked to accomplish this task. In retrospect, individual interviews could have been adopted—perhaps at the same time the initial interviews were conducted.

It seemed from all outward appearances that when the written questions were passed out to each child at the end of the unit, they did not prompt the level of stress that the initial one had produced. Even though the questions were read to all of the children, tears still brimmed in the eyes of two children, but this time the student teacher interceded and took each child aside and read the questions to them. This was also done for the child who could not read due to the severe degree of emotional dysfunction.

Parent Surveys

Recognizing that parents are an essential component in the success children experience is important, but recognition is not enough. It is important for parents to become actively involved with the process. For this reason, upon acquiring written consent from the parents for their child to participate in this research study (Appendix A), the parents were asked to take part in the study by filling out a survey (Appendix J) before the study began. It is noteworthy that a parent survey form was received for each child that participated in the study.

The parent surveys added a different and familial insight into the children's abilities and attitudes toward school and the classroom. Filling out the survey signaled parental interest in their child, the importance parents place upon their child's education, and a willingness to become a partner in their child's school success. The parent responses elicited from the surveys were well written indicating that time had been spent reflecting upon their child's unique needs before answering each question. While reading the surveys, the parents' voices could be heard—quite poignantly in some cases. The parents filled out the final survey (Appendix K) shortly after the unit had been completed.

Field Notes

The role of the researcher is to observe, experience, and record in detail the many aspects of the situation (Glesne, 1999). Of importance to the collection of information about third graders' understanding of place value as presented in the context of an integrated art and math curriculum were the field notes written about the actual activities observed each day of the study by the researcher. It was difficult to observe and fulfill the participatory observation role of the teacher as researcher; therefore, the use of a tape recorder was an essential element in gathering data. I taped over 20 hours of classroom instruction pertaining to this unit and transcribed each of those tapes nightly in addition to filling in my reflections as to how well the day had progressed. On several occasions there were observers in our classroom, and I invited them to write down what they observed, and their reflections were also recorded in my field notes. Participant observation provided the opportunity to assess firsthand how the actions of third graders corresponded to their words, their patterns of behavior; and to experience the unexpected, as well as the expected.

I designed a special notebook for the children to use to record their daily reflections. These notebooks were called Field Notes Journals. These Field Notes Journals were read to ascertain the children's understanding of concepts and terminology. Having the children record daily their understandings and reflections of the integrated art and math lessons in their Field Notes Journals added important data to the study from the children's point of view.

Data Analysis and Coding Procedures

Analysis of the collected information from many sources was ongoing. Further data analysis involved organizing what the researcher had seen, heard, and read so that some understanding and meaning could be derived from this research experience (Glesne, 1999). The information, as has been stated, was generated from several sources including background documentation, conservation activities, initial and final interviews with the children, prior and final written questioning about the children's understanding of place value, teacher/researcher observations and field notes, the children's Field Notes Journals, and parent surveys taken at the beginning and end of the study. Information from these sources was gathered and critically analyzed for data pertaining to this study.

Analysis for this study can be thought of like a kaleidoscope with information evolving from the different turns—meaning the distinct ways in which the children have been observed. Each view is designed to add data helpful to the researcher's thoughts on how children construct logical mathematical knowledge that has been integrated with diverse art experiences. The first view of the kaleidoscopic information emerged from documentation acquired from the enrollment cards that parents were required to complete at the time of their child's enrollment in school. This information provided basic data about each third grade student in the study. Conservation activities were used to assist the teacher in understanding the children's working knowledge of numbers before the study began. Additional personal documentation was acquired from interviews conducted with the children both before and after the study was completed. Parents provided another view of the kaleidoscope by completing the initial and follow-up surveys designed to elicit information about their child's school performance. Another kaleidoscopic view emerged from the written questions about place value the children had been asked before and after the study. Each turn of the kaleidoscope painted a pictorial scene structured to create additional data about the children observed.

From a more interpretive kaleidoscopic view, the thick description generated from daily field notes taken by the researcher from classroom observations as the children participated in the math and art experiences were transcribed daily. Analyzing what the children wrote in their journals at the end of each session provided still another turn of the kaleidoscope. After all of the information had an initial viewing, a more structured system was needed to analyze what that information meant.

Glesne (1999) suggests that in order to analyze the data that were produced by the various methods listed in this study, a coding system is needed to help organize, classify, and find themes within the data. She defines coding as a progressive process of sorting and defining the multitude of collected data. At the beginning of the study the initial goal was to place the information into the generic categories from which the information was collected—field notes, interview transcription, surveys, etc. This was accomplished with a basic filing system consisting of a small filing center with different color-coded file folders identifying each source of information.

As the analysis of this information became more intense, a data display was utilized in order to organize and provide scaffolding to place classified data as it began to emerge. The location of the data display was the floor in the researcher's study; thereby providing easy access to the computer and confidentiality of the information collected.

Once all of the information was collected, I took each generic category and analyzed it for common word phrases. These word phrases were listed on a separate sheet of paper and counted for the number of times they reoccurred in the writers' or speakers' dialogue. The counted phrases taken from the generic categories were then collectively studied and placed under the generalized themes that emerged. As I interpreted each kaleidoscopic view for themes, three voices of data were revealed—mine, the children's, and their parents.

The parent voices as a whole spoke to their children's successful experiences in school, the children's positive attitudes toward learning, and parent opinions about how their children learned best. Word phrases such as repetition, practice, hands-on, and visual learning emerged from the surveys. Final surveys added to the word phrases including thoughts about how much their children had learned when mathematical concepts had been integrated with art experiences. The surveys also discussed the fun their children had experienced as they learned. To make certain that I was not just observing what I wanted to observe from these surveys, I looked for another method of reading and analyzing these surveys. I separated the parent surveys of girls and boys and reread and analyzed them for additional support for my initial findings. Next, I separated the parent surveys of children who had experienced a great deal of school success from those of children whoI knew had struggled in their early school experiences. I defined struggling learners as evidenced by the fact that those children were receiving additional learning assistance in the reading or the learning disabled lab.

I continued this separation of girl/boy thoughts and successful/struggling learners as I reviewed the children's comments in both interviews and what they had written in their field notes. Together, these provided word phrases that spoke to the amount of knowledge, fun, and camaraderie they had experienced as they participated in this unit. The enthusiasm with which they addressed these issues could be heard loudly and clearly. My voice derived its thoughts from my classroom observations, conservation and prior knowledge assessments, and interviews with the participants. My word phrases appeared sometimes to echo those of the parents and children as I found the word "fun" used to describe so much of what had been accomplished in those four weeks. I added word phrases pertaining to the children's engagement in the activities, their eager responses, and improved behavior as the unit progressed.

From these observations, provided by the three voices, emerged themes to pursue as the data were analyzed. The data were then organized and analyzed through themes to provide an understanding of the role that art experiences played in helping children understand math concepts. The data from the themes also provided clues about the children's changing attitudes with regard to math.

Addressing the Issue of Rigor

Dickens and Watkins (1999) state as a criticism of action research that it can become research with little action or action with little research. Frequently, it is mentioned that action research lacks the true rigor of scientific research. Dickens and Watkins (1999) also state the opposite side of this issue of rigor. They write that the validity of the theory is judged by a simple criterion—if the research leads to improvement and change within the context of the situated problem, then it is valid. This research inquiry addressed the issue of rigor by implementing the principles set forth by Lincoln and

Guba (1985). According to Lincoln and Guba (1985), a researcher pursuing qualitative research must address four major issues to establish the trustworthiness of their endeavor.

The first issue addresses the "truth value" of a particular inquiry. In order to establish credibility within the context of the research, the researcher must verify the credibility of the research. This can be accomplished through prolonged observations of the participants, triangulation, thick description, peer debriefing, member checks, and continued analysis throughout the time period that the research encompasses. In the search for truth that Denzin's (1989) triangulation process advocates, I applied multiple methods by gathering research from documents, conservation activities, interviews, parents' surveys, my field notes and observations, written questions answered both before and after the study, and the children's Field Notes Journals.

The second issue concerns the applicability of the research—looking to see if the findings of this particular inquiry have applicability in other contexts and/or with other participants. For example, if art integrates well with math and children's understanding of math is significantly improved, would the same results occur in the areas of social studies or language arts? I have integrated art into every area of the curriculum and found it to integrate easily with other curriculum subjects as well as other mathematical concepts. In particular the "draw a picture" strategy relates to story problems throughout the year in other math areas.

The third area deals with the concept of dependability. Although a qualitative inquiry can never be replicated, the dependability of the research can be assessed by audit trails. Audit trails are detailed paper trails that in this inquiry involved observing students at the same mathematics period every day for four weeks while the children were learning the mathematical concept of place value. During this time detailed notes were taken by the observer with the assistance of a tape recorder. All of these paper trails are filed and available for future reference.

The fourth issue is that of confirmability—which refers to establishing the degree to which the findings of the inquiry are determined by the participants and conditions of the inquiry and not subjectively biased because of the researcher's biases, motivations, interests, and/or perspectives. I checked with participants of the inquiry and consulted with my student teacher who was present for the entire teaching unit to certify that the analysis was accurate in order to assure the integrity of the research. After the interviews with children, I verified with each child that what I had written was indeed what they meant to say, and that I had correctly interpreted what they had shared. When there was time, I played the tapes back to the children because they enjoyed listening to themselves on tape. This provided an opportunity for the children to make corrections to our taped conversations or add to them in any way. Parent conferences that were held the first Monday in November gave me an opportunity to visit with parents about my initial research findings and to check their comments on parent surveys for authenticity. Adhering to these four guiding principles insured an action research inquiry of a rigorous quality.

Summary

This chapter provides the rational for using a qualitative paradigm and speaks specifically to the use of action research methodology. Action research espouses that teachers can be researchers within the context of their classrooms—indeed, they are the experts in the classroom and know how to design and implement curriculum changes to meet the needs of their classroom children.

Therefore, in this inquiry the researcher is myself, using an action research methodology to study third graders at a local elementary school. This study is designed to integrate a variety of art experiences and implement them into mathematical instruction to help third graders understand the mathematical concept of place value. Background documentation, conservation activities, teacher observations documented in field notes, transcribed taped interviews with the children both before and after the study, written questions for the children to answer pertaining to their prior knowledge of place value and their information at the conclusion of the unit, initial and follow-up surveys completed by parents, and the children's reflections written in their Field Notes Journals generated a kaleidoscope of data. This collection of data was coded and analyzed in an effort to elicit information useful to this classroom and transferable to other classrooms and areas of study as well.

By focusing on the integration of math and art in the teacher-guided instruction of place value concepts, the traditional philosophical method by which this instruction is usually approached is deconstructed and reconstructed to better meet the needs of the children involved in the study. The ultimate goal of any curriculum strategy and, most particularly, this art and math integrated approach was to increase children's understanding of place value, create positive attitudes toward math, and produce a group of children committed to the goal of life-long learning.

CHAPTER IV

RESULTS OF THE STUDY

Introduction

At this stage the researcher must stop and reflect upon what has transpired—one must unearth the effects of the actions taken and seek to explain these within the context of the project (McKernan, 1991 p. 319). Qualitative researchers use many techniques to help organize, classify, and find themes in their data, but they still must find ways to make connections that are ultimately meaningful to themselves and the reader (Glesne, 1999, p. 149). This is now the time for data analysis—or data transformation as Wolcott (1994) defines it.

Four themes emerged from the flow of the data collected from parent, student, and teacher/researcher voices that addressed the learning event as it transpired in the classroom environment:

1. The integration of art and math provided a positive learning environment;
2. The integration of art and math helped children understand abstract math concepts;
3. The integration of art and math promoted attitude shifts; and,
4. The integration of art and math provided alternative assessments.

These themes were interwoven and blended into the descriptive transformation of the data. The voices of parents, children, and teacher were heard in data collected prior to the learning event, simultaneously as the learning event evolved, and in the concluding activities of the learning event. These events provided the reader with data transformation of each kaleidoscopic point of view evidenced through the different voices, selecting and portraying details that addressed the study's purpose.

Using Wolcott's (1994) ideas about connecting data with meaning, I analyzed the data allowing the voices of parent, child, and teacher to speak for themselves as to the themes that evolved from a research study that included art experiences integrated into a math unit on place value. To hear these voices clearly and understand the meaning implied by each voice, it was necessary to understand thoroughly the environment in which the study was conducted thereby fulfilling the hallmark of qualitative research—that of being conducted within the context of a naturalistic setting.

The Naturalistic Environment

To understand and appreciate the significance of the inquiry, one must first visualize the environment in which the study took place and its participants—their daily routines, interests, and mathematical abilities preceding the study. Third grade is a busy year for children. It is a "midway" year inserted between the primary grades of kindergarten, first, and second and the intermediate grades of fourth and fifth. Sometimes, third graders are the big fish in the little pond when grouped with the primary grades for school assemblies and programs, while at other times they take on the persona of the little fish when attending functions with the intermediate grades. No one is quite certain where to group third graders as is evident by the fact that third graders at this school have the playground all to themselves at recess. This allows for a certain bonding among third graders—a special time to catch their breath and find out just who they are before being thrown in with other grade levels.

Third grade is a significant year for another reason—achievement tests. For most of the children, this is their first exposure to the term achievement test and the experience of taking a standardized test. For this reason when instruction is given, I use achievement test terminology—math, social studies, science, and reading—because it will be utilized during the achievement-testing situation. Regardless of how one feels as an educator about the purpose and value of these tests, the children are required to take them, and not being prepared for what to expect increases test-taking anxiety. Achievement tests do affect how the curriculum is defined within the year, but the tests themselves do not dictate the curriculum—the children and I do that—and teaching to the test is not a viable option. Keeping these observations in mind, a third grader's day in our room progresses in the following manner.

The Schedule

Children walk into the classroom at 8:30. Their room is organized with desks in various groupings to allow collaboration on different projects. The bulletin boards are filled with the children's artwork except for one that is reserved for Every Day Counts' Calendar and Math Activities. As the children arrive, they store their backpacks on coat racks at the back of the room, check in for lunch, and begin what is called the "energizer." The energizer includes: a word to look up in the dictionary, a sentence to edit, an analogy to solve, a geography map fact to locate, a fascinating fact, and a math problem of the day. These activities are designed to get brains activated for the busy day ahead. The subject of each day's energizer is integrated with the social studies' unit we are currently pursuing. This is also a time for the children to perform their daily chore with their partner—these chores range in nature from weather reporting to supplying assistance to the teacher, but most are related to the Every Day Counts activity that is addressed in more detail later in this section.

A lesson in social studies begins at 9:10 and lasts for approximately 50 minutes. The subject of communities is the focus of the third grade social studies curriculum, and the year is spent talking first about our own community—class, school, and city—then exploring communities of other cultures. Next, the children turn their attention and thoughts to science. A new program called Goals 2000 Science Project is currently being implemented into this school's science curriculum. This program is a hands-on, inquiry-based science curriculum for which I am currently being trained to teach. The Goals 2000 science curriculum for third grade focuses on two units—plants and mystery powders. The science instruction is followed by a short recess—a time to run off some energy and take a break.

When the children return from recess, they participate in an activity that is called Every Day Counts. This activity is the primary source of the chores that the children are responsible for performing. It involves keeping a daily count of coins and bills—the amount of the coins and the bills is determined by the number for the number of days they attend school. For example, if the children have been in school 15 days, they add 15 cents to the coin collector and 15 dollars to the daily depositor. Every Day Counts also includes maintaining a monthly calendar, a running tally of the number of school days attended, and a daily weather report. Many interesting and informative discussions about math and science emerge from this routine activity.

The Every Day Counts activity provides an excellent segue way into the day's math lesson. Approximately 50 minutes are spent daily on the numerous math PASS objectives third graders are required to master during the year. Sometimes, the state-adopted Houghton Mifflin math textbook is used, at other times math units are derived using a variety of professionally published or teacher-made materials. Manipulatives of every shape, color, and kind; buckets of pattern blocks; and wooden place value blocks are available for use when appropriate. Most math lessons begin on the floor; then, depending on the activity, small groups may gravitate to other parts of the room to collaborate on the day's assignment. It is during this segment of time in the day that the research for this study was conducted. Past teaching experience has shown this time period to be an optimal time of the day for children to study math. They have had time to wake up, do some thinking, and play a little—activities that I have found increase attention span.

At 11:50, the children go to the cafeteria to eat lunch except on Friday, "Lunch Bunch" day, when we eat in the room. The noon recess follows lunch, and when recess is ended, the children return to the classroom and relax during one of our favorite times of the day—Read Aloud. During this time period, I read books from different genres to expose the children to a variety of authors and their writing styles.

The afternoon centers on reading and writing activities. Typically, there is one story from a state-adopted reading anthology used as whole group instruction. In addition, there are two or three smaller literature groups that read in "chapter" books appropriate for their reading ability. Writing activities include recording in "lit logs" thoughts or personal reactions to the chapter book the children are reading and daily journal entries reflecting upon the day's learning activities. Special writing projects are incorporated throughout the year to teach prewriting, rewriting, and editing skills. Spelling and phonics are integrated into the energizer, reading, and writing activities. Since the state adopted a Reading Sufficiency Act in 1998, the specific areas of phonics and spelling receive greater attention in the curriculum. Special classes such as music, physical education, library, and guidance close out the day. Every day is a busy one in third grade—there is never a dull moment, and the days pass quickly!

The Learning Event

Analysis of the integrated art/math learning experiences included in this research study relied heavily upon my nightly transcribed field notes that included the daily taped instructional sessions, my observations, and some of the written comments the children had made in their field notes. At the end of each math instructional period, the children were encouraged to write reflections in a special journal. For some children this was easy because they had entered this classroom via classrooms that encouraged daily writing—for others, it was extremely tedious. After the first few attempts, the class initiated the idea of a "starter" sentence for those children who had difficulty expressing their thoughts with pencil and paper. Brainstorming for new vocabulary words, math concepts, and art experiences that had been introduced proved to be an activity that assisted the children to recall what had been discovered that day.

The first session began with the introduction of the place value unit. It involved gathering all of the children together in a circle on the floor at the front of the room for the purpose of informing them of the journey upon which they would soon embark. This journey would require them to become "researchers of numbers." It was explained that during the entirety of this journey they would be learning about numbers while at the same time experiencing many art experiences designed to "go along with" their number experiences. In order to complete this journey, the children were told that they would keep notes about their journey in something called a "Field Notes Journal." From this followed an explanation and discussion of the role of a researcher and the responsibility researchers must assume to observe, understand the situation, and keep accurate and comprehensive field notes about what they had observed and understood. Furthermore, it was explained that I would be observing them and taping our class discussions to discover how well they were learning about numbers in our place value system. My observations included that the children were engaged, enthusiastic, and eager to don the mantle of researchers as was evidenced by the number of children with their hands in the air who wanted to answer or ask questions regarding the upcoming unit. Additionally, some of the children wrote these comments in their journals:

"we are resarchers of numbers"

"we get to keep feel notes"

"I get to do art evry day"

"recherers of numbers"

"hop we do art tiday"

Matrix Construction

The first five lessons of the study focused on the concept of a matrix (Appendix L). An overhead projector was used every day to project a blank matrix for the children to call out numbers for the teacher to record in the appropriate blank square. During this activity the children were looking for number patterns and counting by 1s and 10s. Initial exploration of the matrix progressed to include a larger matrix consisting of more numbers in different counting orders to allow the children alternative number situations. Teaching objectives for the study of the matrix were to improve and enhance the children's understanding of the numbers and how they were positioned, situated, and related to each other. Discovering number patterns and skip counting were important objective targets. Primary vocabulary words such as up/down and right/left were introduced to assist the children in their efforts to describe where the numbers were situated and to identify other numbers in the surrounding area. North, south, east, and west were also used at times for the same purpose. The children had to describe specifically the number placements using those terms. For example, put the number 57 to the right of 56, to the left of 58, up from 67, and down from 47 (Appendix L). I knew the children understood the concept when upon being recognized they were able to give clear and concise directions for the number placements:

"put the 5 in the box to the right of 4 and the box to the left of the 6"

The children were asked questions about what happens to numbers as they moved from left to right, right to left, up to down, down to up, north, south, east, or west to stimulate interest and create awareness of patterns within a matrix system. Each answer given by the children was an attempt to establish some visual contact with an abstract number system. Understanding of this concept was apparent when the children could respond:

> "counting down 16, 26, 36—we're counting by 10s with sixes"
>
> "counting down 28, 38, 48, the number under 48 will be 58"
>
> "going across the top we are counting by ones"

Further understanding was evident when I asked the children to pick a number, choose a row, and count it out. Their explanations included:

> "counting by ones, going across, starting with 10, 11, 12, 13, 14, 15, 16, 17, 18, 19"
>
> "I see a pattern going down"
>
> "I see a pattern going from top to bottom on 5s"

Not all children understood these patterns or the concept of counting by ten using 1s, 2s, etc. after the first two days because wrong responses included:

> "going down with 7s then we will be counting by 7s"
>
> "going down with 8s we will be counting by ones"

This understanding or lack of it was also evidenced by some of the entries in their Field Notes Journal:

> "I didn't now you could count by 7s with ones"
>
> "goin acros the matrix you count by 10s"

More days of practice were conducted than had originally been planned for this activity so everyone could acquire an understanding of the concepts of counting and finding patterns on a matrix.

The last day's matrix activity introduced a number game that we labeled, "the arrow game." It involved using a 1-144 numbered matrix transparency (Appendix C). This matrix began with the number 1 in the lower left-hand corner moving to the right to the number 12 on the bottom row, then the second row starting again on the left with the number 13 etc. until the matrix reached 144 in the upper right-hand corner. The children were told that we would be playing a game, and it was their job to determine what the rules of the game were by guessing the number I had in mind. I would write a number and then show them an arrow, for example 57→. The children would be expected to find the number 58. I would give them an affirmative or negative answer as they began to search for the correct number. After several guesses, the number was identified and another number and direction were given. After multiple experiences finding different numbers using the clue number and one-arrow direction, the children caught onto the game and delighted in each correctly identified number. The next phase of the game was to provide a number with more than one directional arrow for the children to identify. For example the number 57→→↗ would indicate the number 72. This added another conceptual dimension to the game. The children were then presented with the opportunity and the challenge of creating numbers with arrow directions for a partner to solve. That the children enjoyed and understood this game were evidenced in their journal entries of that day:

> "They were in a different order and the game is called arrowdynamic—the game was easy at firs and then it got harder little by little—yet I must say it was very fun—were going to make pichures."

"I researached matrix numbers—we made matrix puzzles for a freand to solve—it was fun—I want to do this game again"

"I had fun doing matrix puzzles"

"they were in a different order and the game was called arrow math—we yoused a lot of dimfront nubers to! and it also was very fun and it was a matrix patern today."

"I want to do this game again—I think most ereyone wants to play again"

Number stumper activities (Appendix M) were also incorporated into these first few lessons. The purpose of the number stumper was to give the children clues about a particular number and a small matrix to mark out the numbers eliminated by the clues given until only the correct number remained. The number stumpers were high motivation activities that reviewed concepts such as odd and even numbers and basic addition and subtraction facts. Logical deduction had to be used to solve the number stumper—a skill that appealed to third graders who liked challenges and figuring out problems that were "kinda" hard. The children were always excited to get a new one each day, and if I forgot to give them one, they reminded me. On most days the children had a number stumper to solve as a "homework" assignment. These number stumpers were assessed for correct answers and filed in individual portfolios that the children had made for the purpose of retaining homework assignments and projects conducted throughout the unit.

During this phase of the unit on place value, the children were also experiencing art activities. These activities would be introduced as their "art connection" during the math period of the day, though the time allotted to accomplish these integrated art experiences was usually in the afternoon and occasionally during the regular Friday art time. The first art experience evolved after reading Lucy Micklethwait's (1993) book *I Spy Two Eyes*. This counting book consists of paintings by famous artists with the objective being to "spy" the number of items painted in the picture by the artist. For example, there is a painting by Van Gogh and the sentence underneath the picture says, "I spy eight boats," and the children looked for the correct number of boats in the picture. It was a unique way to present the artwork of famous masters and draw attention to the details of the paintings, and it was a natural way to integrate art into other curriculum content areas. The children then designed and created original "I spy" pictures using markers, crayons, and samples of wallpaper. After each child shared their picture with classmates, the pictures were displayed on a wall in the classroom.

The next art experience for the week was an art project called a monoprint (Appendix C). This art activity was included to give the children an opportunity to learn how to make a print. Directions for the activity included using tempera paint to create a design on a sheet of wax paper. Upon completion of the design, a white sheet of paper is carefully placed over the wax paper design to create a print. The children were given instruction in how to do this technique. In order to integrate the art lesson with the math lesson, the children were told to paint two matrix numbers and the appropriate arrows pointing to them to show a positional and situational relationship in a matrix. Secondary colors of green, purple, and orange were the tempera colors to be used in the design. These prints would then become "arrowdynamic" pictures.

As the children began this art experience, they noticed immediately that most of the numbers on their classmate's prints were backward, although there were a few children in the room whose numbers printed perfectly. This situation led to the rather humorous realization that children who made their numbers backward on a daily basis were the most successful at this art project! In this instance, the children who attended the learning lab for additional assistance in math were instructing their peers as to how to make backward numbers so the numbers on their prints would be facing the right direction. The number and role reversals were amazing! It was exciting to see class leaders step back and allow children who needed these leadership opportunities to lead the way. This art experience provided a useful technique for visualizing how numbers look both backward and turned the correct way. The discussion of numbers by the children was illuminating as they looked back and forth to the matrix to establish "arrowed" number relationships. This experience resulted in a focused study of number relationships that no amount of "teaching" could have produced. The children discovered their own visual means for learning how to write numbers correctly. Arrowdynamic prints provided problem-solving challenges that the children thought were fun to resolve. Some children were also beginning to make the art connection to math as their journal notes indicated:

> "we are making arrodynamic pictures in art today because we played arrow math and the colors we are going to use are orange, green, and purple
> 3↗→17"
>
> "we are macking Arrordynamic pictures because we played the arrow math game"
>
> "we are going to make pictures of our arrow game"

Number Base Construction

The second phase of the study was designed to allow the children the opportunity to explore other number bases. These mathematical experiences were intended to support the children's construction of place value concepts by allowing them time to work and play in number systems that were unfamiliar to them. For this purpose, the instruction began by playing a game called Zurkle. The idea for the game was based on the theory that it could be played on three different levels: conceptual, connecting, and symbolic. Each level built upon a prerequisite understanding of the level preceding it—in effect guiding children from the concrete stage of thinking to that of an abstract nature.

The conceptual level required the use of game boards—a sheet of paper with half of one side white and the other half blue—and unifix cubes. The game began when the children selected a number from 2-9—a smaller number was easier to establish game rules—to become what was called the "outlaw" number. The "outlaw" number was actually the name of the base number with which the class was working. For example, if the children selected the number 4 to become the "outlaw" number, then 4 would not only be the number that signaled a change in the counting of unifix cubes, but it also established the number base. The first time the game was played the outlaw number was called Zurkle, but in succeeding games using different bases the children had fun making up their own names. Using 4 as the outlaw number the children began to count zero zurkles and zero, zero zurkles and 1, zero zurkles and 2, zero zurkles and 3. Each time a number was called a cube was added. When the outlaw number (0 zurkles and 4) was reached—it was skipped over and the children began repeating the counting process again but this time with 1 zurkle and zero, 1 zurkle and 1, etc. At the first level, the counting process was very concrete as the children took turns naming the next number and simultaneously snapped on a cube. Once the game had been completed for the outlaw number of 4, the children chose another number to be the outlaw number, gave it a name, and the game began again. I knew the children were ready to progress to the next level when the children played continuously without calling out the outlaw number.

The second "connecting level" was achieved using lima beans and soufflé cups instead of unifix cubes. The children called out the appropriate number and recorded that number on their notebooks simultaneously as they put beans in the cups and the teacher recorded the number on the board. This task was easily accomplished by having the children draw a line down the center of a sheet of notebook paper—creating a simple place value board—to record the numbers as they were called. As each number was called a lima bean was placed in the soufflé cup until the outlaw number was reached. Then each cup became a zurkle. This time when the game reached the "outlaw" number, the children began the same counting process in reverse—starting with the "outlaw number," counting backward, taking out beans from the cups, and crossing through the numbers previously recorded as they counted backward to 0,0. Once again, it was easy to observe if any children were having difficulty with this activity because each child was responding as they sat on the floor in a circle when it was their turn.

The third symbolic level required the children to play the game without visual clues. This time they didn't use cubes or beans but called out the numbers and recorded these activities in their notebooks. Once the children understood the game, they moved to wooden base ten blocks—ones and tens—with 10 as the "outlaw" number. This was definitely a symbolic level and caution was needed as this was the first time that a place value construction had been furnished for them—not a construct of their own conceptualization. One child wrote in the Field Notes Journal that she discovered you could play Zurkle in your head—this child was working on the symbolic level. Several days were devoted to these activities—more time than had been planned—but the children enjoyed the variations of the games as was recorded in their field notes:

"we played a game called zurkle—it was fun—it was awesome"

"we had zurkle mats—we liked it a lot"

"we had 3 difnent outlaw numbers—nickle, elmer, knuckle"

I felt the practice was pertinent for understanding concepts to be taught later. More importantly, the opportunity to explore their own systems moving forward and backward in the counting process planted a conceptual seed required to understand the concepts of trading and regrouping procedures to be taught in the following unit.

The art connection for this concept included developing a Wanted Poster (Appendix C). The children selected a one-digit number to become their "outlaw" number and made a Wanted Poster describing that number. They used a sheet of white construction paper to illustrate their "outlaw" number, and then wrote several reasons why this number was wanted for being an outlaw. The children appeared to enjoy this cognitive activity and came up with some clever reasons for numbers "on the lam." For example:

"7 is wanted because it eight 9"

"7 is wanted for being odd—last seen as 7+7—also known as 15-8"

"0 is wanted for zero-zapping people"

The children also used their imaginations to make number critters (Appendix C). Each part of the critter body consisted of different numbers. For example, the shape of the head might be made of a series of 7s and the ears made of 3s. This activity provided the children an opportunity to revisit numbers and their positions in a creative context. Some of the children appeared to need this additional opportunity. The children were encouraged to write stories about these number critters or descriptions of the body parts and why they had chosen to design such a wild and crazy critter. As with the other artwork, the Wanted Posters and "wild and crazy critters" (as they were affectionately "dubbed") found prominent places to be displayed in the room.

A favorite integrated art experience was designing number mosaics (Appendix C). This experience involved taking a brightly colored piece of poster board and drawing a large single digit number. The next step was to cut out and decorate the number by covering it with a variety of sequins, glitter, and colored tinsel, thereby producing a mosaic. They were gaudy, glittery, and gorgeous! The numbers were used in several lessons throughout the study. For many children, this was their first introduction to the word "digit,"and being able to hold one instead of just hearing about it turned an abstract number into a concrete reality. For example, one of the lessons progressed in this manner, the children grouped themselves according to the numbers they had made—for instance, all the 3s sat together on the floor, as did the 0s, 4s, etc. Then one child would call a two-digit number, and the children would decide which of them would come forward to make the number. The physical moving around and trading places with each other allowed the children to visualize physically how different numbers can be created using two or more digits. This activity was further expanded (though not planned) to include three and four digit numbers. The children had a lot of fun pretending they were digits and trading places with their "peer" digits to form different numbers as was stated by these children in Field Notes Journal entries:

> "Today we researached 2 diget numbers and 3 diget number. It was realy funer than fun. Every person had a number. We changed numbers around, but numbers like 222 you can't change."
>
> "Today I lenrned you can usually make six numbers with a three digit number. With a two digit numbers you usually can make two. We always reseach numbers—its fun."
>
> "with 666 you can not make inything but you can with 662"

The children were able to construct four-digit numbers and explore more advanced concepts than I had anticipated in my plans for that day's lesson or than they had experienced to date in classroom instruction.

In order to put the finishing touches on the room for an upcoming Open House, a lesson about Alexander Calder and his mobile inventions was presented. This background information provided the motivation for the children to create their own mobile. Each child constructed a number mobile (Appendix C) using half of a two-liter plastic soda bottle, numbers cut out of wallpaper, and string attaching the numbers to the soda bottle. They were encouraged to use numbers to represent their school desk address, as the mobiles were to hang above their desks. The children really liked the idea that they could pick their own school addresses since they had no control over choosing their home address. This opportunity allowed the children an authentic understanding of the usefulness of numbers in their everyday experiences. For example, if the children wanted their seat address to be 4423 in their third grade room, they would cut out two 4s, a 2, and a 3. If they tired of their original number, the children knew they could change the numbers around and produce several new addresses using the same numbers. When the mobiles were finished, they were hung from the ceiling and were proudly noticeable at Open House as parents could not walk from one end of the room to the other without coming into contact with certain low-hanging mobiles. A child included these thoughts in a Field Notes Journal:

> "Sandy Calder is most famos from making mobiles. His mom was a painter and his dad and grandpa made sculptures. I am making mobiles with my address. It's really fun. I can't wait till I'm done."

Base Ten Construction

The children had experienced the opportunity to work with numbers and their situational relationships via the matrix activities and enjoyed working with other bases. I judged that they were ready to move to the next math concept from comments written in their journals, their explorations with the mosaic numbers, and my observations of their absorption in math as evidenced by classroom discussion and art activities. Behavior interruptions were minimal—almost nonexistent during math period—each child appeared engaged in the many art and math activities. They seemed to be ready to move forward to the next math concept which involved using place value boards and base ten blocks—1s and 10s—to discover how to write numbers from 0-99.

The children worked in pairs on the floor and rolled two number cubes to make a two-digit number. Then they used ones and tens blocks to see how many different ways the number could be shown. Upon completion of the exploring activity, the children were assigned some practice problems in their math book. A main objective of this lesson was to learn and understand all the ways that numbers could be written: standard form, expanded form, numbers and words, number words, and via a place value chart. This was difficult because phrases such as standard form and expanded form presented new terminology. Their lack of expertise in writing sentences "comfortably" was apparent in some of their Field Notes Journal entries:

"we learned what standard forms were—I learned how to expand too"

"we learned a new form and reviewed how to expanded form"

"today we lurned a new thing named stander form"

Succeeding lessons expanded the previous activity to include numbers through 999 and culminated in numbers to 9999. The concept of hundreds was introduced by using a centimeter-squared paper and ones, tens, and hundreds base ten blocks. The goal was to cover every square on the centimeter paper with ones, tens, and hundreds blocks and then count them to see how many of each block had been used. At face value this was an easy challenge and a good way to explore different ways to cover a page with place value blocks, but the children then wanted to know what number they had made. This learning activity involved more understanding of place value and numbers than they possessed at this time. This was frustrating for the children and myself so this activity was briefly explored for any merit it might possess and replaced with place value boards and base ten blocks. The children spent the remainder of the time creating their own numbers, discussing the different ways the numbers could be written, and recording their findings.

The children's familiarity with the place value chart provided an easy transition to using thousands. They had a preview of this concept with their mosaic number activity; therefore, this was not much of a cognitive stretch. The new terminology—standard form, expanded form, a combination of words and digits, and written in words—was practiced daily. Although they were becoming more adept at using these terms, they had not really mastered the concept as was evidenced by the questions that were asked of the teacher and the scarcity of eager hands in the air to answer the teacher's questions.

I felt that art experiences for these concepts were crucial and valuable to enhance the children's understanding. The children made a place value chart of their own using assorted colors of construction paper. They used pre-cut, one-digit numbers to practice creating larger numbers and asked friends to identify the number they had constructed. Activities such as finding the biggest number and smallest number that could be made from the selected numbers they arranged on the place value chart emerged from these experiences. The children engaged in collaborative dialogue that was helpful to their understanding of the numbers and how the value of the numbers was altered when moved from ones to tens to hundreds to thousands. For example, what happens to the number 3 when it is taken from the ones place and moved to the tens', hundreds', or thousands' place? The most frequent comment in their journals pertained to commas:

> "I leard that the , in between the numbers means thousans"
>
> "we played a new place value game—we used hundreds thousands, ten thousands thousands, hundreds, tens, ones to make numbers—it was fun!!!"

> "the comma in numbers like two thousand three hundred thirty five means thousand"

An additional integrated art connection for this place value concept involved the use of rubber stamps (Appendix C) that, when applied to stamp pads and stamped on paper, created a picture of cubes, rods, and flats—math terms the children understood meant ones, tens, and hundreds. Green, purple, and orange colored stamp pads, and white poster board were required to complete this activity. The children either chose what number they were going to stamp or used the stamp first to see what number they could make. The number chosen became the title of their poster—written in standard form. Then they recorded on the poster the various other ways this number could be written—expanded form, place value chart, numbers and words, and words. The only "catch" to this activity was that the hundreds were to be stamped in purple, tens in green, and ones in orange. Every time hundreds, tens, or ones were used on the poster they were to be written with the appropriate colored marker. The intent was to utilize color to enhance the visibility of the different value names, and at the same time furnish the children with a fun opportunity to practice writing numbers and using words like standard form, expanded form, etc. The children wrote:

> "Today we did art and math. You have to do title, stamp, expand, words, graph, combo and the hundreds are purple the tens are green and the ones are orange"
>
> "we did art and math we used 2endary colers on are art pickter we have to put a title, stamp, expanded form, words and a place mat value"

This activity proved to be such a valuable cognitive experience that extra poster board was frequently needed for "start-overs" because the children had made some numbers in the wrong color. The "start-overs" were an assessment of difficulties and understandings the children encountered with this art and math concept.

Designed for the same purpose was the art experience the children called their yarn cards (Appendix C). They thought up and recorded a four-digit number in magic markers on a white 5x3-inch poster card with holes punched around the edges. The children were then to print underneath this number the words "standard form," and on the back of the card, they were to expand this same number writing the words "expanded form" below. Next, they were to weave yarn in and out of the holes punched in the card and tie a bow with the remaining string so that the card could be hung from the chalk board. Once again, the intent was to provide a visual way of interpreting numbers within the context of place value, and once again, the activity provided another means of assessing the children's understanding of the concept of standard and expanded form.

It was during this time that "Mr. Zero Zapper" began to make his presence felt in the classroom. I had coined the term "zero zapper" several years ago to call attention to the vital role that zero plays in place value. It had been my experience as a math teacher for over two decades that zero is a difficult concept for children to understand because of its abstract nature—children tended to leave it out of their numbers. State adopted math textbooks refer to it as a "place-holder," but I have never felt comfortable using that description of zero because the concept of zero is much more than that idea implies. Leaving out the zero when writing numbers indicates a lack of understanding about place value in general. In order to "snag" the attention of those children who suffered from occasional bouts of attentional deficit, "Mr. Zero Zapper" emerged from nowhere when children forgot their zeros—replete with evil laugh. It became an amusing way of children telling other children they forgot a zero. The children made their own zero zapper out of different sizes of pom pom balls, googly eyes, and pipe cleaners. They were attached to the tops of their desks with Velcro. No amount of explaining or reminding the children about the digit zero would have been as effective as the ever visually vigilant "Mr. Zero Zapper" sitting atop their desks.

Pattern Strategy Construction

To develop a stronger visual awareness of the significance that "looking for a pattern" plays as a strategy in solving different math problems, a math lesson was devoted to M.C. Escher and his tessellation creations. After discussing Escher and looking at examples of some of his work, the children were eager and ready to make their own tessellations (Appendix C). This was accomplished by taking a 3x3-inch square of cardboard, changing one side by adding a squiggle or bump and cutting out this part and sliding it to the opposite side where it was taped. The same process was repeated with the top of the square and moved to the bottom of the square and taped. The new shape was then traced on paper over and over to create a tessellating pattern. This was a challenge that took the student teacher, an observer, a visiting teacher from another school, and myself to help the children accomplish. One child's field notes stated that "some of us did not understand the directions very well"—an understatement if ever there was one. The results were worth the effort! The children delighted in the patterns they created by tracing around the tessellation, designing details, and adding color to their creation. The idea of how patterns emerged literally took shape before their eyes. During the discussion about patterns and the directions for creating a tessellation, art words such as rhythm, balance, and repetition were used in a math context—an observation significant to this study. Some of the children's field notes had this to say:

> "I used balance to tesselate on paper. The paderns were the funnest"
>
> "Today we learnd to tesselate, we are making rhtym with our patterns"
>
> "I'm glad that M.C. Escher descoved tesselations or we wont have done are math art"
>
> "Today we learned to tesselate. I can already feel the rhythm, but not the balance. My colors are red, black, and blue."
>
> "We lerned to tesalate and it was so fun I relly want to do it again"

<u>Rounding Numbers and Dollars</u>

The next math concept focused on rounding numbers to the nearest tens, hundreds, and dollars. These three concepts were designed to build upon and increase the number awareness of children and promote an understanding of the term estimation. Starting with the skill of rounding numbers to ten, the children were presented with a sentence strip (Appendix C) that counted to 100 by tens on one line with the appropriate midway number 5 on the line above. For example, 10 and 20 would be an inch space apart on one line and midway between on a line up above would be written the number 15. Each child was equipped with a marker and a strip. Two-digit numbers were called first by the teacher and then by the children to determine to which 10 the number was closest by placing their marker in the space where that number was located.

The children quickly turned this activity into a game by designating the different 10s as "sheriffs" and the number called as a "number in trouble"—one that needed to run to a sheriff for assistance. The question was which sheriff (10) was the closest one to run to for help. This certainly was not in the lesson plans but proved to be a great way to transfer the information learned from the matrix and Zurkle activities. It was also an excellent way of assessing which children were making these transfers easily. The next day the children made individual hundreds strips using one set of colored circles to represent sheriffs and a different color to represent the mid-way station as the children called it. Several children talked about the patterns they were creating as they made their strips. The concept of rounding to hundreds provided the bridge to learning to round dollars. The children's field notes described how a regular math lesson was turned into a fun game:

> "We learned how to round up numbers to the nearest hundred and doller. That game was the funest game I every played"
>
> "We made our own rounding strip—tens wer sherrifs. It was fun and we called it the roundup game"
>
> "We learned how to round numbers to the nearest hundreds and dollars—we still used the sheriffes to round numbers"
>
> "We learned how to round up numbers and take em' to the nearest sheriff! It was fun."

Another art activity using the concept of rounding dollar amounts was to have the children look through magazine ads for items they wanted to purchase. When items were discovered, they were clipped from the magazine and glued onto a sheet of paper to create a collage (Appendix C). Some of the children were familiar with the idea of making a collage and decided to create one that could double as an early Christmas shopping list. Whatever the price of the item in the magazine, the children rounded it to the nearest dollar amount to determine an estimate of the actual cost of their shopping lists. This became a very personalized practice of rounding to the nearest dollar, though adding up the total dollar value brought with it sobering realism.

Symbol Construction

The symbols for greater than and less than were concepts that had been taught in earlier grades, and the children could vaguely remember the teacher talking about a "big alligator mouth" eating the big numbers. This foundational idea was something to build upon, but did not eliminate the children's confusion about how the symbols worked. Perhaps the children forgot how to use the alligator tool because someone else had constructed it. The most difficult problem appeared to be that the symbols were abstract. I hoped I would be able to add concreteness to this numerical concept by encouraging the children to develop their own visual clues after studying correct examples of the symbols in context with numbers. They were encouraged to find their own ways to figure out the symbol and report them to their classmates. This appeared to direct their attention to each symbol for closer scrutiny as to how they worked.

To provide a visual concept, the children did crayon resist pictures (Appendix C). They drew pairs of numbers on white paper with orange or yellow crayon and inserted the proper symbol between the two numbers. Then they painted over the numbers and symbols with watered-thinned black tempera paint. The symbols jumped out at the children with such clarity that the first few pictures brought gasps from the artists. It brought gasps to the teacher as well when it was observed that some children had turned their symbols the wrong way. This was an excellent way to assess how well the children had understood this concept only with giggles and a few "oops!" instead of tears as was evidenced with the prior knowledge paper and pencil activity.

Draw-A-Picture Strategy

Another requirement of the place value unit called for the children to learn how to utilize the strategy of "draw a picture" in order to make sense of difficult story problems. Multiple problems were presented orally to the children as a whole group activity to explore different approaches that could be used for illustrating story problems. These illustrations helped visualize the information in the problem, decide what question the problem was asking, and find a solution to the problem. Strategies such as a T-chart were devised and labeled so that the children could see the patterns that some of the problems presented. The children explored possible ways that story problems could be represented without actually drawing people or other objects. As story problems were orally presented, the question was asked what could be done to see this problem more clearly. The children began to respond, "Draw a picture!" When asked more specifically how this could be done, wonderful discussions unfolded as to the multiple ways the solution could be accomplished. For many children the word "strategy" appeared to be a new word because many felt the need to define it in their journals:

> "we learned that stragey is a tip of plan how we solve are homework we use a plan and draw a pickyer".

"today we took a hard strategy. Strategy means a plan. We had to draw a picture to figure it out."

"we learned some strategy and that it meant make a plan."

Money Construction

The last math concepts to be included in the place value unit were those of finding the value of coins and counting change. To master these concepts, the children took turns calling out specific amounts of change for their classmates to make. This gave them the opportunity to explore how many different ways the amounts could be produced. For example, if a child asked the group to find $.56 then the children would look for the largest number of coins and the smallest number of coins that could be used make this amount. They enjoyed saying, "I can make this amount with three coins, can you guess my coins?" They loved doing these coin counting activities as was evidenced by their field notes and mine. When asked to write about why they had enjoyed this activity, most responses dealt with the experience of handling the play money—they liked to play with the money, and the children felt this helped them to understand how to count change for the first time. The money itself provided a visual image. From that day forward the class and I used the coin counter activities in Every Day Counts to make up money problems in addition to counting orally the change the children in charge of the coin counter had selected for that day. This provided daily practice with this concept—and it was needed.

Aside from the actual concept of counting change, I discovered that some of the children did not have a clue as to whose picture was on each coin, had very little historical knowledge of the Presidents pictured on the coins, and, therefore, had no understanding of why each of those Presidents might have been selected for this honor. This presented the perfect opportunity to integrate a little social studies with math and art.

The next day's math lesson was about money, too, but the challenge for the day was to choose a partner, make up a problem about going to the store and buying an item, giving the clerk some money, and counting out the change. This activity was practiced many times before turning the children loose to try it themselves. A sample problem made up by one of the children went like this:

> "Yesterday, I went to the grocery store and bought a banana that cost me $.56 but I didn't have exactly $.56 so I gave the clerk a $1.00. How much change did I get back?"

The children used their play money and started counting with the $.56 on their way to a dollar. The first step was to make it to a rounded number—for example they learned to start counting with a penny 57, 58, 59, 60. From there it was easy to skip count to a dollar. As evidenced by my field notes and observations as different children counted money, this was an area where lots of help and practice was still required. Another activity that had helped prepare the way for this concept was the counting by 10s the children had done with the matrix activities and the sheriffs they had constructed when we did the rounding activities. This was evident by their oral responses:

"We can use our sheriffs for this."

"It's like when we rounded to the nearest 10 or 100"

These responses by some of the children indicated that they were transferring the information from the rounding and matrix activities to help them understand counting change. Once classmates brought up these connections other children began to understand the concept better. The practice the children received in counting by 10s using six, for example 6, 16, 26, 36, etc. also helped to set the stage for enhancing the children's change counting abilities. This was a bonus I had not expected. All of the children were engaged in this activity. As additional practice, the children were also assigned the task of drawing their change on paper. For example, if an item cost $.25 and the clerk was handed $.50, the children were asked to count the change and draw a picture of the coins they used. In this case, they might draw a picture of five nickels or two dimes and a nickel—any combination was acceptable as long as it was accurate.

The art connection for this activity employed the use of stamps (Appendix C) with coin pictures on them. The children used blank flash cards, drew a picture of what they wanted to buy, and stamped the money amounts they estimated would be needed to purchase the item on the flash card. They wrote how much the coined amounts equaled using the dollar sign and decimal point in addition to what the numbered amount looked like when they used the cent sign to write the amount. It proved to be a fun way to count money, and for some it provided the basic practice needed to be able to recognize the different coins and their value. Some of the children also enjoyed using real coins to make rubbings and then totaling up the value of the picture. They called these their "valuable pictures." I was pleased with the connections the children had made with the money—most particularly in the area of counting change—though this was not a mastered concept for some of the children at this point.

Dragon Construction

The final art experience of this unit was making egg carton dragons (Appendix C). The children used half of a Styrofoam egg carton that had been cut down the middle to construct a place value dragon. They used pom poms and googly eyes to add features to the dragon. On the dragon's side the children labeled the segmented egg holders ones, tens, hundreds, etc. Then they used beads and dropped them into the holes to make different numbers that they asked a friend to identify.

The use of these dragons was very abstract. It required the children to understand the place value concept to provide logical reasons for the large numbers they created. The level of the child's understanding was evident by the answers they gave to the question, "How can so few beads make such a large number?" Whatever the level of understanding, the children loved their dragons and could make huge numbers with them—especially those who had labeled to the hundred thousands. One thing it did accomplish was that some of the children acquired the ability to read and verbalize very large numbers.

Themes

The analysis of data regarding the integration of art and mathematics yielded four themes. The first of these themes was the positive learning environment created by integration. The second theme addressed how the integration of art and math helped children understand abstract math concepts. The third theme to emerge dealt with the subject of attitude, and the fourth theme addressed alternative assessment. Each of these themes will be discussed linking them to pertinent data.

The Integration of Art and Math Provided a Positive Learning Environment

Though the study was not specifically designed to promote a positive and interactive learning environment for students, an integrated approach incorporating the subjects of math and art resulted in this outcome. Many factors are necessary to create a positive learning environment for all children, not just those who have always enjoyed success at school. It is important to create an interactive classroom to affect the kind of learning experience teachers and parents want children to encounter. A positive learning environment often leads to the successful acquisition of skills (Eisner, 1982). Parents provided important information about how they perceived their children's past school success, and addressed the question of how their children best acquired knowledge. Therefore, before the unit on place value was initiated, the parents of these children shared their perceptions of their child's learning success to date according to responses on the initial parent survey. The parents of all but five children answered that their children's progress had been of a very positive nature.

"did good in all of his grades"

"no academic problems"

"regular and steady"

"good and pleasant"

The five parents who indicated that there had been problems included statements such as:

"a need for improvement in areas of writing skills and math" "had had behavioral and learning problems since first grade and seems to be having no progress"

"struggles but wants so badly to do well"

Predictably, these responses came from the parents of children who had been identified as learning disabled.

Parents spoke directly to the type of classroom environment in which the children learned best as one that provided:

"lots of nurturing"

"calm learning environment"

"interesting"

"couched in games"

To parents, the classroom was the learning environment, and when this environment was nuturing, calming, interesting, and couched in games, their children learned more successfully. At the end of this instructional period, all parents, not just those who felt their students had always been successful, expressed that the children had profited from an integrated method of instruction. All parents voiced the opinion that their child had experienced progress in acquiring a basic understanding of the place value concept. The parents based this assessment upon their child's ability to relate to them what the child had learned during the past few weeks. Much of this communication took place on the evening of the Museum Tour that was held to celebrate the successful conclusion of the learning event. Many of the parents' responses on the final survey could be interpreted to mean that an integrated approach had provided a positive interactive learning environment for children because their children had acquired an understanding of the place value concept. Some responses included:

"it made math more fun and enjoyable"

"it keeps kids interested"

"captures children's attention"

"takes boredom out of the picture"

Another reason that an integrated approach to learning created a positive environment was attributed to the fact that it made learning enjoyable. The children enjoyed learning through an integrated art/math approach. The parents stated it in their final surveys:

"it made math more fun and enjoyable"

"it took anxiety out of the picture"

All children, regardless of gender or ability, mentioned it over and over in their field notes. What the teacher thought of as math instruction was disguised as fun games for the children to play. They usually began or ended with some liking for the math or art activity they had done that day.

"I had fun doing matrix puzzles"

"it was a fun game and I want to do it over again"

"we played a game called zurkle—it was fun—it was awesome"

"it is fun to research numbers"

"it was funer than fun"

The final interviews included comments with regard to how well they had liked math the past few weeks:

"math was fun because we got to paint and color and round numbers"

"the art activities made the math fun to do"

It is interesting to note that the children's statements included both the word art and the word math. In their initial interviews when asked to come up with an activity where art and math could be accomplished at the same time, the children had trouble affecting an answer to the question. At the end of the unit, art and math had become integrated from the children's perspective.

My own written observations included that the children were engaged in the learning process and having fun—that included the teacher as well. When the teacher is having fun teaching, it is a good sign that the children are engaged in the learning activity and the need to redirect children who have lost interest is less evident. I wrote in my field notes towards the middle of the second week that the children were more engaged in learning, better behaved in math instruction, and more helpful—less combative—toward one another as they worked in their groups.

The concept of collaborative learning became an important focus of this classroom during the study. It began with large group circle activities centered on the concepts of the matrix and Zurkle games but smaller groups emerged as the art connection time approached. Transcribed tapes testified to the continued growth of cohesiveness among the children as they patiently helped each other during these activities. The research of Vygotsky (Bedrova &Leong, 1996) referring to the learning that results in social interaction seemed believable and valid as children worked in their groups discussing their plans for completing the art activities that connected with the place value math concepts. The incident with the Arrowdynamic pictures is an excellent example of children who struggled collaborating with students who did not understand what it meant to struggle and the resulting respect gained by all children for their classmates. Collaborative art/math experiences like this one increased the positive dynamics of classroom community in a way that would be difficult to reproduce in a different manner.

The collaborative effect of this study was also born out by the fact that the children wanted to do their final interviews as a group. The children had loved those moments alone with the teacher and the tape recorder as was evidenced by the fact they often quarreled over whose turn it was to go next. Some four weeks later, the children were willing to forgo their individual turns and enjoy the dynamics of a group session that shared and revisited the events of the past few weeks. This was appropriate because the children had learned to work collaboratively throughout the learning event. They had promised to listen to each other and allow each other time to speak, and they were true to their word. They listened respectfully to each other as can be heard on their tapes and read in the taped transcriptions. For example, one taped session went like this in answer to the question about what the students thought they had learned:

Student 1: "I learned to count money better than I did"

Student 2: "I learned about 3 digits numbers—to tell you the truth I didn't have a clue what those were"

Student 3: "I learned that you don't exactly have to use pennies all of the time when your are counting—you can use more than one thing"

Truly, they had learned to value not only each other's opinions but, more importantly, each other. I felt certain that much of the new knowledge that the children constructed about art and math had been learned from one another through the social interaction. The language expressed and utilized through collaborative work times had played a central role in their mental development of place value.

The Integration of Art and Math Helped Children
Understand Abstract Math Concepts

This theme addresses the analysis of data derived from parent surveys, the children's thoughts expressed in the group interviews, and my observations. The study investigated what role the inclusion of art experiences played in helping children understand the abstract concept of math. The parents addressed this idea in response to a question on the final survey that asked if they thought art should be integrated into all of the math units in third grade and if the answer was yes why they felt that way. Their responses were as follows:

"It enhanced the hands-on aspect"

"Makes it easier to learn and understand math"

"It helps maintain information learned"

"Art makes math more concrete"

The children discussed art and math in the final group interviews. It became evident in these interviews that the art activities held special significance for the children other than those of just being fun. Some of their comments were:

"Art helped us understand a little bit more about math"

"Everyone should know how to draw pictures so the could see their answers"

"Art showed us how to build numbers"

"Showed us different ways to make numbers"

"I thought art helped me understand the basics of the number system"

"Sometimes I have trouble with math but when we did the art with the math is helped me to see better."

"Gives a clearer picture of what it does in your head"

"It is better than someone just telling you how to do things"

When asked to comment upon what art activities helped them learn best, responses ranged from the first activity we did—the I Spy pictures—to the last coin-stamping experience; there was not one activity selected more frequently than any of the other activities. Clearly, the children enjoyed all of the activities and enjoyed discussing the merits of each one. Clearly, this quote by one child described the learning event best:

"If you went back to compare last year with this year, this year was a lot more inspiring for math."

An analysis of the conservation activities conducted with the children before the learning even occurred indicated that all but six of the children in this class were ready to begin a unit in place value. These six children would need extra attention and help throughout this unit—four of the children received additional help from the learning lab. For the remaining two children, it was my sole responsibility to monitor and modify instruction when necessary. Therefore, these children figured significantly in my observations and field notes. It was interesting to note that at the group interviews, these children were two of the most vocal and enthusiastic proclaimers of the benefits of art to help them see math better at the group interviews.

The final pencil-and-paper question assessment indicated significant learning from the prior knowledge assessment. On the prior knowledge assessment, the average number of questions answered was five as compared to 13 on the final assessment. The children had gained an understanding of place value, but perhaps more significant was a comparison in the way the children approached answering the pencil-and-paper questions. When these questions were first posed to them, the following comments and reactions were observed:

"what does this mean"

"I don't understand this"

"I don't know how to do this"

"what's place value"

Not only did the children not understand the terminology at the beginning of the learning event but, from an emotional point of view, the questions were frustrating and several children burst into tears. Others put their heads down on their desks and refused to engage in the activity at all. These behaviors were less apparent when the paper-and-pencil questions were asked at the end of the unit. This implied that they had at least gained understanding of the terminology and a better understanding of many of the skills.

Though it is difficult to determine if the art experiences were the key to unlocking the abstract concepts of place value, the opportunity to learn visually with hands-on art experiences appeared to enhance learning. The theory behind Gardner's (1983) Multiple Intelligences places a central role in the success of this learning event. The children had the opportunity to learn through logical mathematical and visual instruction. Other intelligences utilized the time to reflect and write about their understandings in their Field

Notes Journal and included activities that afforded the children time to visit with each other about math and art. Clearly, the average score of the answers of the pencil-and-paper assessment improved, the parents felt their children had gained an understanding of place value, and the children expressed over and over how much they felt they had learned. Just listening to the level of discussion generated around the lunch table convinced me that the hands-on art experiences had been a catalyst in promoting the positive feeling of success that these children felt about the learning event.

The Integration of Art and Math Promoted Attitude Shifts

Part of this study addressed the issue of children's attitudes toward math. In the initial interview with the children, they were asked first how they felt about school to discover whether school provided a positive experience for them in general. Every child indicated that they liked school.

> "I like it a lot"
>
> "I like the stuff we do and my classmates"
>
> "I like everything the way it is."

When given the opportunity to express ways they would like to change school, they were hard pressed to come up with significant changes. They did express a desire for cleaner facilities and less dissension among their classmates during recess time. Some of these remarks included:

> "if people were kinder to each other"
>
> "put more conflict managers on duty at recess because there's a lot of conflict going on out there"

"no fighting"

"if people wouldn't litter at recess"

"clean up the hallways"

As might be predicted, all 20 children expressed a liking for art activities, although only one child cited art as a favorite subject. When asked what type of art activities the children enjoyed, they listed:

"free-hand drawing and sometimes tracing"

"mixing colors and painting"

"really like to draw and color"

"draw with markers"

"building things out of stuff"

In answer to the question of why they liked doing art so much, responses ranged from their enjoyment of the different activities to thinking they were "good at it." One child implied expertise in this area was because, "after all, I have been coloring since preschool!"

Not so predictable was that of the 20 children in the classroom, 14 children chose math as their favorite subject—seven boys and seven girls. On those children who did not list math as their favorite subject, when asked specifically how they felt about math and why, they responded with positive answers for the following reasons:

"you get to do interesting things"

"because I always get it done"

"because you get to add and subtract"

"its really fun"

"I like doing the puzzles"

Only one child in the class did not express a positive attitude toward math—quite the opposite, this child did not like math at all. Important to this research is the fact that this child did not do well on the place value activities that were conducted before the unit began.

Of significant interest to this study was why children chose math to such an extent that math was cited frequently as a favorite subject. When asked why math was their favorite subject, the responses included:

"because I like taking that challenge"

"because I'm good at it"

"because I do well in it"

"I'm really smart in it"

"I can relax and do it"

"I do best at it"

"cause I'm good at doing things that are 'kinda' hard"

When asked what it meant to do a subject well, one third grader stated that it meant

"getting everything right and staying up with everyone"

This simple answer spoke volumes about how children assess their own success in the classroom. I had never really wondered how children viewed what it meant "to do subjects well;" therefore, I found this comment insightful, and it increased my understanding of how children assess their personal classroom performance.

One last interview interpretation that had interesting connotations was the response children frequently gave when asked what they liked to do best at school. This question was constructed with the idea that children might give responses such as PE, music, play with friends at recess, visit the library, etc. The children repeatedly interpreted this question to mean what subject they like to study best. I wondered if perhaps this meant that the children viewed school primarily as a place to learn, or if they would have answered this question differently if someone other than their teacher had asked it. The most positive interpretive analysis is that school is fun, and learning is the "best" thing they like to do at school. Clearly, engaging children in instructional activities that integrated two favorite subjects meant that this study began on an enthusiastic note.

It was established through the first interview that most of the children expressed very positive attitudes toward math often listing it as their favorite subject. However, the results of the study indicated that although the children expressed positive attitudes toward math, their behavior during traditional math instruction often indicated a lack of motivation and attention. Though behavior is a separate issue not generally regarded as an attitude—it does reflect attitude (Glasser, 1969). The expressed attitude of fondness for the subject of math was not always evidenced by the behavior of some students. For example, during the first week of the study an observer recorded the spontaneous behaviors of the children during the course of the instruction:

"red-headed child is talking and not paying attention"

"black-haired child sucks thumb and pencil"

"two blonde-haired girls talk together"

"thumb sucker seems in world of own—no attention"

"large child keeps moving the overhead"

"when the teacher's back is turned people start talking"

Other examples of misbehavior and lack of attention were evident in the taped transcripts as I reviewed my techniques to re-engage children who had mentally left the premises. For example, the snap of fingers indicated my attempt to reclaim the attention of some children. Calling on children who were not paying attention to answer questions or using their names while in conversation with other members of the class were also signals that these children were not fully engaged in the learning activity. This spoke to certain members of the class who, though they expressed a liking for math, affected an attitude of disinterest and disengagement during math period. Their engagement in the math activity increased as they realized that each new concept brought with it the promise of an art experience. Their attention also appeared more focused when whole group activities such as the Zurkle game were introduced. This was evidenced by the reduced number of times it was necessary to interrupt the instructional process to address a child's inappropriate behavior. The decrease in the frequency of interruptions was also monitored by the amount of time it took on the tape to complete a lesson. At the beginning, taped sessions ran approximately an hour. Towards the conclusion of the unit, less teacher-led instruction and more student interaction was heard on tape. The children's behavior was not perfect, but it was vastly improved—the flow of classroom interaction and inquiry went more smoothly.

Another area of disinterest manifested itself when it was time to record reflections in the children's Field Notes Journals. Some children blatantly refused! A few of the children literally could not compose a sentence and covered up this inability with a negative show of willful behavior—in some cases breaking pencils and throwing papers. This necessitated my modification of teaching style to accommodate the needs of those children who were unable to write a sentence. Once we began writing a starter sentence on the board, some of the willful children were the ones who volunteered to make up the sentence for that day. Having fun experiences with math and art apparently provided the children with enticing experiences to write about in their journals. As their behavior improved, I sensed their attitudes toward math became as genuinely positive as the children had expressed them to be in their initial interviews. The children's field notes reverberated with the joy of learning.

Integrating Art and Math Provided Alternative Assessments

Evaluating the children's understanding of place value to determine if the art experiences had helped the children understand this unit was important and challenging. The children and I spent one day reviewing all the mathematical concepts they had learned. This turned out to be visually facilitated by the displayed artwork in evidence all around the room. I could point to one project and they would tell me what they learned and why they remembered it. For example, looking at the crayon resist pictures reminded them of the greater than and less than symbols they learned and their construction of rules for applications of the symbols. As the children observed all of the artwork hanging on the walls and clothes-pinned to chains in some areas of the room, they decided that the room had been turned into an art museum of numbers. They wanted their parents to experience the museum first hand. This proved to be the best assessment of the children's understanding of the unit they had just completed. They identified as a group all of the concepts and activities they had experienced since the place value unit had been initiated (Appendix D). These concepts became the basis for a printed handout that each child used as a program guide for taking parents on a tour of the museum. In effect, they became docents in a museum of their own creation. Children could be heard in conversation throughout the room explaining to parents how and why each art experience was created. Some parents responded to this event in the following manner:

> "When I asked my child what place value was, s/he had no trouble explaining it to me."
>
> "It was fun watching my child demonstrate numbers to the ten thousands with her dragon."
>
> "I was very impressed with what I saw Tuesday night. What a great way to add fun into learning!"
>
> "I learned so much about place value from my child on the walk-around Tuesday night."

Another method that the children found valuable for assessing their own growth was the portfolio they had been keeping since the unit on place value began. Included in the portfolio were homework assignments from the textbook, number stumpers, matrix activities, and the results of the prior assessment and final paper–and–pencil questions. The children expressed surprise and pleasure as they looked through their math portfolios and witnessed for themselves the progress made in understanding the place value concept.

I found that the art experiences provided an ongoing assessment of how well the children were understanding each place value concept. For example, the collage and rounding activities provided an assessment of how well each child could round dollars. The crayon resist provided instantaneous assessment of how well the children understood the use of the greater than and less than symbols. It was much easier to work with children and correct their math misconceptions through this art process. I observed that the children were less anxious about corrections when they centered on their art.

The benefit of these forms of alternative assessment provided an authentic understanding for me of the totality of what the children had understood of the place value unit. Trying to make sense of printed questions involves reading skills that do not always test math skills and penalize children who have difficulty reading and understanding the question that is asked of them. The art experiences added another dimension to the child's understanding and provided another method for assessing each child's place value understanding.

Summary

Chapter IV provided a detailed account of the results derived from an action research inquiry. This inquiry was conducted to discover what role art played in helping students learn the abstract mathematical concept of place value and if these art experiences also helped to develop positive attitudes toward math. The chapter described the learning environment in which the study took place and the events that occurred prior to, concurrently with, and after the study's conclusion. It sought to address several themes that emerged from the voices of parents, children, and teacher as it described the fun that learning became when teaching methods included hands-on instruction. Finally, it described the positive learning results achieved from an integrated learning environment in which the communication between parents, children, and teacher flourished. An integral part of the chapter focused on the narrative description of the instructional methods that were used to introduce place value concepts and the integrated art experiences in which the children were involved.

Analysis of the data indicated that the children did learn about the mathematical concepts of place value. The opportunity to assess how well the children had understood this unit on place value, how they felt about this learning event, and their construction of the idea that two favorite subjects can occur simultaneously was provided. All children showed improvement in the ability to answer questions correctly with paper and pencil about the mathematical concepts included in this unit. Final assessment of how much the children had learned about place value was observed through a variety of approaches. These approaches included written answers to the pencil and paper questions, comments of the children recorded during the final interview sessions, written comments in Field Notes Journals, taped oral comments during classroom instruction time, art exhibits, the children's ability to tell their art/math stories to their parents during the Museum Tour Night, and homework assignments in portfolios.

The children's behavior improved as the unit progressed. Their ability to pay attention, display appropriate classroom behavior, and participate in classroom activities appeared to indicate that when children are engaged in an instructionally integrated classroom environment, positive attitudes are created, and the learning event becomes a reality.

CHAPTER V

CONCLUSIONS, IMPLICATIONS, AND SUGGESTIONS FOR FUTURE RESEARCH

Introduction

Eisner (1998) writes that since the turn of the century behaviorist and positivist assumptions about the nature of knowledge have shaped the dominant methodological orientation of educational research. He adds that researchers are recognizing that tight experimental laboratory controls do not lend themselves to the environment of the classroom and school and are, therefore, seeking other approaches. This study utilized the "other" approach—a qualitative action research approach—for gathering data about children in the naturalistic environment of their classroom. Furthermore, the classroom teacher conducted the research in an attempt to understand how children construct mathematical knowledge.

The intent of this action research was to determine the role that integrating art experiences into a unit on place value might play in helping children understand an abstract mathematical concept. In addition, this research sought a more enlightened understanding of how art experiences would affect the children's attitudes toward math. This chapter synchronizes and simultaneously weaves together a summary of the events that occurred throughout the research's instructional stages and the conclusions resulting from the research analysis as they relate to current educational theories. It briefly discusses possible limitations of the study, explores viable recommendations and implications for classroom practice, and offers suggestions for the direction future research should take with regard to related topics.

Summary

The conceptual seed for this action research began with my feelings of disequilibrium—as labeled by Piaget—over my ability to understand how children cognitively process mathematical concepts, more specific to this research, how children cognitively construct the concept of place value. Utilizing theories and current research on this topic, I created a four-week unit on place value appropriate for third grade instruction. Scaffolding for the unit was provided by Standard 6 of the National Council of Teachers of Mathematics and the state's Priority Academic Student Skill pertaining to number sense and numeration. The format of the unit was uniquely designed to integrate diverse art experiences into every conceptual teaching lesson to enhance the children's ability to understand place value concepts. The intent behind the inclusion of art experiences was to provide children with another method for learning mathematical concepts. I also wanted to know what effect the art experiences would have on children's attitudes toward math. This newly designed math unit was implemented into my classroom of 20 children in the fall of 1999.

The sources of collected data for the research fell into three general time classifications—those acquired before the actual instructional unit began, those collected as the unit progressed, and those collected at the conclusion of the place value unit. In each of those classifications, collected data emanated from three voices—parents, children, and teacher as each voice contributed pertinent research information. Background information about the children obtained from enrollment cards that parents had filled out at the beginning of the school year was the first source of data acquired for the study. Other sources of data collection involved information gathered after using some of Piaget's conservation activities and additional place value exercises to determine how well each child was able to understand the concept of numbers (Copeland, 1984). Supplementary research data were gathered from a variety of sources: initial and final taped and transcribed interviews with the children, parent surveys both before and after the instructional unit, taped and transcribed classroom instruction that included observations by the teacher, and written questions before the study to determine prior knowledge and afterward to assist with the evaluation of learning that took place. Data were generated from the Field Notes Journal used by each child to record daily reflections of their learning experiences. Individual math portfolios were created to assist the children in assessing their ongoing progress.

Data acquired before the instruction of the place value unit began determined that most children were ready to learn the concept of place value and identified children who would need special assistance. Parent surveys revealed that parents were knowledgeable of their children's attitudes and achievements pertaining to school. Interviews with the children established that all of them enjoyed participating in a wide array of art experiences, and all but one of the children in a classroom of 20 professed a positive attitude toward math. At the beginning of the study, none of the children could conceive of any possible way that art could be integrated with math, but at the study's conclusion, the children were able to look around them and connect their displayed artwork with place value math concepts.

The first math concepts taught to the children focused on a matrix to fulfill the mathematical objective of looking for patterns and the situational and positional relevance of numbers first from 0 through 99 then increasing to more advanced numbers. Art experiences for these concepts included "I Spy" pictures based on Lucy Mickletwait's (1992) book, I Spy, and the Arrowdynamic pictures achieved through the art process of monoprinting that used the matrix as both a reference and subject of printing.

The next mathematical concepts taught were designed to provide the children with the opportunity to explore other number bases. The game Zurkle was introduced to present these concepts. Wanted Posters and glittery number mosaics were art experiences integrated with these number base concepts. The children made number critters to explore how numbers could be manipulated to make pictorial representations.

To assist the children in their understanding of base ten numbers and their various written forms that could be used to express these numbers, the children used base ten stamps on poster board to practice writing the different ways that numbers could be recorded. The children made yarn cards and wrote a number in standard form on one side and expanded that same number on the back of the card. Other art experiences designed to connect art and math were the children's construction of individual place value charts and a personalized Zero Zapper.

Several noted artists were subsequently drawn into this integrated art/math unit on place value. Teaching the children about M. C. Escher and his creation of the Tessellation visually enhanced the strategy of looking for a pattern in "story" problems. Another artist, Alexander Calder, famous for his mobile inventions, was a reference used to introduce the children to the activity of constructing four-digit address mobiles that hung above their desks.

Children always struggle in their attempts to find strategies to help them understand the complexities of story problems. They have difficulty deciding what operation the question is asking them to perform. Therefore, the children were taught to analyze word problems with the help of a "draw a picture" strategy and were shown how to depict a representation of the details of the problem without actually drawing real figures.

Another mathematical concept explored was the identification and use of the symbols greater than and less than. The children artfully explored these symbols using crayon resist as the medium. Rounding numbers to the nearest ten, hundred, and dollar amount was taught using number strips that indicated counting either by 10s or 100s and showed the halfway numbers of 5s and 50s midway between the 10s and 100s. The children made their own 100s strip and transferred their understanding of rounding 100s to that of rounding to the nearest dollar amount. Further art activities included using blank flash cards and money stamps to draw pictures of items the children thought they could buy with the amount of money they had stamped on the card. The children also cut out pictures including the prices from catalogues of items they wanted to buy, pasted them onto construction paper to make a collage, and rounded the prices to the nearest dollar.

The results of this integrated art/math approach to teaching place value were positive. Assessing what the children had learned was accomplished through the pencil-and-paper questions at the end of the unit, artwork that displayed their understanding of various concepts, and comments via the Field Notes Journal and final interviews. The children enjoyed creating these art experiences while at the same time learning math concepts. Parents played an active role in the research by completing meaningful and reflective surveys about their children both before the research and after attending the Museum Tour Night. The strong bond of communication among the children, parents, and teacher was apparent throughout the research study.

Conclusions

A myriad of conclusions can be drawn from this research, but the most important one is that integrating diverse art experiences with the abstract mathematical unit on place value produced successful learning results. This conclusion was evidenced from assessments of the children's ability to understand place value ranging from written and verbal responses to paper-and-pencil questions to reviews of each child's portfolio to the children's own proclamations of learning. These assessments indicated that all of the children learned—not just the mathematically talented. It would appear that these favorable results were directly related to the children's ability to transfer learning by modifying or adapting a set of skills learned in one setting to those of another setting (Eisner, 1998). The art experiences helped to provide a favorable learning environment, supplied the children with several cognitive aides and, in the process, appeared to promote and sustain positive attitudes of the children toward learning mathematics.

The cognitive aides and their apparent positive influences on attitude added insight to this action research. The contributions are addressed in the two sections that follow.

Cognition

The first conclusive issue of this study addressed what role art might play in helping children understand the abstract concept of place value. The role that art played is described in the following manner.

Art Experiences Produced What Could Be Described as a "Linking" Occurrence to Assist the Children in Their Understanding of Place Value Concepts. The children spoke the same logical mathematical vocabulary—matrix, patterns, greater than, etc.—while they linked these concepts to the visual art experiences of painting, stamping, making mosaics, constructing collages, and printing. This process allowed math concepts to link to art experiences enabling learners to visualize and conceptualize the mathematical concept being presented. The art activity enhanced the children's ability to transfer what they had learned in a math instructional setting to an art setting. In the process, it linked a math vocabulary to that of an art experience thereby clarifying one learning experience in math with an integrated art experience. For example, the "arrowdynamic" pictures were linked to the matrix concept and making the mosaics linked the mind's images of a single glittery number to a mind full of larger numbers, etc. These art/math activities appeared to be memorably linked in the children's minds because the recall of a specific artwork sparked a cognitively linked mathematical learning objective.

The Success of this Unit Spoke to Gardner's (1983) Pluralistic Views of How Children Construct Knowledge. The art experiences were of cognitive importance in that they "repeated" the logical mathematical lesson but in a different context. This provided children who were not predisposed to learning from logical-mathematical strategies an alternative way to learn the math concept. The art experiences were designed to enable the child to repeat the morning's math lesson in an artistic, visual style.

It provided a repetitive approach to practice math in a "non-boring" manner—as one parent noted in the final parent survey. This type of practice did not involve problems to be copied from a numbered page in a math textbook, but it did encourage the children to revisit the taught math concept from a visual approach. For example, the base ten stamps and coin stamps produced images that afforded the children the opportunity to re-enter the abstract realms of the base ten number system and count money through a visual method. Children could focus on number and money relationships with one another as they collaborated on these visual experiences. This art/math experience would have been impossible to generate under traditional math circumstances. Taught independently, the subjects would have failed to produce these same learning results, but integrated they combined to produce a positive learning environment for children to construct place value concepts.

Art Experiences Furnished the Children with Stories to Tell. In some cases, the art experiences allowed children an opportunity to communicate in symbols certain math concepts for which the words were not yet conceptualized. Each art/math experience became a story—as children explained what they had painted, stamped, cut, or glued, there was an experiential math story to accompany the procedure. These stories spoke to Vygotsky's theory that social interaction plays a fundamental role in the development of cognition (Bedrova & Leong, 1996). The stories began in collaborative group sessions as the children actively discussed with their friends how to approach each art experience and how it connected with the math lesson, and it allowed the children to express their ideas in a creative way. Exchanging views with partners as the children worked was definitely a main element in the way children went about their art experiences. The art/math stories were reviewed several times as the children planned for the night of the Museum Tour. On that evening the children ushered their parents to the site of each activity, and as they did so, the children once again told their art/math stories. Parents commented in their surveys that it had been quite a learning experience for them.

Each time the story was told, whether it was to a classmate or an adult, provided a vehicle for elaborating about the strategies, plans, and processes of the art/math experience. The art/math activities encouraged the children to develop words for the art experience and the math concept in a social situation and provided reinforcement to the math skill that had been taught. Every recitation personalized the story until it became more indelibly etched in each child's memory. The integration of art and math provided the Vygotskian tools of communication for the children.

The Integrated Art/math Experiences Generated an Associative Means to Maintain Newly Acquired Place Value Math Concepts. The theory that an association of ideas is formed by combining two sense perceptions—in this case math concepts and art activities—that are experienced together applied to this learning situation (Bruner, 1996). The children had only to look around the room at their artwork to find evidence of the math skills learned. For instance, they would look at their crayon resist pictures and remember the < > concepts. When they viewed their Wanted Posters hanging on the wall, they associated this art activity with memories of sheriffs and rounding activities. This ability was evident during the final interview with the children. When responding to final interview questions, the children would look around the room for visual clues to refresh their memories of the place value concepts that had been learned the past few weeks.

Brunetta (1997) wrote that children are better at understanding and retaining abstract math concepts through art. The associative aspect of art served as a memory jogger for math concepts. The frequency of the memory joggers as children viewed their room encouraged the retention of math skills—place value skills that had been taught more effectively with the additional visual help the art experiences provided. Often, freshly planted math ideas lie dormant in the brain for extended periods of time—at least until they are needed again. An additional benefit of displaying all of the art/math projects around the room was that everywhere the children looked, there were instant reminders of what they had experienced.

<u>The Art Experiences Provided Hands-on, Concrete Experiences for Children to Use in Tackling Abstract Math Concepts</u>. The difficulty and abstractness of the mathematical concept of place value was camouflaged with visual, concrete, hands-on art experiences that provided the children the means to handle challenging activities. According to Piaget (Kamii, 1994), children's knowledge is not absorbed passively from the environment but is performed in the child's mind and emerges as the child matures and constructs knowledge through interactions with the environment. The minds of children were actively engaged as they interacted with art mediums to construct new understandings about math.

Children who were performing in the concrete, operational stage were constructing abstract knowledge as they experienced it in a hands-on, concrete way. As the children created their own visual images, they constructed their own bridges from concrete to abstract (Yackel & Wheatly, 1990). Sketching, printing, and painting were important tools used to make abstract concepts realistic.

Attitude

The second conclusive issue of this study addressed the improved attitude of some children in the classroom. This improvement could be addressed through four major thought avenues: art helped improve behavior; art provided an emotional outlet for children; art made the unit fun and was therefore motivational; and art alleviated math anxiety. The following conclusions were drawn from evidence regarding the children's classroom behavior.

Though Many of the Children in this Classroom Professed Positive Attitudes Towards Learning Math, Their Behavior During Periods of Instruction and Their Listening Skills Indicated this Was Not Always True. Once the children realized that art activities were on the agenda everyday, they began to listen for the art connection.

The Art Activities Allowed These Children to Express Their Emotions in an Acceptable Way (Schirrmacher, 1988). Instead of breaking pencils and throwing tantrums, the children were able to engage in art activities and learn math simultaneously. The episodes of pencil breaking and emotional outbursts were reduced when art outlets were provided.

Math Became a Fun Experience as Was Commented upon by Parents, Children, and Teacher. Learning that is fun produces better attitudes so that more learning could take place. The art experiences helped to make this unit fun. When students were able to visualize mathematical problems through their own artistic devices, they were able to enjoy math while expressing themselves artistically (Miller, 1996).

Art Alleviated Math Anxiety. More than once, simply taking a pencil out of a child's hand and substituting a crayon or paintbrush eased the threat of tears and helped the child still maintain the belief that s/he was "good in math." Failure to do well in this abstract unit was averted because the children were able to learn through the visual intelligence strength as well as the logical-mathematical one (Gardner, 1991). Art eased anxiety and revealed to the teacher that children are not as afraid to ask questions in art as they are in math. There were no tears when art was the focus of the lesson because the children apparently felt confident doing art—there was not the added pressure of producing right and wrong answers. Children appeared to take risks with art that they did not feel comfortable taking in math.

The Pride the Children Felt as They Surveyed Their Learning Environment and Saw Evidence of Their Artwork Surrounding Them Did Wonders for the Attitudes of Those Children Who Suffered from Bruised Self-Esteems (Goldberg. 1997). All of the children, regardless of past math success or lack of it, discovered they had a knack for turning art experiences into adventures in learning math.

Implications for Practice

Based on the observation and documentation of art and math experiences in the classroom and reactions to these experiences as expressed by the children, the parents, and my notes, the following implications for teaching mathematics through an integrated art approach emerge.

The Most Significant Implication from this Research Centers on the Importance of Utilizing an Integrated Subject Approach to Classroom Instruction. For more than a decade learning theorists and curriculum specialists have encouraged schools to pursue the benefits of an integrated curriculum experience for children for various reasons. It is suggested that integrated learning experiences encourage children to make connections between and across the disciplines, thereby enabling the transfer of knowledge to occur. Integrated learning experiences allow children the access to classroom instruction that incorporates a variety of approaches that address different learning style preferences and intelligences (Gardner, 1993). It provides pluralistic instruction to furnish children opportunities to learn through their intelligence strengths.

Integrated learning experiences furnish children a more realistic and authentic glimpse of the real world. Integrated learning helps children understand that to be successful employees of a work force requires thinking and problem solving skills that are learned through an interdisciplinary approach to learning.

Integrated curriculums illustrate to children how it is possible to think in more than one subject at a time. For instance, at the beginning of this study, when children were asked in their initial interview if they thought that learning math and doing art activities could be done at the same time, the children had no answers. Yet, by the end of the study, they had only to look around the room to find multiple evidence that math and art can be experienced at the same time. These combined experiences also revealed that subject matter absorption and problem solving skills could be transferred from one discipline to another.

Integration of subject areas must be utilized to survive the overwhelming expansion of information that educators find themselves asked to teach. While the length of the school day has stayed the same, knowledge has grown. To ensure that the newest and perhaps the most valuable knowledge does not fall through the traditional cracks of classroom learning, the integration of subject areas must occur.

A Second Implication of this Study Is That the Often Marginalized Role of Art in the Classroom Should Be Revisited. The results of this study strongly evidenced that children love art, research reports children need art, and school district practice shows that the art programs are usually the first budget areas cut when school allocations must be streamlined. Yet, the opportunity to participate in an art program is not a luxury or frill but the right of every child to have the opportunity to own (Eisner, 1976).

The art experiences that were part of this unit's math instructions provided concrete learning experiences for children. It can be said that when the children worked on art experiences they were collaboratively constructing knowledge. The children were using the languages of art and math as they discussed plans for the project at hand. The children utilized cognitive skills as they organized their thoughts, made choices about how they would accomplish the latest art/math challenge, and, in the case of the monoprints, were challenged to solve the problem of making numbers that were turned the right direction. Some members of the class had not experienced much success in school until the very moment they were asked by a classroom leader to please explain how numbers could be made in such a manner as to produce them correctly on the paper. What a feeling of empowerment the activity of art created for this child as s/he tried out the new label of art expert! This revisits the integrated approach to classroom instruction. If the integration of subject areas is to become a reality, art should be the first integrated subject to be utilized. From this study's experience, it added the special spice to the study and turned the classroom into a work of art.

A Final Implication this Study Speaks to Is That of Instruction and Assessment. Research has found that instructional strategies must match up with assessment techniques (Herman, 1992). Good assessment is built on current theories of learning and cognition and grounded in views of what skills and conceptual understandings students will need for future success. The results of this research go a long way toward advocating authentic assessment for the subject of math that traditionally assesses student learning by means of pencil-and paper-assessments. In this study, it was found that every art project lent itself to assessment as it provided proof of the understanding of a concept taught.

Meaningful learning for children is a reflective, constructive, and self-regulated event (Herman, 1992). In this learning context the children were able to express their understanding of the math concepts through the Field Notes Journal, artwork, and their self-regulated portfolio. As the children communicated the intent of their art projects, assessment of their understanding of the math concept rang out loud and clear. These assessment examples were more indicative of what the children had learned than the pencil-and-paper questions that were answered by "test anxious" children. The math portfolio allowed teacher, student, and parent to look at the progress that had been made in the understanding of place value.

This research study produced implications with regard to how math could and should be taught. It speaks to the positive outcomes that happen for children and their classroom community when new teaching methods are utilized to integrate two subject areas.

Suggestions for Future Research

During the process of this research study, several areas for potential future research studies emerged. The following discussion addresses thoughts about these possibilities.

<u>A Suggestion for Future Research Based on the Research for this Study</u> – might address the concept of moving away from traditional teaching with the use of a state-mandated textbook as the sole basis for a math program. The traditional mathematics textbook is structured to pace children through a scope and sequenced math program that typically does not provide time for children to explore and make connections with concrete materials. The scope and sequence chart of the math textbook provides an impersonal look at children's needs based on research of children who are not present in my classroom and who exhibit needs other than those addressed in the book. Glasner (1969) feels that a serious failing in most school materials is that emotion has been drained

out of them. The curriculum of children in the classroom needs to reflect the emotional culture of children. Textbooks, by their very nature, are impersonal, designed for mass publication, and marketed for the purpose of convincing school districts to purchase them. Reflecting teachers are in a better position to create materials and design a curriculum to meet the needs of the children. This does not advocate a mass book burning by any means, but rather suggests that the use of textbooks be limited and used when appropriate for practice activities, not as the sole means of instructional inspiration.

Traditionally, textbooks tend not to provide a support for children whose learning strengths are through different intelligences as described by Gardner's (1993) research on multiple intelligences. Textbooks are typically designed for children whose strengths embrace learning through the logical-mathematical intelligences, and skills are tested through those same intelligences. A teacher-created unit allows teachers to develop strategies that encourage students to use concrete, hands-on materials to construct knowledge for success. A teacher-created unit allows for enough time and the opportunity for children to explore mathematics through all of the multiple intelligences, thereby erasing the word failure from the picture.

Another Suggestion for a Research Study from Data Collected from this Study – supports the theory that parents involved as partners in their children's school activities help ensure school success for their child. The opportunities for parent participation in this study were numerous, and this participation created a bond of communication. Research indicates that student achievement is maximized through parent involvement

(Slostad, 1999). Positive attitudes, better behavior, and success in school programs are attributes associated with children whose parents are actively involved in school.

Communication establishes a relationship between parents, teachers, and children that is non-adversarial by nature—the parents know and understand what is occurring within the walls of the classroom and feel at ease discussing the progress their child is experiencing. The initial surveys invited parents to discuss their children, the success they had experienced in previous years, and their child's specific learning needs in a relaxed manner before sitting down at a conference table to discuss academic and behavioral achievement at conference time. The parent surveys, interviews with the children, and the museum tour provided the opportunity to visit with parents and really enabled me to understand the children in the classroom, their needs, and the parents' goals for their children. This research strongly indicates that parent surveys should always be a part of getting to know the families and the children to maximize and facilitate classroom learning in every possible way. Never in past years have I had the opportunity to know parents as I have through a research study such as this.

Data from this Study – speaks to the fact that children should have a voice in deciding what goes in the classroom, and this might present an area for future research. The first opportunity for the children's individual voices to be heard was through the initial interviews. It helped the children to realize that what they felt about school was an important aspect of their classroom and their opinions were valued. It established a classroom community. Teacher/student interviews should be a permanent part of the classroom agenda.

Scaffolding needs to be in place to establish a flow of continuity of learning within the classroom, but the children need to know that they have the opportunity to express opinions that influence decisions made in the classroom. The two most exciting activities that happened in the classroom were suggested by the children. The first was the Museum Tour for their parents, and the second was the decision to conduct the final interviews in small groups over lunch. The Museum Tour was a celebratory evening for parents, students, and the teacher, and the interviews were sources of pleasure as the children reflected upon the past art/math unit. This was an example of children participating in the "policy making" decisions of the classroom and another example of parents being involved in their children's successful school endeavors. Both activities invited the children to display their pride for a room that reflected their endeavors—the ownership and community they felt were important elements in the classroom.

<u>There Is Always a Need for More Research</u> – that explores strategies that enhance and facilitate children's construction of knowledge. Gardner's (1983) research has made a significant difference in the way instruction is presented to children in the classroom and the materials that are available to assist children in their constructions of knowledge. Continued research into the role that the visual arts play into this understanding will always be important to address the diverse needs of our school populations. As the complexities of society increase to become more tangled, the population of children more richly diverse, and the research theories more numerous, it is imperative to have trustworthy inquiries that speak directly to the issues of how to educate children.

The Theory Advocating Teacher Research in the Classroom – should be strongly encouraged. It is the opportunity for teachers to study educational problems within the constructs of a natural learning environment. It provides teachers the opportunity to study a problem, look for solutions, and improve practice in the process. Teacher research affords the opportunity to share the information gained with other teachers and other areas of study in hopes of improving their practice as well. Kincheloe (1989) expresses these ideas about teacher research:

> The benefits go beyond the effort to escape the blinders of instrumental rationality and to gain insight into the dynamics of their classrooms. When teachers listen to their students and elicit their opinions and perspectives, a variety of benefits are derived. It allows for a healthier, more authentic, teacher-student relationship which inevitably leads to better communication. The student, and in many cases, the teacher, is confirmed, her experiences validated. (pp. 104-105)

The benefits of teacher research demonstrate to students in the classroom that learning is life-long as teachers strive to show by example what it means to be a lifelong learner.

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APPENDIXES

APPENDIX A

PARENTAL CONSENT FORM

Parental Consent Form

I, ____________________________, give my permission for my child, ___________________________________, who is a student in Mrs. Nancy Greer's third grade class at Skyline Elementary, to participate in the research study: The Integration of Art and Math Activities to Teach Place Value, conducted by Nancy Greer who, in addition to being my student's teacher, is a doctoral student at Oklahoma State University. I understand that information gained from this study will be confidential and the identity of my child will remain anonymous. I understand that participation of my student is voluntary, that I have the right to withdraw my child from the study at any time, and that the study will result in no cost to me. I understand that I will receive a copy of this form to keep and that my child will be verbally advised of the study.

I may contact Nancy Greer, Dr. Margaret Scott, or Ms. Sharon Bacher at University Research Services, 305 Whitehurst Hall, Oklahoma State University, Stillwater, Oklahoma, 74078, at any time regarding the study.

____

Parent Signature

____

Date

APPENDIX B

NCTM 1989 STANDARDS/OKLAHOMA STATE

D. O. E. PASS OBJECTIVE

NTCM 1989 STANDARD 6

- In grades K-4, the mathematics curriculum should include whole number concepts and skills so that students can—
- 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.

PASS–Priority Academic Student Skills—Oklahoma State Department of Education

Number Sense and Numeration

The student will construct and interpret number meanings and place value concepts through practical, everyday experiences and the use of manipulatives.

The student will:

- Read, write and use numbers to describe and interpret mathematical situations.
- Compare and order whole numbers.
- Make generalizations from a variety of patterns and relationships of whole numbers including odd and even number patterns.
- Recognize the relative magnitude of numbers.
- Use concrete models of thousands, hundreds, tens and ones to develop the concept of place value

APPENDIX C

ART EXPERIENCE DIAGRAMS/DESCRIPTIONS

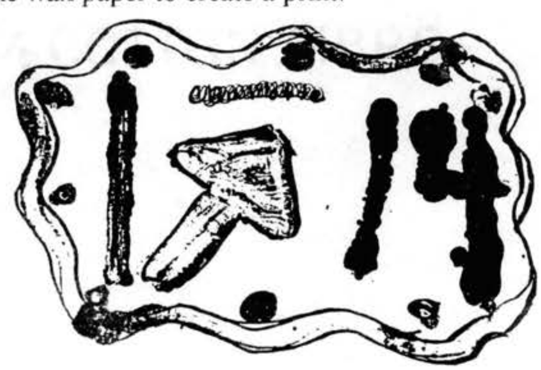
Listed below are the diverse art experiences integrated into this unit on place value and brief description of how each experience was accomplished.

Introduction to the Unit Art Experience

This experience was introduced through means of Lucy Micklethwaits's book, *I Spy Two Eyes.* This counting book to 20 provides reproductions of paintings by famous artists and focuses on "spying" a particular number of specified items in each painting. It was used to show students how art and math could be integrated. At the end of the reading, the children created their own original works of art choosing one number and illustrating that number in their work.

Monoprint

Pressing a sheet of paper onto a surface where paint or ink is smeared makes a monoprint. The monoprint was designed to integrate into the children's study of the matrix and the arrow matrix math game. The children used a copy of the matrix as a reference, painted a number and a directional arrow pointing to another number with tempera paint on wax paper. The white paper was then pressed on top of the wax paper to create a print.



Wild and Crazy Number Critters

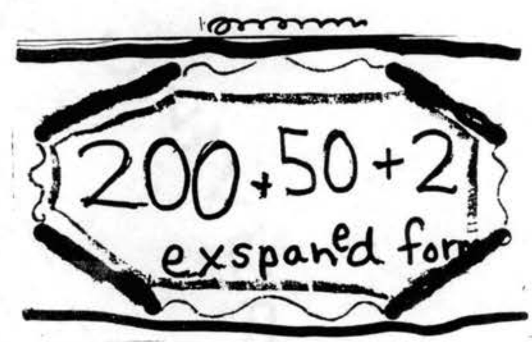
The number critters were animals—either imaginary or real—drawn using different numbers as the body, nose, etc. Contextual background for the picture was also made up of a variety of numbers. The numbers could be turned in any direction. A challenge was issued to add the total of the numbers used in the drawing. The experience was designed to show ways that numbers could be integrated with art.

Mosaic

This art experience was designed to help the children understand the meaning of the art vocabulary term, mosaic. The children used a piece of poster board in a color of their choice and drew single-digit number as large as they could. This number was then cut from the board. The children designed a mosaic using glitter, shiny foil, and pieces of paper to glue in a pattern on the number. These numbers, once they dried, were integrated into math lessons by the artist to act out different numbers that could be made and promote discussions about the value of different numbers in different places.

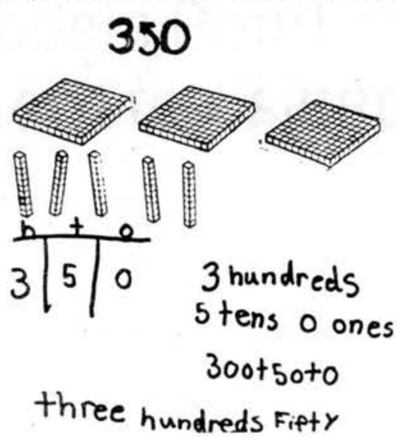
Yarn Pictures

This experience used a 4x5-inch card in which holes had been punched around the edges. The children were to write a number on one side of the card in standard form and turn the card over and write the same number in expanded form using crayons or markers. They finished their pictures by weaving multicolored yarn around the edges and tying it in a bow to be hung above the chalk-board. This art experience was designed to extend the math lesson on standard and expanded form.



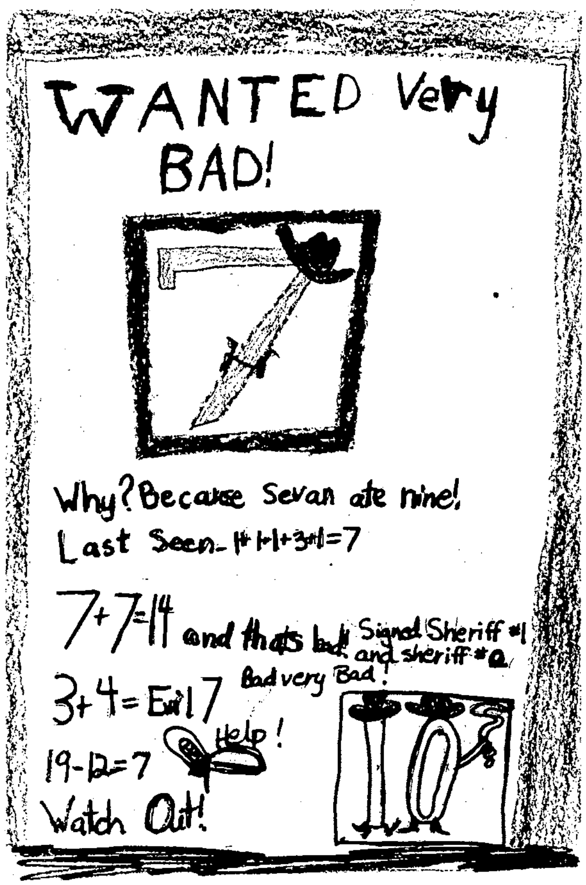
Place Value Pictures

This activity used base ten place value stamps and stamp pads in secondary colors to make a place value picture. The children stamped a number using one color for hundreds, a second color for the tens, and a third color for the ones. They identified the number they had stamped and then wrote it in all of the different ways they had learned that numbers could be written—standard form, expanded form, words, a place value chart, and a combination of words and numbers. This experience was designed to build upon the math concept that numbers can be written in different forms.



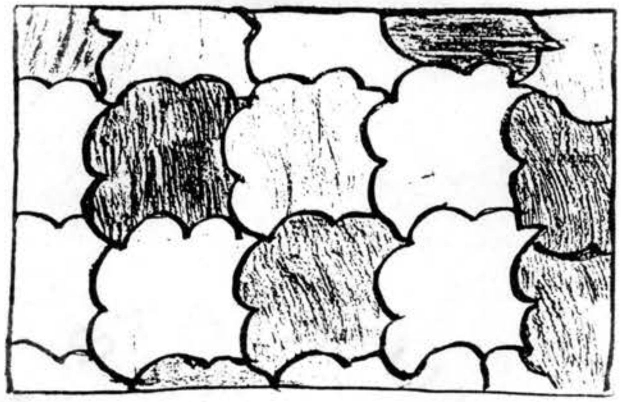
Wanted Poster

The children chose a number to be the subject of a Wanted poster. They began the poster by writing the word WANTED in big letters at the top. Then they were to draw a "mug shot" of the number. Then they were to record reasons why the number was wanted. For example, if they chose the number 3 they could say that this odd number was wanted for coming between the even numbers of 2 and 4 when counting. This integrated experience was designed to show understanding of numbers in situational contexts.



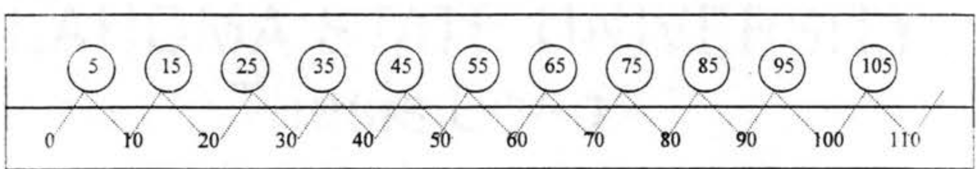
Tessellating Pictures

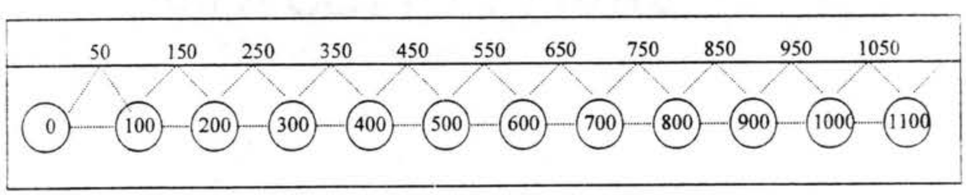
This art experience was introduced with presented information about M.C. Escher and visual examples of his artwork. To do this activity, the children were to change two sides of a cardboard square to create a tessellation pattern. Then they traced that pattern over and over on pieces of large construction paper. They added color and details with crayons. The art experience integrated with the math concept of looking for a pattern.



Rounding Strips

In an attempt to provide a visual picture for the children while they were learning to round numbers to the nearest 100 and dollar amount, the children created a rounding strip that provided them the concrete experience of moving counters to the nearest 100 or dollar amount. To do this the children each had a sentence strip and colored circle stickers. With a ruler they measured one-inch intervals starting at one end of the strip and proceeding to the other end. A colored circle sticker was placed at each mark and designated a 100—staring with 0 and counting by a hundred. On a line above the circle stickers and halfway in between each hundred another circle sticker of a different color was placed and labeled 50—counting by hundreds. For ex. 50, 150, 250, etc. The children could use the strips to visually locate a number and "see" to which hundred it was closest.



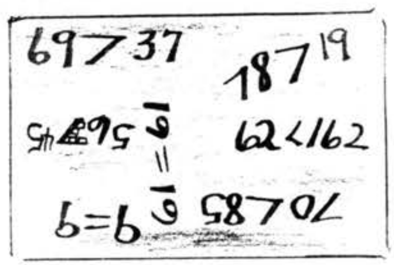


Collages

After a discussion about collages, the children found pictures and prices of items in catalogues, cut the pictures and the prices from the catalogues, and pasted them on a primary colored piece of construction paper. They were to round the price of the chosen items and write the rounded price next to the actual price. Additionally, they were to add their rounded amounts and record that number on the back. This activity was designed to provide more experience at rounding dollar amounts.

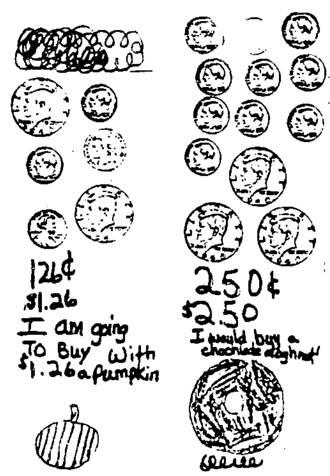
Symbolic Pictures

Employing crayon resist, the children used orange crayons to write two pairs of numbers and inserted the symbol < or > between the numbers showing the correct symbolic relationship. They were encouraged to fill an entire page with these number pairs and symbols. Then they painted over these crayoned numbers and symbols with watered-down black tempera. This integrated art experience provided a visual picture of the concept of greater than and less than.



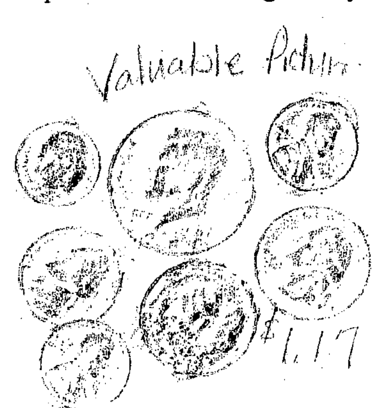
<u>Coined Flash Cards</u>

Using a blank flash card, stamps reflecting the different sides of coins, and stamp pads, the children chose an item to buy and drew a picture of it on their flash card. Then the children stamped what they estimated would be the actual cost of the item under their picture on the flash card. The stamped value was written using a dollar sign and decimal point as well as writing it with the cent sign. This activity encouraged mathematical thinking in estimation, rounding, and money and provided visual practice.



<u>Valuable Pictures</u>

This experience involved using real coins, placing them under sheets of white paper, and rubbing over them with crayons or pencils. The children added up the value of their picture and recorded the value using the decimal point and dollar sign as well as writing it in cents. The activity provided hands-on visual experience in counting money and writing it in two equal but different styles.



Place Value Critters

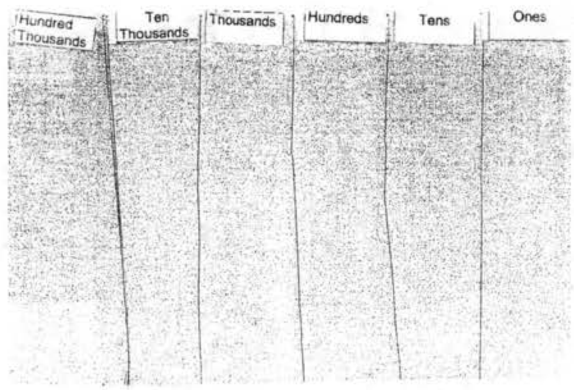
Using one cupped side of a Styrofoam egg carton, the children created snakes, dragons, and in one case a truck using googly eyes and pompoms. Each cup was given a value—ones, tens, hundreds, thousands, ten thousands,hundred thousands, etc.—which was written along the side of the appropriate cup. When the critters were completed, the children would drop beads into each cup creating numbers. This art activity provided extra practice with large numbers.

Number Mobiles

After a discussion of Alexander Calder and his invention and construction of mobiles, the children designed their own mobile to hang above their desk. This mobile consisted of half of a two liter pop bottle, four strings, and numbers the children had cut from wallpaper. The children attached the wallpaper numbers to one end of the string, and the pop bottle to the other end of the string. Decorations were applied to the pop bottle, and when finished the mobile was attached to a paper clip attached to a string that hung from the ceiling above their desks. The children cut numbers needed to make their own "desk address." The children used these number mobiles to see how many different numbers could be made using four digits.

Place Value Chart Placemats

These charts were made from different colored pieces of construction paper. The children labeled the wide side of the paper ones, tens, hundreds, thousands, ten thousands, and hundreds thousands. Then lines were drawn with rulers to make columns between each designated value. Creating their own place value mats visually enhanced the children's understanding of the order in which place value occurs.



This is a picture of the cover of the children's Field Notes Journal

APPENDIX D

UNIT FOCUS

This unit reviews and develops concepts of positional notation—place value and money. Students compare, order, and round, and identify place values to help them better understand numbers.

Concepts and Skills

- Use a matrix to predict number patterns
- Use other bases to explore place value concepts
- Use place value to write numbers through 99
- Write numbers through 999 in standard and short word form
- Use Look for a Pattern strategy to solve problems
- Use Draw a Picture strategy to solve word problems
- Use the symbols <, >, and =
- Round 2-and 3-digit numbers to the nearest ten or hundred
- Find the value of a group of coins

APPENDIX E

CONSERVATION ACTIVITIES

<u>Conservation of Number</u>: This activity involves showing the child a set of objects in a row and then changing their arrangement to some other pattern such as circular to see if children realize the number stays the same.

<u>Conservation of Equivalence</u>: This activity involves comparing two sets, each containing the same number of objects, and then varying the arrangement of the objects in one row to see if the child realizes the number is the same in both rows.

<u>Conservation of Grouped Number</u>: This activity involves having a child bundle three sets of ten Popsicle sticks from a total of 34 and then asking the child if there were just as many, more, or fewer after they unbundled one set of 10.

<u>Conservation of Quantity</u>: (a) This activity involves asking the child (while demonstrating with cups), "If I give you some water in one cup, will it be the same if I pour it into two cups?" "Now if I give you these two cups of water and we pour the water into that tall glass, which would you rather have?'

(b) This activity involves working with two balls of modeling clay containing the same amount. If the shape of one is changed to flat or lengthened or if the ball is made into smaller balls, will the child recognize that the amount has not changed?

APPENDIX F

PLACE VALUE SURVEY ACTIVITIES

Activity Using Base-Ten Blocks

Materials:

Base-ten blocks: 40 unit blocks, 6 tens, 1 one hundred

Objective:

Make the number 52 with blocks.

Procedure:

A child is presented with base-ten blocks and asked to make the number 52 using the blocks. If the child does not understand the task, various restatements should be offered, such as “so they will count up to 52.” When the child is finished, the interviewer will ask, “how do you know that is 52?’

Levels of Performance

Level 1: The child was unsuccessful in making 52

Level 2: The child was successful, but usually began by attempting to use only the unit-blocks. After discovering that the quantity available was insufficient, he or she eventually solved the problem by using some of the ten-blocks.

Level 3: The child quickly chose five ten-blocks and two unit-blocks

In the second part of the task, children who were successful in making 52 are asked to find another way to represent the number 52. The above levels of performance could be used to evaluate the children’s success with second part of this task.

Place Value Survey Activities

Materials:

48 lima beans and nine 1-ounce plastic cups

Objective:

Correctly count the number of beans in the cups and those left over.

Procedure:

In individual interviews, present each child with 48 lima beans and nine 1-ounce plastic cups. Ask the child to put 10 beans into each cup. When there were four cups, each containing 10 beans, and 8 loose beans, ask the child how many beans there were altogether. Ask how he or she knew there were that many beans.

Levels of Performance

Level 1: The child was unable to give a reasonable number. (Small counting errors can be ignored)

Level 2: The child depended heavily on counting by ones rather than using more efficient methods (counting by tens, etc.)

Level 3: The child used an efficient method such as counting by tens and mentally adding or counting-on the remaining 8 beans.

APPENDIX G

STUDENT INTERVIEW QUESTIONS

Initial Questions

1. What do you like to do best at school?
2. If you could improve school in any way, what would you do?
3. What is your favorite subject at school? Why?
4. What is your least favorite subject at school? Why?
5. What subject or subjects do you feel you do best or are most successful?
6. Do you like to study math? Why or why not?
7. Do you like to do art activities? Why or why not?
8. Can you think of any ways that it would be possible to do art and math at the same time?
9. If you ruled the school day, what if any changes would you make?

Final Questions

1. How did you like doing math these past few weeks?
2. Can you share with me what was the most important thing you learned in math that you didn't know before we started the place value unit?
3. What was the most beneficial thing we did that helped you learn about place value? (Think about all of the activities we did.)
4. Did you notice any differences about the way you learned math in the place value unit from the other units we have studied?
5. Did you learn anything new about art? (Colors, shapes, or how to make something new).
6. If you could decide how math should be taught everyday, what recommendations would make?

APPENDIX H

PRIOR KNOWLEDGE ASSESSMENT

Write the number in standard form.

1.

2. 300 + 40 + 1

3. One thousand three hundred four

__________________ __________________ __________________

Write the number in expanded form.

4. two hundred eighty-seven

5.

6. 6415

__________________ __________________ __________________

7. Write the numbers from least to greatest. 28, 188, 129

____

8. Write <, >, or = in the ○. 451 ○ 415, 886 ○ 886, 3313 ○ 4412

9. Round the numbers to the nearest ten. 76________, 31_________,

88__________

10. Round the numbers to the nearest hundred. 210 _________________,

460 ______________, 750 ___________________

11. Write the money amount. Use a dollar sign and decimal point.

5 dollars and 42 cents ___________________

12. Draw a picture to solve the following problem.

Charlene made a pattern with stars. She pasted them in this pattern: 2 gold stars, 3 red stars, 2 silver stars, 2 gold stars, 3 red stars, 2 silver stars, and so on. If Charlene used 28 stars, how many times did she show the whole pattern?

13. Draw a picture to solve the problem.

Dan is taller than Bob. Chris is shorter than Bob. Pat is taller than Dan. In what order would they line up from tallest to shortest?

APPENDIX I

PLACE VALUE UNIT ASSESSMENT

Write the number in standard form.

1. ______

2. 500 + 8 ______

3. Two thousand six hundred twelve ______

Write the number in expanded form.

4. six hundred seven ______

5. ______

6. 2029 ______

7. Write the numbers from greatest to least. 7, 607, 317

______

8. Write <, >, or = in the O. 391 O 319, 686 O 686, 1090 O 1009

9. Round the numbers to the nearest ten. 12 ______, 56 ______,

156 ______

10. Round the numbers to the nearest hundred. 275 ______,

318 ______, 762 ______

11. Write the money amount. Use a dollar sign and decimal point.

8 dollars and 16 cents ______

12. Draw a picture to solve the following problem.

Megan made a leaf pattern with maple, oak, and beech leaves. She glued them down in this pattern: 2 maple leaves, 1 oak leaf, 2 beech leaves, 2 maple leaves, 1 oak leaf, 2 beech leaves, and so on. Megan had 14 leaves. What did she need to complete this pattern?

13. Draw a picture to solve the problem.

In a race, Dan finished in front of Bill and behind Amy. Joe finished behind Bill. In what order did the students finish the race?

APPENDIX J

INITIAL PARENT SURVEY

1. How would you describe your child's past progress in school?

2. Does your child like school? Why or why not?

3. Please list areas of strength for your child and why you think these are strengths.

4. Please list areas of weaknesses for your child and why you think these are weaknesses.

5. How do you think your child learns best?

APPENDIX K

FINAL PARENT SURVEY

1. Were you aware that your child has been involved in learning about place value these past weeks? Why or why not?

____

____

____

2. Did your child share with you any of the activities or concepts that happened in class during the place value unit? If yes, could you briefly make note of them?

____

____

____

3. Please feel free to make any comments with regard to the success of the place value unit or about the success that your child experienced?

____

____

____

4. Would you recommend that math units always include art activities? Why or why not?

____

____

____

APPENDIX L

MATRIX EXAMPLES

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

0	1	2	3	4	5	6	7	8	9
10	11	12	13	14	15	16	17	18	19
20	21	22	23	24	25	26	27	28	29
30	31	32	33	34	35	36	37	38	39
40	41	42	43	44	45	46	47	48	49
50	51	52	53	54	55	56	57	58	59
60	61	62	63	64	65	66	67	68	69
70	71	72	73	74	75	76	77	78	79
80	81	82	83	84	85	86	87	88	89
90	91	92	93	94	95	96	97	98	99

133	134	135	136	137	138	139	140	141	142	143	144
121	122	123	124	125	126	127	128	129	130	131	132
109	110	111	112	113	114	115	116	117	118	119	120
97	98	99	100	101	102	103	104	105	106	107	108
85	86	87	88	89	90	91	92	93	94	95	96
73	74	75	76	77	78	79	80	81	82	83	84
61	62	63	64	65	66	67	68	69	70	71	72
49	50	51	52	53	54	55	56	57	58	59	60
37	38	39	40	41	42	43	44	45	46	47	48
25	26	27	28	29	30	31	32	33	34	35	36
13	14	15	16	17	18	19	20	21	22	23	24
1	2	3	4	5	6	7	8	9	10	11	12

APPENDIX M

NUMBER STUMPER

Find the mystery number! Cross out the number or numbers for each line.

It is not 67, 68, 69, _________.

It is not 7, 8, 9, ____________.

It is not 17, 18, __________, 20.

It is not 32, 33, 34, __________..

It is not 65, 64, ______, 62.

It is not 39, 40, 41, _________..

It is not an even number.

10	19	21
30	35	40
42	63	70

The number stumper is:

APPENDIX N

INSTITUTIONAL REVIEW BOARD

APPROVAL FORM

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD

Date:	September 2, 1999	IRB #:	ED-00-148
Proposal Title:	"INTEGRATING ART AND MATH: TEACHING PLACE VALUE IN THIRD GRADE"		
Principal Investigator(s):	Margaret Scott Nancy Greer		
Reviewed and Processed as:	Exempt		

Approval Status Recommended by Reviewer(s): Approved

Signature:

Carol Olson, Director of University Research Compliance

September 2, 1999
Date

Approvals are valid for one calendar year, after which time a request for continuation must be submitted. Any modification to the research project approved by the IRB must be submitted for approval. Approved projects are subject to monitoring by the IRB. Expedited and exempt projects may be reviewed by the full Institutional Review Board.

VITA

Nancy Greer

Candidate for the Degree of

Doctor of Education

Thesis: INTEGRATING ART AND MATH: TEACHING PLACE VALUE IN THIRD GRADE

Major Field: Curriculum and Instruction

Biographical:

Education: Graduated from Northwest Classen High School, Oklahoma City, Oklahoma in May 1964; received Bachelor of Science degree in Elementary Education from Oklahoma State University, Stillwater, Oklahoma in May 1968; received Master of Science degree from Oklahoma State University in 1983; completed requirements for the Doctor of Education degree with a major in Curriculum and Instruction from Oklahoma State University in May 2000.

Experience: Elementary Teacher, Stillwater Public School System, Stillwater, Oklahoma, 1978-2000; English as a Second Language Teacher for the Adult Education Program, Stillwater, Oklahoma, 1989-1997; Stars' Coach for students at risk, Stillwater Public School System, Stillwater, Oklahoma, 1987-1997 and 1999-2000.

Professional Memberships: Delta Kappa Gamma Society International, Beta Delta Chapter of Gamma State; National Writing Project; Stillwater Education Association; Oklahoma Education Association; National Education Association.