THE USE OF IMAGERY TO SOLVE MATHEMATICAL WORD PROBLEMS BY SECOND GRADE STUDENTS

By

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CHAPTER I

INTRODUCTION

The study of imagery has moved in and out of favor among philosophers, researchers, and educators throughout history (Kosslyn, 1983). Kosslyn defined imagery as the ability to recall and contemplate something in its absence that enables the individual to think about it when it is not there. Researchers have agreed that an image is a mental associated response to a verbal or visual provocation and is based on an individual's past experiences (Carey, 1915; Piaget and Inhelder, 1971). Imagery is a complex subject to study because it includes not only visual and auditory images, but also gustatory, olfactory, kinesthetic, and tactile images (Begg, 1983; Broudy, 1987; Bugelski, 1983; Kosslyn, 1980; McKeller, 1957; Paivio, 1971; Richardson, 1983; Sheikh, 1983). To add to the complication of the study of imagery, individuals reported varying degrees of intensity of images that range from very sharp and clear to vague and fuzzy in detail (Carey, 1915; Thompson, 1990).

Examining an individual's imagery presents specific problems for researchers in that it is language dependent. Because language is developmental, it is especially difficult to test young children (Piaget and Inhelder, 1971). Although these children may have the capacity for creating images, the researcher's knowledge of those reported images is limited to the child's ability to verbally relay descriptions of his or her images to the researcher. As a result, most of the research conducted on imagery involves young adult and adult subjects.

Critiques of imagery tests suggested that the researcher's request for a subject to describe his or her image may, in fact, be the subject's response to the power of suggestion by the researcher and may or may not have been present before the question was posed to the subject (Eagan, 1989; Rohwer, 1970; Sutherland, 1971). Eagan and Sutherland questioned if the types of imagery tests, like patterns, rotating figures, ink-blot tests, etc. reflect the way individuals utilize imagery in solving their everyday type of personal problems.

In mathematics there is much public and professional concern over many students' inability in the United States to solve mathematical word problems (Ahlgren, 1991; Kantrowitz and Wingert, 1992). Most of these mathematical word problems come from textbooks in which Wheatley (1991) found that students rarely have an opportunity to use imagery in solving the problems because it is considered to be nonessential.

For many students, language in these word problems is a factor contributing to the difficulty they have because the problems do not utilize the oral languages used in their daily lives (Earp and Tanner, 1980; Zimmerman, 1989). DeCorte, Verchaffel, and DeWin (1985) found that textbook word problems were stated too briefly and were too condensed. Textbook word problems do not provide the necessary background information enabling the student to understand the word problem and to determine what procedure to utilize to solve the problem, even though she or he often possesses the computational skills needed to solve it (DeCorte, Verchaffel, and DeWin, 1985; Desforges and Cockburn, 1987).

The Standards adopted by the National Council of Teachers of Mathematics (NCTM, 1989) suggested using mathematical word problems from children's literature because it provides more detail and reflects real life situations. Much has been written about the educational benefits of the integration of mathematics and children's literature (Brown, 1986; Harsh, 1987; Richardson and Monroe, 1989; Thorton and Randall, 1993; Tischler, 1988; Whitin and Wilde, 1992). However, the genre of folktales, which reflects the oral languages used by the students in their daily lives, has not been specifically addressed as a possible connection with mathematical word problem solving.

Bettelheim (1976, p. 5) contended: "A story must relate to every aspect of a child's personality for the story to enrich life, stimulate imagination, help develop intellect and clarify emotions." Bettelheim is convinced that the traditional folktale meets these needs better than any other type of children's literature.

Storytellers contend that the characteristics of traditional folktales provide rich problem-solving situations that require the listener to use imagery in understanding and solving problems presented in the story (Baker and Greene, 1977; Livo and Rietz, 1986). Many professional storytellers have stated that children use imagery to make meaning of the story as they listen to it being told to them (Baker and Greene, 1977; Livo and Rietz, 1986; Nelson, 1990). However, little research has been conducted to support this broadly held opinion.

In mathematics, there have been numerous studies conducted on students' use of imagery to solve problems (O'Daffer, 1986, Rohwer, 1970, Wheatley, 1991). However, the vast majority of these studies are limited to spatial imagery in geometry and the reproduction of patterns (Eagan, 1989). Research that specifically focuses on childrens' use of imagery to solve mathematical word problems is unavailable. A great deal of research exists that examines a specific part of the complex operations required to solve mathematical word problems. Eagan suggested that more research is needed that would provide a holistic approach and contribute to educators' understanding word problems.

Purpose of the Study

The focus of this study was to determine if second grade students created images in response to hearing a folktale and if they used those images as a strategy to solve mathematical word problems. The subjects' responses to hearing a folktale and explanations of how they solve word problems provided clues to images they employed. The childrens' responses were categorized by the types of imagery they describe which included visual, auditory, olfactory, gustatory, tactile/texture, and emotive. Tactics used by the students to solve mathematical word problems were classified by the strategies students employed to solve them. Patterns and relationships were identified to explain the phenomenon.

Research Questions

The following questions guided this study:

1. Do young children, ages seven and eight, have the ability to create images in response to listening to a traditional folktale?

2. If so, what types of images do children report in response to hearing a traditional folktale told to them?

3. Is one type of imagery used more frequently than other types of imagery?

4. Do students use images when they decide how to solve a mathematical word problem?

5. Once children decide how to solve a mathematical word problem, do they utilize images to solve the problem?

Assumptions of the Study

The following assumptions directed this study:

1. Images reported by the student were based on her or his previous experience and knowledge (Nelson, 1990).

2. Students listened to the same story but reported different images in types and intensity (Nelson, 1990).

3. Students used images in different ways to solve a mathematical word problem (Eagan, 1989).

Definition of Terms

Several key terms were used throughout the study. The definitions of these terms are provided:

Auditory Imagery is the ability to recall sounds.

Emotative Imagery is images that involve the emotional responses related to the personal feelings of the listener and the imagined feelings of characters in the story.

Gustatory Imagery is images related to the sense of taste.

Images are sensory patterns which serve as a visual, auditory, kinesthetic, or tactile substitute for some alleged likeness.

Olfactory Imagery is images related to the sense of smell.

Tactile/Texture Imagery refers to images related to the sense of touch.

Traditional Folktale is a story passed down by word of mouth.

Visual Imagery is the ability to call up mental visual representations of a person or thing. It is a mental picture of something that is not actually present.

Limitations of the Study

The study had some limitations that should be considered in order that the findings be viewed in their proper perspective:

The findings of this study were limited to two intact classes of second grade students' verbal responses to a traditional folktale and their reported problem-solving strategies as they solved a mathematical word problem based on that folktale. While the students listened to three stories, only the last story provided the context for the study. Because only one story was used for the study, generalizations were not applicable. The reported observations in this study were defined, as Erlandson et al. (1993) pointed out, by the specific context in which they occurred.

Limitations in evoking responses from the students may have been a factor due to the type of questions employed in this study. The questions posed to the students were purposely open-ended to avoid leading the students' thinking. Open-ended questions enabled students to contemplate, and their responses reflected their own images and interpretation of the traditional folktale.

All of the students in the class participated in listening to the story, class discussion, and solving the mathematical problem. However, only the actions, responses, and observations of the students who had written permission from their parents to participate were reported in this study.

Summary

Research that specifically focused on children's use of imagery to solve mathematical word problems was unavailable. While a great deal of research exists that looked at many parts of the complex operations required to solve mathematical word problems, no research was found that provided a holistic approach to understanding the word problems that this study proposed. This study attempted to provide some insight to fill that void by providing a broader understanding of the phenomena.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

This study explored the role of imagery strategies that second grade students use to solve mathematical word problems. The review includes the following section titles: (1) Historical Overview of Imagery Research, (2) Imagery Theories, (3) Imagery Tests, (4) Imagery and Learning, (5) Mathematical Word Problem Characteristics, (6) Mathematical Problem Solving and Imagery, (7) Mathematics and the Literature Connection, (8) Storytelling of Traditional Folktales, and (9) Conclusion.

Historical Overview of Imagery Research

Imagery has a long and tortuous history in philosophy and psychology (Kosslyn, 1983). From ancient time onward, man has contemplated and questioned the existence of mental imagery. Individual differences in visual imagery and failure to realize their existence has affected theories of thought and knowledge throughout history (Thompson, 1990). It was taken for granted from the beginning of psychology that the memory of an experience consisted of the imaginal reproduction of the experience. Imagery was considered the same in nature as the actual experience, but of weaker intensity (Carey, 1915).

Theories about the nature of thought and knowledge were often based on the assumption that one's thinking was universal. Thompson (1990) examined the writings of Aristotle, Plato, and Socrates for evidence of each philosopher's ability to create and use imagery. He describes Aristotle as a highly imaginative thinker who generalized his style to others. Thompson (1990) quoted Aristotle as saying:

> . . . under the influence of the image or thoughts in the soul you calculate as though you had the object before your eyes. The soul never thinks without an image. A man cannot know anything without sensation. He cannot think without an image (p. 144).

In contrast, Plato's writings indicate that he was less visual. Forms he described were less shape oriented. Thompson (1990) reported that Socrates could not only close his eyes and remember something without actually seeing it but also described his thinking as an image that the mind was simply carrying on a conversation. Socrates utilized both visual imagery and auditory imagery without favoring one over the other.

Scientific investigation into imagery did not begin until the end of the nineteenth century. The first published self-report inquiry into imagery was conducted by Fechner in 1860 (cited in Thompson, 1990), in which he compared mental images with after-images. Thompson also described Galton's 1883 imagery research as the first well-known systematic investigation with a long questionnaire administered to a large number of people. Subjects were asked to imagine specific objects and report clarity and coloring of the image. In 1897, Binet (cited in Piaget and Inhelder, 1971) wrote of his research in the book <u>Psychology of Reasoning</u>, in which he presented the reasoning process as a series of associations between images. The most intensive direct investigation into the function of images was conducted by Betts (cited in Carey, 1915) in the 1910 study, <u>The Mind and Its' Education</u>, in which he investigated voluntary and spontaneous imagery. Perky's (cited in Kosslyn, 1980, 1983) classic study provided evidence that people can sometimes mistake an actual picture of an object for an image. These early psychologists believed memory consisted of images based on one's experiences (Rasinski, 1985).

From 1860 until 1913, the study of mental imagery was a central part of psychology (Klinger, 1981). This pursuit of knowledge was abruptly halted, however, when the Behaviorists concluded that mental events were not valid objects of scientific inquiry. Cooper and Shepard (1973, p. 75) referred to this time as, ". . . the period of behaviorist-induced skepticism."

Research in this area did not resume until the 1960's. Prominent researchers Kosslyn, Paivio, and Piaget were among the first inquirers to conduct imagery studies at the end of the Behaviorist era.

Imagery Theories

Dual Coding Theory

Paivio (1969, 1971) conducted his classic paired associate study that explained the relationship between imagery and language. This dual-coding theory hypothesized that verbal and nonverbal information were processed independently, but were, at the same time, interconnected. Paivio based his findings on neurological and psychological research which revealed that the brain stores at least two different modes: imaginal and verbal. He concluded that imagery allowed the learner to transfer a verbal input into a more concrete imaginal one (Broudy, 1987). Sadoski, Pavio, and Goetz (1991, p. 463) contended that the ". . . dual coding theory suggests that cognition consists of two separate but interconnected mental subsystems, a verbal system and a nonverbal system." Paivio (1969) argued that imagery and comprehension were not identical but were especially related in the case of concrete material.

Developmental Theory

The objective of Piaget and Inhelder's (1971) study was only concerned with imagery and its relationships to the functioning of thought. They considered the study of imagery necessary in order to understand the memory in the child, even though it was not fashionable at that time. He believed the problem of images and their stages of development, if any, were less obvious than that of operations of intelligence. Adults were capable of imagining static objects, movement, and known transformations, like dividing a square into two rectangles. To Piaget and Inhelder it was clear that these imaginal representations were not formed with the same facility in each case. They concluded that there was a hierarchy of image levels which may correspond to stages of development, but which also correspond to degrees of increasing complexity. The Piaget and Inhelder (1971) studies attempted to sort these degrees of complexity into a structural classification.

Piaget and Inhelder (1971) classified images in terms of their content, either visual or auditory, and according to their structure. They classified the structure in two categories. The first was reproductive, which represented an individual's ability to evoke images of objects or events that were already known to that individual. The second structure was anticipatory, which referred to an individual's ability to produce an image and move or transform the image so the individual views the image from a different perspective.

In their research in child psychology, Piaget and Inhelder (1971) found that there was a hierarchy of image levels. Children younger than the age of five did not have the ability to generate and use abstract images without assistance. Rohwer (1970) concluded that these younger children did not have appropriate language capabilities to verbally categorize information and that it was a matter of language development. Children between the ages of five and eight developed imagery but were unable to use it with some materials until they reached the age of 11. However, Piaget and Inhelder (1971) concluded that most older children and adults possess some degree of ability to generate and utilize visual imagery.

Core Theory

Kosslyn (1980, 1983) developed the core theory in an attempt to understand people who claim to "mentally picture" an object and then describe it from different angles (like scanning or rotating). He compared these mental pictures of the information-storing brain to that of the information-storing capacity of a computer. The input conditions and output characteristics of the process determined the sequence of events that took place. He characterized images as transitory data structures in an analog spatial medium, and suggested that quasi-pictorial images were a medium for spatial representation that allowed a person to compose numerous perceptual memories into a common framework. Kosslyn concluded that many sorts of inferences about the relative spatial positions of parts were easily derived from the image representation and were useful as computational aids.

Imagery Tests

While it is acknowledged by experts who study imagery that individuals differ in imagery ability, the problem for all researchers has been to determine how to identify and measure an individual's use of imagery. One major difficulty has been that imagery has been classified in multiple ways by different researchers. Early tests of imagery concentrated on an individual's ability to recognize and reconstruct sense impressions that related to an individual's past experience and, in some cases, to make new creations from these experiences. Rorschach's ink-blot test and Bett's 150-item Mental Imagery Test are probably the best known examples (Sutherland, 1971). Researchers moved from sense impressions to constructions using words. The bulk of research on imagery in this area has been conducted with paired associate tasks pioneered by Paivio (cited in Rohwer, 1970) in which he found that concrete nouns rated higher in their capacity for arousing imagery than did the abstract.

Sutherland (1971) cautioned that much of the information gained from tests on imagery come from an individual's account of their own experiences, which he contended are not always reliable and are difficult to compare with other people's responses. Carey (1915) considered children to be incapable of making introspections with any degree of accuracy. Other researchers questioned whether the subject's response was influenced or inspired by the researcher's suggestions that the subjects describe their images (Eagen, 1989; Rohwer, 1970). Eagen (1989) and Sutherland (1971) raised doubts that imagery tests reflected the way imagery is used in everyday life to solve real life problems.

Imagery and Learning

Mental imagery is a phenomenon most individuals encounter on a daily basis (Kosslyn, 1983). Images are involved in a wide range of mental activities from daydreaming and memorizing facts to solving problems. Precisely what images are, however, is difficult to determine. Kosslyn (1980) defined imagery as the ability to contemplate something in its absence that provides a way to think about it when it is not there.

Piaget and Inhelder (1971) defined imagery as a mental associative response to a word, a verbal or nonverbal stimulus that can be dynamic and variable, rather than being a fixed portrait.

Other researchers of imagery specifically addressed all sensory patterns of imagery that include not only visual and auditory but gustatory (Begg, 1983; Broudy, 1987; Bugelski, 1983; Kosslyn, 1980; McKeller, 1957, Paivio, 1971; Richardson, 1983; Sheikh, 1983). Furthermore, these researchers indicated that an individual's images can be classified by varying degrees of intensity. In many studies they were characterized as strong, intense, sharp, or dull (Bugelski, 1983; Kosslyn, 1983; Nelson, 1990; Piaget and Inhelder, 1971).

For individuals to utilize memory to facilitate knowledge, the person's brain must construct and store information so it can later be recalled to make comparisons or analogies with new receptor activity. Many researchers believe that the images generated by an individual represent a previously perceived experience and are a part of one's memory (Barker, 1987; Bugelski, 1983; Piaget and Inhelder, 1971). Klinger (1981) referred to this organization of the brain as schema:

> A schema is that portion of the entire perceptual cycle which is internal to the perceiver, modifiable by experience, and somehow specific to what is being perceived. The schema surfaces and is changed by that information; it directs movements and exploratory activities that make more information available, by which it is further modified (p. 5).

Bugelski (1983) concluded that schema involves the formation of images. He believed they were derived as a result of language development used in performance tasks. Rohwer (1970) agreed that a child's verbal interpretation increases the capacity to use imagery effectively. The schemata enhances the interpretation and storage of information as it is coded in images.

Paivio (1969) confirmed in his studies that there was a relationship between language and imagery in which images may be thought of as a conditioned sensation for which appropriate words function as conditioned stimuli. Paivio found that imagery plays an important role in the recall of text material. He suggested that individuals use "dual coding" strategies, which use both images (nonverbal system) and words (verbal system) as mediators in learning and memory. The implication that information can best be presented to children in order to increase their own powers of learning is that information should be presented in both verbal and visual formats (Carbo, Dunn, and Dunn, 1986; Rohwer, 1970). In studies conducted by Carbo, Dunn, and Dunn, they extended the list of imagery options that aid in learning to include tactical kinesthetic and olfactory. These researchers stated:

> Learning style is the way that students of every age are affected by their (a) immediate environment, (b) own emotionality, (c) sociological needs, (d) physical characteristics, and (e) psychological inclinations when concentrating and trying to master and remember new or difficult information or skills. Children learn best only when they use their learning style characteristic advantageously; otherwise, they study but often forget what they tried to learn (p. 2).

One clear evidence of educational significance was that of imagery instructions. Imagery as a mnemonic device was established by Paivio (1971). He found on numerous occasions that instructing pupils to use imagery produced improvement in word learning tasks. Pressley (1976) found imagery instructions facilitated recall and helped children remember a story they were reading.

Mathematical Word Problem Characteristics

There is continuing public concern over the many students at all grade levels in the United States who experience difficulty in solving word problems. Often teachers of mathematics at all grade levels are held responsible by the public for the deficiency in students' problem-solving skills (Desforges and Cockburn, 1987). President George Bush reflected this belief in his "Education 2000" budget that targeted mathematics and science education for improvement, with special emphasis placed on re-training teachers (Kantrowitz and Wingert, 1992).

Clearly, there is a problem in mathematics education. The students' abilities to solve mathematical problems presented in word form falls short of the goals set for them by school systems and the public. Teaching students to master the skills needed to solve word problems is a primary goal of all mathematical education. Studies have indicated that children's difficulties in solving word problems stated in the traditional form are not primarily due to lack of computational skills but to their lack of understanding of the problem (DeCorte, Verchaffel, and DeWin, 1985; Desforges and Cockburn, 1987). Sangalli (1991) found that students need to learn to think with mathematics rather than respond to mathematical problems with routine procedures. They need to use mathematics to formulate questions and make sense of the answers.

Because of a heavy reliance on basal mathematics programs by educators, there is a need to analyze word problems in textbooks and the teaching instructions used to teach word problems (Kameenui and Griffin, 1989; Randall, 1981). Wheatley (1991) pointed out that students rarely have opportunities to use imagery in solving these problems because there is an absence of spatial activities in textbooks, and imagery is considered to be nonessential. Many researchers expressed concern that the language used in word problems does not represent the oral language of the students (Earp and Tanner, 1980; Zimmerman, 1989).

Yancey (1981) defined word problems as the independent translation of the words used to describe a problem into an appropriate number of sentences which accurately aid in performing the associated algebra and/or arithmetic involved. Many educators and members of the public consider word problems to be the most difficult area of mathematics for elementary students (Zimmerman, 1989). Responding to this awareness, problem solving has been the primary target for mathematics educational research (Desforges and Cockburn, 1987). The NCTM (1989) Standards stated that the focus of school mathematics must be in problem solving. More current researchers and policy makers still cite the need for continued emphasis in problem solving (Desforges and Cockburn, 1987; Kameenui and Griffin, 1989; Kantrowitz and Wingert, 1992; Langford, 1986).

Some textbook word problem characteristics appear to increase problem solving difficulty for students. DeCorte, Verchaffel, and DeWin (1985) found that word problems were ambiguous because they were too brief and too condensed. Zimmerman (1989) found that word problems contained mathematical vocabulary that was unfamiliar to students and they were not representative of real life problems encountered by the student.

Mathematical Problem Solving and Imagery

When researchers make references to imagery in mathematics, they almost always are referring to visual imagery. Presmeg (1986) broadly defined visual imagery in mathematical terms as ". . . a mental scheme depicting visual or spatial information" (p. 297). The vast majority of research conducted on imagery and mathematics was concerned with spatial imagery that was limited to geometry and visual patterns. Both of these areas are visual in nature and require a different type of visual imagery than the imagery used to solve word problems (Eagan, 1989).

One of the NCTM (1989) Standards set for grades K-4 is to develop spatial sense. Although it addressed geometry, the standard has a broader application that would include word problems:

> Spatial sense is an intuitive feel for one's surroundings and the objects in them. To develop spatial sense, children must have experiences that focus on geometric relationships; the direction, orientation, and perspectives of objects in space; the relative shapes and sizes of figures and objectives (NCTM, 1989, p. 49).

Exercises that ask children to visualize, draw, and compare shapes in various positions help develop a student's spatial sense. Rohwer (1970) contended that when an individual creates a mental image of an object and then manipulates it mentally, it will have significant practical application in one's ability to use mathematics. O'Daffer (1986) suggested that using manipulatives and visual models while learning mathematics would build a collection of mental images that could be recalled when needed in mathematical thinking. These images could provide insight into solving other types of problems.

Wheatley (1991) stated that learning new ideas and solving nonroutine problems are situations in which imagery is an essential useful tool. He found (in a study of sixth-grade pupils who tried to solve a word problem of the length of a fence around a walkway that surrounded a pool) that most did not use visual imagery to solve the problem. Few successfully solved the problem, although they were capable of forming the images needed to solve the problem. Wheatley found that when students were encouraged and given opportunities to form mental images, most of them were capable of doing so, and when encouraged to use imagery, their mathematical power was greatly increased. Broudy (1987) suggested that in modern life the role of imagery may well be crucial to problem solving, and there is a need for more research on the use of imagery to solve word problems.

Forrester (1990) reported that previous studies on estimation have ignored or glossed over the use of images, but research involving primary school children found the children's explanations of their attempts to estimate lengths and distance placed imagery as their primary strategy of solving problems. Related to their imagery strategies were comparisons, counting, and, when the study was replicated with intermediate elementary school children, multiplication.

Researchers concluded that imagery instruction can be helpful to students because it gives meaning to their mathematical activity (Forrester, 1990; Thompson, 1990; Wheatley, 1991). Direct instruction on the formation and use of imagery increases the awareness of mental imagery, in both teacher and students, and can lead to more flexible teaching methods which consider the different ways individuals think and their interaction with mathematical concepts.

In Yancey's (1981) study of fourth grade students, she found that students who received imagery instruction generated more diagrams to represent the inherent structure of mathematics word problems than did those students who did not receive instruction. Tests showed those students who received instruction performed significantly better on word problem skills and had an improved attitude toward mathematics. A child's comprehension and retention of the subject matter is greatly increased as the result of the child being taught to generate elaborations of stories, both verbally and spatially (Linden and Whittrock, 1981; Pressley, 1976).

As the elementary school mathematics curriculum responds to the emphasis placed on problem solving, the use of student's drawings and pictures has increased. These drawings and pictures are a representation of their individual visual images. Teaching and encouraging students to use drawings and pictures in solving problems help students clarify their understanding of mathematical spatial concepts and should be used as a teaching strategy (Yackel and Wheatley, 1990).

As students solve problems through the use of visual imagery, they need to develop a vocabulary that is appropriate to describe those images (Yackel and Wheatley, 1990). Communication plays an important role in helping children make connections among physical, pictorial, symbolic, verbal, and mental representations of mathematical ideas (NCTM, 1989). Describing and explaining promotes communication and clarifies the thinking and understanding of not only the student who is speaking, but the student who is listening as well. Kamii (1984) pointed out that teachers' concerns should be on children's thinking rather than on their writing abilities to solve word problems. Children's verbal explanation of story or word problems reveals the children's natural intuition and logic as to how they solve problems and provide teachers with insight into the student's thinking.

Class discussion provided second grade students with a way to describe their visual images to the teacher and fellow classmates in a study conducted by Yackel and Wheatley (1990). The discussion provided an alternative method of expressing their visual imagery and was expressed in three-dimensional terms. These researchers found the students' abilities improved to elaborate or alter their visual images as they reflected on their classmate's descriptions. When children discuss and solve problems, they are able to connect the language they know with mathematical terms that are new to them and in this way make sense of those problems (NCTM, 1989).

Mathematics and the Literature Connection

The NCTM (1989) Standards stressed the importance of mathematics being connected to everyday experiences that take place both in and out of school. Not only do children need to see the connections between different areas of mathematics like geometry, computation, and problem solving, they also need to see the connections between mathematics and other subjects taught in school. Children's literature provides problem-solving situations that can be integrated with mathematics. When students make these connections it enables them to become aware of the usefulness of mathematics. Without this connection, children will see mathematics as a collection of isolated topics. The NCTM (1989) Standards asserted that children have a better chance of retaining concepts and skills when they are exposed to integrated topics.

In Root-Bernstein's (1987) study of lifelong learners, he found that many creative individuals were successful creators in more than one field of study. Each subject in the study indicated that individuals used the knowledge and discipline of one area of study to create in other fields of study. Solutions to the problems required the utilization of imagery and role playing. The real life problems these individuals dealt with were not neatly categorized as scientific, artistic, political, or otherwise, but were combined. Root-Bernstein concluded that this insight necessitates a reintegration of the curriculum, and that mathematics should be a part of that integration of the curriculum.

Whitin and Wilde (1992) agreed with Kenneth Goodman, a leader in the whole language movement, who cautioned that mathematics instruction needs to move toward a more holistic problem-solving focus if youngsters are to learn to think mathematically and see it in all of their life experiences. Whitin and Wilde suggested that children's literature provides a means to bring mathematics into the integrated whole and make it possible for children to have authentic experiences with math. Children tend to think of mathematics as computation and as an isolated topic, but their literature provides them with a model for problem-solving experiences. Children's literature reflects their everyday experiences and abounds with relevant examples of situations that require thinking and how people solve problems (Brown, 1986; Harsh, 1987; Richardson and Monroe, 1989; Tischler, 1988; Whitin and Wilde, 1991).

Storytelling of Traditional Folktales

While much has been written on the subject of using children's books to present relevant mathematical problem-solving situations to children, the genre of folktales of children's literature in storytelling form has, to date, been omitted as a viable connection with problem solving in mathematics. A review of the literature indicates that traditional storytelling of these folktales could be particularly relevant, since it indicates a strong connection between folktales, storytelling, imagery, and problem solving.

Bettelheim (1976, p. 5) noted: "Nothing in the entire range of children's literature, with rare exception, can enrich and satisfy a child like the folk fairy tale." He contended that these stories enrich the child's life by stimulating her or his imagination, helping to develop intellectually, clarifying the emotions, and suggesting solutions to the child's problems and promoting self-confidence. Bettelheim reported that children, both normal and abnormal, at every level of intelligence, have found folk fairy tales to be more satisfying than all other children's stories. Storytelling of traditional folktales consists of three elements: the story, the storyteller, and the listener. Baker and Greene (1977) described storytelling as a sharing experience in which a common experience is created by enjoying a story together. Storytelling produces a relaxed, restful feeling. It draws people together, establishing a happy experience.

The storyteller works with words. Storytelling is the primary vehicle for maintaining oral literature and is an ancient form (Livo and Rietz, 1986). Unlike the written story, storytelling reflects the everyday language spoken by the people that portrays the culture and community. When the listener hears a story, he creates images and feels emotions that are evoked by the story. Listening to stories introduces children to patterns of language that are characteristic of folktales and extends the child's vocabulary (Baker and Greene, 1977).

Many storytellers report that children produce mental images when they hear a story. As children listen to stories, it is assumed that they visualize the characters, the scenes, and the actions. However, little research has been conducted to confirm this belief that is widely shared by the large number of storytellers who practice and write about the art of storytelling.

The research most relevant to this study was conducted by Nelson (1990) in which she found that fourth graders reported the use of images and connected those images to meaning sources. She categorized the children's images in terms of visual, auditory, texture/tactile, olfactory, gustatory, sense of being, and emotive. Visual and emotive images were reported more than the other images. Visual imagery was characterized by three-dimensional space, particular point of view, sense of color, light, motion, age, time, and character transformations. Nelson found the children were active "meaning makers" who were involved in constructing their own imaginary.

Traditional folktales have characteristics that provide some insight into children's fascination for these stories. Characters are easily recognized by the listener as being either good or bad. The beginning and end of the story is clear. Expectation is created at the beginning, elaborated on in the middle, and is satisfied in the end. Each story is set up from the beginning to solve a conflict or problem. Every action in the story is focused on that central task. Action dominates these stories. The fast-paced action moves the story rapidly from one event to the next (Baker and Greene, 1977; Eagan, 1989; Lukens, 1986). Bettelheim (1976) noted that it is characteristic of traditional folktales to state a dilemma briefly and pointedly. The child comes to grips with the problem in its briefest form, simplifying the situation. Eagan attributed this to the fact that the story has been told for hundreds of years and is honed down to the point to where only the essential details are included.

Eagan (1989) lamented that in education there is little room for our emotional lives. She pointed out that we make sense of the world and our experiences, both affectively and cognitively. How people feel is important and provides the motives for actions. Human emotions and intentions make things meaningful. If those emotions and intentions are cut off, it reduces affective meaning. Folktales provide an avenue for feeling emotions. These stories foster capacity for compassion and humaneness in the listener, enabling the child to feel joy about another being's happiness and experiencing another's fate as his or her own (Baker and Greene, 1977). When stories evoke emotions they enable the listener to recognize significance in his own life (Livo and Rietz, 1986).

Livo and Rietz (1986) provided the National Association for the Preservation and Perpetuation of Storytelling definition of storytelling as:

> . . . an art form through which a storyteller projects mental and emotional images to an audience using the spoken word, including sign languages and gestures, carefully matching story content with audience needs and environment. The story source reflects all literatures and cultures, fiction and nonfiction,

> for educational, recreational, historic, folkloric, entertainment and therapeutic purposes (p. 7).

Conclusion

While there has been extensive research conducted on the many complicated aspects of imagery, the research of imagery as it relates to mathematical problem solving has focused on spatial imagery in geometry and the reproduction of patterns.

This study was primarily concerned with how imagery is used to solve word or story problems. The NCTM (1989) Standards and mathematics educators suggested the use of children's literature to generate mathematic problems that reflect real life situations. Children's books provide a way to integrate mathematics with other subject areas in the curriculum. Numerous storytellers report that listeners of traditional folktales create images to generate meaning from the stories. These stories are reported to be rich in story problem-solving situations. Little research has focused on children's use of imagery to solve work problems, and none exists that focuses on children's use of imagery to solve word problems based on folktales.

CHAPTER III

RESEARCH DESIGN

Introduction

This chapter presents an explanation and description of the research study. It includes the methodology employed, a description of the subjects, data collection procedures, data analyses, and summary.

The purpose of this study was to determine if second grade students use imagery to solve mathematical word problems and, if so, to provide an understanding of how they utilized their images in solving mathematical word problems. As discussed in the review of literature, researchers in mathematics have largely ignored the use of imagery in word problems, limiting most imagery inquiry to spatial imagery used in geometry and reproduction of patterns. This study sought to expand the educator's knowledge that includes imagery as a possible function of children's strategies for solving mathematical word problems.

Thornton and Randall (1993, p. 298) stated: "A holistic view of the nature and power of mathematics can and should be nurtured by emphasizing mathematical connections." The Standards adopted by the NCTM (1989) encourage these connections by integrating mathematics with other areas of studies (such as literature) in order for students to recognize mathematics in all areas of their lives. To study the phenomenon of imagery as a possible strategy in problem-solving situations, this study used mathematical problems taken from a traditional folktale to provide a more holistic approach to the inquiry.

Methodology

The focus of this research was to obtain an understanding of a second grade student's ability to create images and utilize those images in solving mathematical problems. The research was a qualitative study that employed a case study methodology. Gay (1992, p. 235) defined a case study as ". . . an indepth investigation of an individual, group, or institution." Gay explained that the purpose of a case study is to determine the factors that have resulted in a behavior of a subject in the study and to determine why. This study was considered a case study because it examined a group of second grade students and the utilization of their images in an educational setting. Merriam (1988) encouraged educational researchers to use qualitative case study because it is ". . . an ideal design for understanding and interpreting observations of educational phenomena" (p. 2).

The paramount objective in qualitative research was to understand the meaning of the experience from the perspective of the subject of the study (Merriam, 1988). Fetterman (1989) referred to this view as that of the insider's perspective. It resulted in an unfolding of multiple realities with interactions between the students, classroom teacher, and researcher over time. Guba and Lincoln (1981) referred to this as an emergent design which cascades and is never really complete. Erlandson et al. (1993) classified this approach as that of creating reality in which the researcher assumes that each person connected with the research operates within realities he or she has constructed. They cautioned that no two individuals have constructed identical realities. The researcher, too, came to the setting with a constructed reality. As Erlandson et al. pointed out, the challenge for the researcher of this study was to develop an inquiry that developed and verified the many shared constructs in such a way that it provided a meaningful expansion of knowledge.

Guba and Lincoln (1981) asserted that the construction of realities must depend on some form of consensual language. The review of literature on imagery for this study confirmed the importance of language in the study of imagery. Language is the avenue by which a person communicates to the researcher the images of visualization, hearing, feelings, smells, etc. Earlier research (Piaget and Inhelder, 1971; Pressley, 1976) stated that what can be determined about a student's ability to create images is dependent on and limited to the student's ability to verbalize his or her images. This study attempted to expand our understanding of an individual's ability to create images by including drawings by students to detect evidence of images.

Because this area of study is dependent on language development, most previous studies have been conducted with older individuals. While the predominant number of studies have focused on older subjects, there are a few studies that have focused on students as young as seven and eight years old (Piaget and Inhelder, 1971; Pressley, 1976). Again, these researchers cautioned that what they reported was reflected by each subject's ability to verbally communicate that information. Erlandson et al. (1993) referred to the relationship between language and experience as a two-way street. Language is empty without the experience, and experience is meaningless if an individual does not have the language to give the experience meaning. Because the subjects chosen for this study were seven- and eight-year old second grade students, the need for a consensual language was of utmost importance in constructing reality. Guba and Lincoln (1981) cautioned:

> The constructed realities ought to match the tangible entities as closely as possible, not, however, in order to create a derivative or reconstructed single reality, but rather to represent the multiple construction of individuals (p. 84).

Qualitative research methods are adaptable to dealing with the multiple realities that were detected in this study. Lincoln and Guba (1985, p. 40) stated: "Qualitative methods are more sensitive to and adaptable to the many mutually shaping influences and value patterns that may be encountered in a study."

Subjects

This study involved two intact second grade classrooms. Both classrooms had 15 second grade students, consisting of seven females and eight males. Twenty-four of the 30 second grade students received parental consent to participate in the study (Appendix A). Eleven of these students were boys and 13 were girls.

The elementary school is located in a small, rural mid-western town which, according to the 1990 census, has a population of 650. The majority of the parents in this setting have agricultural-related jobs and the remainder of the parents work in surrounding towns within a 25-mile radius. The elementary, junior high, and high school share the same campus; so there is interaction among students of all ages. The student body of the school is composed of approximately 94% Caucasian students, 5% Native American, and 1% Hispanic students. No Afro-American students attend the public school.

The teachers in this study were both Caucasian females. One of the classroom teachers in this study has been teaching for 17 years; the other teacher has been teaching for 21 years. Both of the teachers' experiences have been at the elementary school level. Not only are both teachers experienced, but each one has, throughout her career, continued to take education courses at a nearby university and to attend conferences related to her professional development. Currently, one teacher is completing her degree in Elementary Education Administration and the other teacher has her Master's degree in Curriculum and Instruction. This school and these classes were chosen because the teachers regularly teach mathematics in conjunction with children's literature. The students in these classrooms are familiar and comfortable with problem solving in story format.

Because of my experience in the classroom educational setting and with integrating storytelling in the curriculum, I told the traditional folktales for the study. I am a storyteller and a member of the professional storytelling organizations, "The National Association for the Preservation and Perpetuation of Storytelling" and "Territory Tellers." I have told stories to children in classrooms and in school library media centers for 14 years. I taught second grade students in a contained classroom for three years and served as the library media specialist at the elementary level for seven years. On numerous occasions I have provided presentations to educational professional organizations and conferences on the educational benefits of integrating storytelling with subjects in the curriculum.

Data Collection Procedures

Because an extensive description was needed in order to understand the students' strategies in solving word problems, a qualitative approach to collecting and analyzing the data was used for this study. Unlike most research in this area, this study was not limited to a narrow focus of one or two contributing factors but attempted to discover multiple factors involved in the students' use of strategies in this educational setting.

Federal regulations and Oklahoma State University policy require review and approval of all research studies that involve human subjects before investigators can begin their research. The Oklahoma State University Research Services and the Institutional Review Board (IRB) conduct this review to protect the rights and welfare of human subjects involved in biomedical and behavioral research. In compliance with the aforementioned policy, this study received the proper surveillance, was granted permission to continue, and was assigned the following number: ED-93-051 (Appendix B).

Permission to conduct qualitative research of the second grade students through the use of folktales was requested from the superintendent, the principal, and the participating teacher. Once obtained, letters were sent to parents of the subjects requesting permission for their children to participate in the study. Parents were informed of the nature of the study and information that would be sought from their children. The subjects of this study were advised of the intent of the study and their agreement to participate in the research was requested. The subjects were advised that they were free to decline to participate or withdraw from the research at any time (Appendix C). Data were collected through observation, interviews, and documents. These different types of data collection procedures were employed to insure that all the subject's different opinions, interpretation of the story, and problem-solving strategies were sought out and represented in the study.

Observation

A major form of data collection for the study was observation. The period of observation covered two months, beginning in April and ending in May. As a participant observer, it was possible to record behavior as it was happening. Classroom observations were recorded in the form of journal entries made each time the classroom was visited. Merriam (1988) pointed out that the participant observer is able to see things firsthand and to use his or her own knowledge and expertise in interpreting what is observed.

On four different occasions I observed the second grade classroom, to become familiar with the teacher, students, classroom, and school facility. These observations enabled me to discover the classroom teachers' questioning techniques and student responses to solving mathematical word problems that come from children's literature.

Because I am a storyteller and have told traditional folktales to elementary school children on many occasions and in many varied settings, I told the stories for this study. This provided me with the unique opportunity to closely observe the responses of the students as they listened to the stories. My experiences in this area allowed me to make adjustments in the storytelling based on the students' reactions. It is a common practice for storytellers to make adaptation in the stories based on the audience's reactions to the story. My 14 years of experience as a storyteller aided in recognizing their responses.

I made two additional visits to the classroom to tell traditional folktales to the children and to observe their reactions. The first story was: "The Nanny Goat and the Seven Little Kids." The second story was: "The Three Billy Goats Gruff." Nelson (1990) referred to these visits as "warm-up" storytelling visits to acquaint the children with the format of storytelling and to enable them and the storyteller to become familiar with each other. It also provided me with an opportunity to consider and experiment with open-ended interview questions.

After the student discussed the story, the interviewer posed mathematical word problems based on the folktale (Appendix D). Emphasis was placed on the process of solving the problem, not on the correct answer. The basic question that guided the children's discussion was: "How did you solve the problem?" Both classroom teachers agreed with the NCTM (1989) Standards that mathematical communications help children to clarify their thinking and sharpen their understanding. Ample time was allowed for each student to discuss the story and solve the problem.

Interviews

In qualitative research, interviews are used as a major source of collecting data. Interviewing is necessary when the researcher cannot observe feelings, thoughts, or interpretation of the subject (Merriam, 1988). Because the study of an individual's ability to produce and utilize images cannot be directly observed, research in this area was largely dependent on the subject to verbally communicate that information to the researcher. Interviews allowed the researcher to penetrate into the subject's viewpoint (Merriam, 1988).

Interviews enabled the researcher and respondent to move back and forth in time (Lincoln and Guba, 1985). This is a necessary element in research when we are interested in past events that are impossible to replicate (Merriam, 1988) or to interpret the present and predict the future (Lincoln and Guba, 1985). Fetterman (1989) asserted that interviews are ethnography's single most significant data-gathering technique because they put into the larger context what the researcher observes and experiences.

Semistructured interviews, guided by a set of basic questions, were employed for this study (Appendix E). Neither the exact wording nor the order of the questions were predetermined (Merriam, 1988). Data were obtained through interviews with the students and the classroom teachers. The interviews were conducted using an individual format that included the informant and the interviewer on a one-to-one basis. Merriam referred to this type of interview as a conversation with a purpose. Although the interviewer directed the conversation to obtain the special kind of information needed for this study, the direction, focus, and topic of discussion were all determined by the children's responses (Nelson, 1990). The interviewer used probing questions, based on the children's responses, in order to obtain detailed information of the children's images and usage of their images. Adequate time was allowed for all children to respond to the questions.

My third and final visit to the classroom was to tell the folktale "Fat Cat" (Appendix F), which took approximately seven minutes to tell. This story provided the context for the study. After the students listened to the story, each student was asked to draw a picture of "Fat Cat" and a scene from the story. While the class drew pictures, the classroom teacher and I interviewed each child on an individual basis. We alternated roles of interviewer and observer. While one interviewed the student, the other observed and took notes of the student's responses to the story. While the study did not specify that the interviewer adhere to a list of specific questions to guide the interview, a list of suggested questions to detect the creation of images was provided. The students were asked to describe characters and scenes from the story and to discuss any images they had as they listened to the story.

As the interview was being conducted with the student, the classroom teachers and I continually asked each student to check our interpretations and notes of their responses to the interview questions. This was done to confirm or clarify our interpretation of their responses and observed behavior to determine accuracy. At the end of the interview, we summarized our understanding to the child to verify the data.

Documents

Each student was asked to draw a picture of "Fat Cat" and a scene from the story. The drawings were analyzed in terms of the scene chosen and details that were included and omitted. The pictures of "Fat Cat" served as the data analyzed for the spatial portion of the mathematical problem-solving analyses.

In addition to observations, notes taken for journal entries, semistructured-structured interviews, and other documents were examined. These documents included the classroom mathematics textbook; the teacher's planning book; and resources used on integrated units of study, bulletin boards, and displays of students' products, notes, and writings by the classroom teacher on the integration of mathematics and literature; and the children's drawings in response to hearing the story of "Fat Cat."

Data Analyses

Erlandson et al. (1993) contended that the researcher is the most significant instrument for collecting data and for analyzing that data, because the researcher can collect and analyze in an interactive process. Researchers have pointed out that analyses of qualitative data was a progression and was continuous (Erlandson et al., 1993; Guba and Lincoln, 1985; Merriam, 1988). It takes place as the collection of data is being conducted. In a naturalistic study, data collection and data analyses involve an inseparable relationship and is a major feature that Erlandson et al. contended cannot be overemphasized.

Marshall and Rossman (1989) explained data analyses as the process of bringing order, structure, and meaning to the mass of collected data. It enables the researcher to make sense out of the data when it is consolidated, reduced, and interpreted to establish relationships and patterns (Merriam, 1988).

Erlandson et al. (1993) stressed the importance of the use of triangulation in data analyses because it enables the researcher to check the statements of individuals against the observed behavior and various records and documents.

Data were analyzed using triangulation techniques. Erlandson et al. (1993) defined triangulation:

> Perhaps the best way to elicit the various and divergent constructions of reality which exist within the context of a study is to collect information about different events and relationships from different points of view (p. 35).

Through the use of triangulation the commonalities and differences reported by the subjects of this study were verified. These different methods and perspectives were compared to each other in order to cross-check data and interpretations (Guba and Lincoln, 1981) as the data was analyzed in relation to the research questions in Chapter I.

In this study, the data were analyzed according to the suggestions provided by Lincoln and Guba (1985) to construct reality in qualitative research. All of the units of data, which included the journal entries of the observations, interview responses of the subjects, and documents, were recorded on 3 x 5 cards with separate pieces of information written on each card. Inductive analysis was used to sort the data into categories based on their commonalities. Category labels were assigned to each card to distinguish categories. Occasionally, a single unit of information was categorized in more than one category. All cards that had the same category label were placed in one group and were analyzed to determine what images the students created in response to the stories they heard, and their explanation of how they used imagery in solving mathematical word problems. Patterns and relationships of the students' reported images and their usage of images were identified based on the analyses of data from the different sources. The process enabled me to analyze the data from specific pieces of information to general statements about the phenomena. The process was repeated three times to enable the researcher to focus the content of each category. Conclusions were drawn from the analysis and triangulation of the data. After the report of the study was written, the classroom teachers read the paper to corroborate the findings.

Summary

Previous research indicated that students of all ages have the greatest difficulty in mathematics with solving mathematical word problems. While the research has focused on many possible single causes for this dilemma, no other research has examined the problem from a holistic point of view that includes imagery as a possible strategy for solving word problems. The use of qualitative research provided an extensive description that enabled this study to add to the body of knowledge that deals with solving word problems. A qualitative study allows and invites the reader to take an active role as it puts the reader vicariously into the context and allows him or her to interact with the data present (Erlandson et al., 1993). This study sought to collect an extensive description using the naturalistic approach and presented a holistic approach to the study of the phenomena that would be of interest and benefit to educators.

CHAPTER IV

RESULTS OF THE STUDY

Introduction

This chapter describes second grade students' responses to listening to a traditional folktale and solving mathematical word problems based on the story. The study was designed to explore the images reported by seven- and eight-year-old second grade students and to determine what role their images played in deciding how to solve the problems. Once the child determined how to solve the problem, this study examined the usage of the students' images to solve the problems.

For the purpose of this study, imagery was defined as the ability to recall or contemplate something in its absence that enables the individual to think about it when it is not there (Kosslyn, 1983). Data confirmed earlier findings by Klinger (1981), Kosslyn (1980), and Thompson (1990) on imagery research that the imagery ability of individuals differs greatly. The responses of the children indicating their ability to generate images varied greatly among the subjects. Some students reported no images: "I don't know what Fat Cat was like." "I can't describe it." Other students indicated the ability to create images with the following statements: "I just saw it in my head." "I used my imagination." "I watched it in my head." "I closed my eyes and I could see it." "I pictured it in the air."

Images reported by the students were complex and represented many types of imagery. Table I illustrates the categories of images reported by the students, the number of times the type of image was reported, and the number of students who reported images in their oral responses and an explanation of their illustrations of the story. These results indicated that most, but not all, second grade students were able to generate images and that these images were varied and complex. Of the 24 students who participated in the study, 3 students reported no imagery, and 21 reported some type of imagery.

TABLE I

CATEGORIES AND NUMBER OF IMAGES REPORTED
(n=24)

Category of Image Reported	Number of Images Reported	Number of Students Reporting Image
Visual	70	21
Auditory	23	16
Olfactory	13	12
Gustatory	1	1
Tactile/Texture	10	10
Emotional	28	20

Children's Images Reported

Categories of the reported images were generated from the data. Specific language and description by the student had to precisely indicate the category to which the data would be categorized. The categories were created by examining the students' reported images for patterns and relationships of images. Table II (page 41) indicates the different categories of images in this study.

Visual Images

The majority of images reported by the second grade students were visual images. Of the 145 images identified, 70 were categorized as visual. The students reported images throughout the story, from the beginning to the end.

Visual images of the physical description of characters in the story were reported in the following details:

> The old lady had gray hair and was sort of fat and wore old slippers.
>
> The wood chopper had coveralls on and rubber boots and an old hat on. He was very fat.
>
> Fat Cat was big and fat, about one yard long. He was blackish brown, real ugly. He wasn't a very nice cat because he ate everyone. He was gross, slimy, mean, ugly, covered black with oily stuff. He's mean and ugly.

Children provided details of scenes from the story that were not addressed during the telling of the story:

> I was thinking the red jay birds would be in, you know, one of those sinks you keep outside with water in it. One of those--- [Interviewer: 'Birdbaths?']. Yes, that's it. They would eat crumbs out of it. The cat came walking down the street and they tried to fly but he ate them. They would have baby birds in the eggs in their nest. [Interviewer: 'How do you know that?'] I watched it in my head.
>
> I could see the cat walking down the path. It was just plain dirt.

TABLE II

CATEGORIES OF IMAGES REPORTED

Category	Characteristic of the Image	Example
Visual	Images with a sense of sight.	"I used my imagination to picture how he moved around."
		"I watched it in my head."
		"I could just see them."
		"It's like your dream. If I close my eyes, I can see people I don't even know."
Auditory	Images with a sense of hearing.	"I listened real good and can kind of hear it in my mind."
		"The ax made a 'sss' sound when he chopped wood."
		"The birds would go 'peep, peep, peep.'"
Olfactory	Images with a sense of smell.	"When the old woman cooked the gruel, I could smell the smoke from the wood fire."
		"The seven dancing girls would smell good because they had perfume on."
Gustatory	Images with a sense of taste.	"It [gruel] would taste like soup made with onions, tomatoes, cheese, and crackers."
Tactile/ Texture	Images with a sense of touch.	"If you touched his [Fat Cat's] stomach, you could feel hands and feet of people inside."
		"He [Fat Cat] would feel hard when you touched his stomach."
		"It was made of silk and had velvet hearts on the dress."

TABLE II (Continued)

Category	Characteristic of the Image	Example
Emotive	Emotional responses related to personal feelings and imagined	"When he ate those people, I was scared."
	Feelings of characters in the story.	"I kind of cringed when he ate them up."
		"It is a sad story because the woodcutter cut open the cat. I love cats."
		"The little girls screamed at him because they didn't understand or when they got scared."

Children included descriptions of activities of the character in the story:

> The girls were dancing to songs. They had a radio, like, you know, like sort or rock and roll that comes from that [named the city] station. They were skipping and dancing.
>
> The old man [parson] would go like with his crooked . . . ., with his crippled . . . ., whatever it was [staff]. [Gestures indicated he guarded his face with his face with his staff.] He would get scared because the cat would get bigger. The preacher would close his eyes when the cat started to eat him. He was trying to run, but he got too scared and fell to the ground.

Visual images reported were complex and had different attributes. More than one of these attributes were used to establish subcategories of visual images. The subcategories included: color, motion, three-dimensional space, and size.

Sense of Color

Student responses indicated a sense of color. Objects and characters were described in a wide and varied array of colors. Color was reported 28 times by 20 students. Table III indicates the colors children reported.

TABLE III

SENSE OF COLOR

Subcategory of Visual Images	Descriptive Nature of Subcategory	Example
Sense of Color	Indicates brilliance, shade, or hue of an object.	"Fat Cat was black and orange."

Fat Cat was described in multiple colors and patterns of color:

He was orange.

Fat Cat was black and white and a little orange.

Fat Cat was gray and black with white feet.

Fat Cat was black and orange.

He was fat with black and orange stripes.

The cat was striped, like Garfield, black.

Fat Cat was beige with orange stripes, just like my cat.

He was black and big, big, big.

He had little black stripes.

He was brown.

The cat was gray.

He had black and white stripes.

He was sort of goldish color, with dark brown--a Siamese! That's what he was!

Students described the clothing of the characters using many colors and rich detail:

My favorite character was the girl with pink because pink is my favorite color, and I think it's pretty. She had a pink dress on and a pink purse. It's real pretty. She has tights on.

The lady with the pink parasol had a pink dress on with silk on the bottom and velvet hearts on the dress.

The girls would have blue dresses on with purple shirts and yellow stripes. They have blond hair.

The lady cooking would have a white apron on with a turquoise dress with purple stripes and a little flower right here [gestures to the center of her neck] and some red ruffles on her arms. Her hair would be brown.

The seven girls dancing were pretty. They had pink dresses with ruffles on the bottom and a pink bow in their hair.

The little old lady has gray hair, a bonnet, and a blue dress.

He had on gray pants and just stood there.

The woodcutter wore bib overalls with a red shirt.

The woodcutter had on a flannel shirt. It was red and black, blank pants, and a big brown hat.

Although the birds in the story were not identified, some students described the birds in terms of color:

The birds were blue jays.

The birds were red jay birds.

That's what I saw: black crows.

Objects in the story were also described in color:

The woodcutter had an ax. At the top it was silver and red like my Dad's ax.

In the drawings, several students colored the ax gray with a red tip.

The pot was black and big.

In summary, the students described the character, clothing, and objects in terms of color. The children's responses strongly indicated that color was evident in their visual images.

Sense of Motion

Students' reports of visual images indicated that they "saw" the scenes and characters in action or movement. Students often used gestures to communicate movement. Motion was reported 20 times by 19 children. Table IV indicates movement reported by the children.

TABLE IV

SENSE OF MOTION

Subcategory of Visual Images	Descriptive Nature of Subcategory	Example
Sense of Motion	Indicates something that changes place	"Birds moved in a shaky way." "I could see the smoke going up in the air."

Students reported that they saw the characters in the story in motion:

He [the parson] was trying to run, but he got scared and fell to the ground. [Interviewer: 'What made you think that happened?'] You know, it's like in the movies.

They [the birds] flew away into a tree and the cat sneaked up on them and ate them. [Interviewer: 'How do you know that?'] I watched it in my head.

He [Fat Cat] was licking himself.

Girls were singing. Other people were around them, and they were playing instruments.

I could see Fat Cat walking down the road.

The birds were flying around, and those five birds were pecking seeds.

When the girls were dancing; some stopped and were still. Others were dancing and playing because some saw Fat Cat before others did.

The girls were skipping and dancing.

The birds went up and down, pecking.

They [the birds] moved like in a cartoon, but they didn't talk.

He [Fat Cat] was funny when he walked. He wobbled.

Some descriptions of movement by the students indicated a definite rate or pace of movement:

The little old lady moved slow.

The preacher was a steady, slow walker.

Fat Cat couldn't walk fast because his fat stomach would wiggle.

When the cat walked, he walked slow because he was so fat. I can see it in my mind; all of them moved.

The birds had their heads go up and down when they ate and moved to another spot.

Students used body gestures to communicate motion, direction, and pace of action:

> The birds went up and down, pecking. [The student used his head to imitate the birds bobbing their heads up and down.]
>
> I could see the old woman stirring the gruel in the pot and hear the spoon scraping the edges of the pot. [The student used her hand and moved in a circular motion to indicate the old woman's movements.]
>
> The woodcutter cup open the cat like this. [The student's hand gestures moved in a downward motion, indicating the woodcutter cut the cat's stomach open in a vertical cut.]

In summary, these examples of movement reported by the students indicated that their visual images were not stationary like an illustration in a book, but moved from one space to another space and at a definite rate of speed. As one child reported, when asked to explain why she thought the characters moved the way she reported: "They moved like in real life." Gestures aided the child in communicating movement.

Three-Dimensional Space

Some of the images reported by the students indicated a sense of three-dimension space. The children described how characters interacted with each other and with objects in the story that indicated dimension. Words like "around," "up," "away," "down," "bumps," "on," and "in and out" suggested depth, volume, and varying distances. Three-dimensional space was reported 11 times by 9 children. Table V (p. 48) indicates three-dimensional space reported by the children.

Characters were seen as moving in their environment and interacting with objects in the scenes that were described:

> When the birds were eating, they'd put their beaks down to pick up the food and would hop around to get some more.
>
> The birds were flying around.
>
> The old woman could smell the smoke because it went up in the air.

TABLE V

SENSE OF THREE-DIMENSIONAL SPACE

Subcategory of Visual Images	Descriptive Nature of Subcategory	Example
Three-Dimensional	Refers to the sense of depth and distance.	"I can see him sneaking up on them [girls]." "I could see the smoke going up in the air."

I could see the ax coming down when the hunter cut open the cat.

The cat walked down the road.

His [Fat Cat's] stomach would be lumpy and have bumps and stuff with all of those people in there.

His [Fat Cat's] stomach would have ruffles on it.

The cooking lady would have some red ruffles [in and out hand gestures indicating large ruffles] on her dress.

The lady with the pink parasol had a pink dress on with silk on the bottom and velvet hearts on the dress. It is made of silk and has dollies on it.

I could see the old woman stirring gruel in the pot and hear the spoon scraping the edges of the pot.

In summary, the student's responses indicated that their visual images are viewed in three-dimensional space that includes depth and boundaries. They reported that the characters moved around in these spaces, interacting with each other and with objects in the scenes.

Physical Size

Some of the images reported by the students indicated a sense of specific size and shape. The children described characters and objects in terms of "big," "little," "small," and "long." Some students included specific estimations of sizes. The children made use of similes to compare the size of character to objects with which they were familiar. Physical size was reported 11 times by 7 children. Table VI indicates a sense of size reported by the children.

TABLE VI

SENSE OF SIZE

Subcategory of Visual Images	Descriptive Nature of Subcategory	Example
Three-Dimensional	Refers to the sense of size and shape.	"Fat Cat was very big and fat!" "He was real, real skinny at the beginning."

Students described Fat Cat by his size:

Fat Cat was big and fat. He would feel lumpy because he ate the pot.

Fat Cat was a big, old, fat cat. He looked like a big glob walking.

He was real fat and weird looking, with his huge stomach.

He is very fat. He is black and big, big, big!

He had big eyes, a little nose, big ears, and really long whiskers.

The students' description of Fat Cat indicated that they imagined the character in different sizes in different parts of the story:

> At first he was little, then he got bigger.
>
> At first he was skinny, then he was great big at the end.
>
> He was real, real skinny at the beginning. He would be hard at the end because his stomach would be full after he ate all those people.

Some students indicated they used familiar objects or animals to compare and describe characters in the story:

> Fat Cat was beige with orange stripes, just like my cat.
>
> I saw my cat.
>
> Fat Cat was like an elephant.
>
> He [Fat Cat] looked like Garfield.
>
> Fat Cat looked like a cat on the Bart Simpson show. I watched a show and that cat gets fatter.
>
> When she cooked the porridge or oatmeal, it made the kitchen smell like misty in the kitchen, the steam, like when my Dad cooks.

Three students described the size of the character in estimated lengths. Each child who reported the length also used hand gestures to indicate his or her estimate:

> Fat Cat was big and fat, about one yard long.
>
> Fat Cat was about three feet tall.
>
> Linconlot was about five feet tall, with brown eyes and hair.

In summary, the students described their images of the character and objects in the story in definite size and shapes. These sizes and shapes changed when the story indicated a change was needed. Students used hand gestures to communicate size. Comparing the unknown characters and objects with those known to the student aided them in describing sizes and shapes.

Summary

The students' account of visual images generated from the story were subcategorized by color, movement, three-dimensional space, and size. The subcategories of visual images reported by the students in the study indicated that the visual images were many, complex, and different for each listener. Characters and objects familiar to the students influenced their visual imagery of characters, objects, and scenes in the story. Descriptions of characters and objects from the story provided the vast majority of reported visual images. Students used body gestures to communicate their visual images. The numerous visual images reported by the students supported the contention that seven- and eight-year-old students create visual images in response to listening to a story.

Auditory Images

Of the 145 images identified in this study, 23 were auditory. Eight of the students in the study reported no auditory images. The remaining 16 students' responses indicated that they heard sounds and conversations between the characters as they listened to the story. The following responses are examples of background noises children stated they "heard" in the story:

> The ax made a 'sss' sound when he was chopping wood.
>
> I could see the old woman stirring the gruel in the pot and hear the spoon scraping the edges of the pot.
>
> When the oatmeal was boiling, it went: 'glug, glug, glug, glug.'
>
> I could hear the birds real soft, like peeps.
>
> The birds crowed at him [Fat Cat].

Some students told of conversations they "heard" between the characters in the story:

> I could hear them talking. Fat Cat told him he was going to eat them and I could imagine the people saying, 'Don't eat us!' But he ate them anyway.
>
> The Fat Cat said: 'I'm going to eat you!' I can still hear Mrs. Wolfe saying that.
>
> When the cat goes up to the seven girls dancing, I can see him going up to them and stuff like that and hear them say: 'What have you been eating, my little cat? You are so fat.'

Two students provided examples of an imagined conversation that Fat Cat had with himself:

> I think the cat said to himself: 'I'm still hungry!'
>
> The girls, before they were eaten, started to scream, and I think the cat said: 'Lunch time!'

Music in the story was mentioned by several students:

> The dancing girls had a record player that they were dancing to.
>
> Girls were singing. Other people were around them, and they were playing instruments.
>
> When the girls were dancing, they had music to dance to.
>
> The girls were dancing to songs. They had a radio like, you know, like sort of rock and roll that comes from that [named the city] station. They were skipping and dancing.

In summary, there was a wide range of reports by students regarding auditory images. One student's account of auditory images was: "They moved like in a cartoon, but they didn't talk." The following statement illustrates how another student experienced the story quite differently: "There were lots of sounds. Everything had sounds." Of those students who reported auditory images, there are indications that they "heard" specific sounds that corresponded to specific parts of the story. This suggests that for these students there is a direct connection between auditory images and visual images. Paivio (1969, 1971) referred to this connection as "dual coding."

Olfactory Images

Images related to the sense of smell are referred to as olfactory images. Twelve of the students in the study reported no olfactory images. Twelve students' responses indicated images that were classified as olfactory images. Examples of this type of imagery are as follows:

> The gruel smelled like stew, but I could see the smoke going up in the air.
>
> I could smell the stew.
>
> The gruel smells bad; the stuff stinks.
>
> When the old woman cooked the gruel, I could smell the smoke from the wood fire.

Several students used olfactory images to characterize some of the individuals in the story:

> The cat did not smell good because he was a dirty cat.
>
> The cat smelled bad, like oil and smog.
>
> He [Fat Cat] digs in the dirt and plays in trash cans.
>
> That's what that cat does and would smell like it.
>
> The girls, seven dancing girls, would smell good because they had perfume on.

In summary, most olfactory images reported were in response to the cooking food and smoke from the fire. The word "gruel" was not familiar to the majority of the students, and they used their imaginations and food that was familiar to them to bring meaning to the word. Olfactory images were also used to explain the personality and type of character described in the story.

Gustatory Images

Gustatory images refer to those images related to the sense of taste. The vast majority of the students did not generate gustatory images in response to listening to this story. Only one child provided an example of this type of image: "It [gruel] would smell like the soup. It would taste like a soup made with onions, tomatoes, cheese, and crackers."

Tactile/Texture Images

Tactile or texture images refer to the sense of touch. Of the 145 images identified in this study, 10 were categorized as tactile or texture images. Fourteen of the students in the study reported no tactile or texture images. The remaining 10 students' responses indicated a sense of touch, with references to fabrics, structure, and exterior surface of objects. The following responses are examples of tactile or texture images children reported in describing Fat Cat:

Fat Cat was soft and furry.

He has short hair and it would feel like silk or velvet.

Fat Cat was full, round, and soft.

He was gross, slimy, mean, ugly, covered black with oily stuff.

His stomach would feel wiggly like jelly.

He would feel bumpy and lumpy with all those people inside his stomach.

If you touched his stomach, it would be hard, and hard to push down on because he had lots of people in him.

His stomach would have ripples in it. He wouldn't feel smooth.

If you touched his stomach, you could feel the hands and feet of the people inside.

Students also described clothing in terms of fabric:

> The lady with the pink parasol had a pink dress on with silk on the bottom and velvet hearts on the dress. It is made of silk and has dollies on it.

> The woodcutter had on a flannel shirt. It was red and black, black pants and a big brown hat.

One child described the surface of the road: "I could see the cat walking down the path. It was just plain dirt."

In summary, some of the students generated tactile and/or texture images in response to listening to the story. Most of the images reported in this category were in conjunction with their visual imagery description of Fat Cat.

Emotive Images

Of the 145 images identified in the study, 28 were emotive images. Four of the students reported no emotive images, and the remaining 20 students discussed emotive images. Emotive images are the emotional responses related to personal feelings and imagined feelings of characters in the story. The emotive images reported by the students covered a wide range of feelings that included: happy, glad, funny, silly, wonder, scared, confusion, sad, excited, and afraid. The following student comments are examples of the students' personal feelings while listening to the story:

> It scared me when he ate the first little boy, because I didn't know Mrs. Wolfe was going to do that [eating sound].

> I felt scared [giggled] and then I jumped. Every time Mrs. Wolfe said, 'I'm going to eat you,' and he [Fat Cat] ate them, I kind of cringed.

> The story sort of scared me because when Mrs. Wolfe went grrr--- [eating sound], I wasn't expecting it. I was afraid of when he would eat the next person.

> I was a little bit scared while listening to the story. I was anxious because I didn't know what he was going to eat next.

The story made me feel jumpy and excited.

I would not want to meet him [Fat Cat]. It was a sad story because the woodcutter cut open the cat. I love cats. I have six cats.

The story made me sad, because when the cat ate all the people it made me sad.

It made me happy. It was funny when he got fatter.

When the wood chopper chopped the cat open, it made me glad because all the people were freed.

I liked the story. It was good. I kept wondering if somebody was going to get killed.

I wondered what was going to happen next after he ate the lady and everything else. There was a great big pot in there.

I especially liked the last part. It made me happy when all of the people got to come out of the cat's stomach.

Some identified feelings of the characters in the story:

The preacher would close his eyes when the cat started to eat him. He was trying to run, but he got too scared and fell to the ground.

The little girls probably screamed at him because they don't understand or when they get scared.

When he ate the old woman, she was real scared inside.

The girls danced around and were having some fun tap dancing and also some regular dancing, like dancing to some country music.

Fat Cat would feel grumpy with all that food in his stomach.

I liked them [seven girls dancing] because they were calm. They weren't running around. They were nice.

I think the cat said to himself: 'I'm still hungry!'

One child compared Fat Cat to the wolf in the story, "The Nanny Goat and the Seven Little Kids":

This story was like 'The Nanny Goat and the Seven Little Kids.' The cat was like the wolf. He was hairy, fat, and ugly. He'd claw the daylights out of you! Why do you think he ate all of those people?

Students indicated a sense of emotional identification with characters in the story. Table VII indicates the students' responses to the question: Which of the characters would you like to be if you were a character in the story?

TABLE VII

CHARACTER IDENTIFICATION

Character From Fat Cat	Boys	Girls
Woodcutter	7	1
Fat Cat	4	1
Dancing Girl	0	5
Lady with the pink parasol	0	4
Birds in a flock	0	1
Old lady	0	1

When asked why they chose that particular character, the following explanations were typical:

> I would like to be one of the dancing girls, because I like to dance. They were real pretty.
>
> It would be fun to be one of the birds because then I could fly.
>
> I would like to be the woodcutter in the story and save the day.
>
> Fat Cat, because he is tough and mean.

The boys and girls had strikingly different responses to this question. The boys not only identified with the male characters in the story, but they also identified with the personality and characteristics of the chosen character. The boys wanted to be the hero of the story or to be tough like Fat Cat.

In contrast, only one girl chose to be the woodcutter because she wanted to be the hero of the story. The one girl who wanted to be the cat selected him because she loves cats, not because of the personality of Fat Cat. One girl chose the old woman because she thought the old woman was funny, and she liked to talk like an old lady. One girl chose the bird because she would like to be able to fly. Nine of the girls chose either the dancing girl or the lady with the pink parasol because of their feminine qualities. Some of their descriptions included:

They were pretty.

They were calm.

They were nice.

They smelled like perfume.

They wore fancy clothes.

The children's explanation of why they would like to be a chosen character in the study indicated a strong identification with traditional sex role models for each gender.

In summary, the children's responses of emotive images indicated an interaction with their feelings and the story as they listened to it. Each child expressed a feeling in direct response to his or her description of a scene that took place in the story. Gestures such as eyes getting bigger, shrinking back, and laughter further supported the contention that children do emotionally interact with a story and that emotive images contribute to their personal interpretation of the story. The children's explanations of their reactions and the behavior of character in the story suggested that the listeners lived through the experiences via emotive images. The data further suggested that these experiences aided the students in understanding their own emotions as well as those of the characters in the story. By identifying feelings, students also suggested motives for the behavior, as was illustrated by the student who commented: "He'd claw the daylights out of you! Why do you think he ate all of those people?"

The children's responses indicated that they did identify with characters in the story, not only by gender but by personality traits as well. These identifications indicated a strong reinforcement of traditional sex role models for each gender.

Responses also indicated that the children experienced compassion. One little girl stated that she was sad because the cat was killed. She explained: "I am a cat lover." The same scene was viewed differently by another student, who commented: "I especially liked the last part. It made me happy when all of the people got to come out of the cat's stomach." These responses indicated that the listeners' emotions affected the meaning drawn from the story and that it was different for each listener of the story.

Image Summary

The children's reports indicated that most, but not all, of the students did generate images and that the images were many, complex, and different for each listener. Visual images were the most numerous images reported and provided rich, descriptive details of the characters, objects, and scenes. The students' accounts of visual images generated from the story were subcategorized by color, movement, three-dimensional space, and size. The visual images reported by the students in the study indicated that the characters and objects familiar to them influenced their visual imagery of characters, objects, and scenes in the story.

Other images children reported included auditory, olfactory, gustatory, tactile/texture, and emotive. Of those students who reported auditory images, there are indications that they "heard" specific sounds that corresponded to specific scenes in the story, which suggested dual coding. Olfactory images were used to explain odors and the personalities of characters in the story. The vast majority of students did not report gustatory images. Tactile/texture images were reported to describe textures and compositions of characters and objects in the story. Not only did the students report their emotional responses to the story, they also speculated on the feelings of the characters in this story. There is also a strong indication that the students utilized emotive images to identify with characters in the story based on gender and traditional sex roles.

The numerous images reported by the students supported the contention that seven- and eight-year-old students create images in response to listening to a story.

Solving Mathematical Word Problems

The mathematical word problems taken from the story of "Fat Cat" included the following mathematical operations: estimation, addition, more than and less than concept, subtraction, and a spatial problem. Three mathematical word problems were posed to the students.

Addition Word Problem

The first problem asked the students to estimate how many characters Fat Cat ate. The interpretation of characters varied with the students.

Some included not only the animal and people in the story, but objects like the pot and gruel, the parasol, and the crooked staff which Fat Cat ate also. Table VIII lists the estimates of the children.

TABLE VIII

ESTIMATIONS

Estimated Number of Characters Fat Cat Ate	Number of Students Who Estimated That Number
7	1
8	3
9	1
9 or 10	2
10	1
12	2
14	2
15	3
17	1
19	3
20	3
25	1
28	1

Students were asked how they could check their estimate to determine how close it was to the number of characters Fat Cat ate. Table IX (p. 62) indicates the students' choices of algorithm to solve the problem.

Although 21 of the 24 students stated that they would add the characters, their strategies for carrying out the algorithm varied greatly. Many of the students used more than one strategy to solve the problem.

Table X (p. 63) indicates the different strategies employed by the students to add the characters Fat Cat ate in the story.

TABLE IX

ALGORITHM CHOICE FOR PROBLEM NUMBER ONE

Problem	Add or Count Them	Did Not Know
How would you check your estimate?	21	3

The dominant strategy applied by the students to add the characters Fat Cat ate was to use their fingers. Although the teachers in these classrooms encourage the students to use their fingers for calculation, some students kept their hands in their laps or below the table as they added. Others placed their hands on the table and demonstrated how they added on their fingers. One girl explained: "Fingers help me count a lot." In contrast, another girl was proud that she did not use her fingers: "I never use my fingers. I just know how to add."

Several students asked for pencil and paper. One student used tally marks to add the character. All other students who requested paper wrote numerical numbers on the paper and added them. Most all of these numbers were written in a vertical line. Only two students wrote the numbers in a horizontal line.

TABLE X

STRATEGIES FOR ADDING

Type of Strategy Used	Number of Students Who Used the Strategy
Count and added, using fingers	14
Added the largest numbers first and then the smaller numbers	6
Requested paper and pencil to write numbers on paper	5
Named the characters in order	4
Added to the previous total as they named them	3
Requested that the story be told to them again and they would add as they listened	2
By gender and then added birds	2
Added part of the characters, held that number in memory, added the rest of the characters and added that number to the number in memory	2
Counted under their breath and nodded head	1
Tally marks	1
Changed the number (8 to a 7, then added that 7 to 7 more equals 14, then added the 1 back on)	1
Calculators	0

Four of the students named the characters in order, but for some students that interfered with their solving of the problem. One student asked: "Do I have to go in order?" When the interviewer told him that he did not have to go in order, he changed his strategy by adding the two largest numbers first and then adding the remaining character. Adding the two largest numbers (seven dancing girls and five birds in a flock) was the procedure chosen by six of the students. One boy explained: "It's easier that way because then you just add one to it each time and that's real easy."

Three students added to the previous total as they named the characters. One boy explained the procedure:

> He ate the pot and the gruel-- that's 2, and the old woman--2 and 1 is 3, and the 2 boys--3 and 2 is 5, and the 5 birds--5 and 5 is 10, and the 7 dancing girls--10 and 7 is 17, and the lady and the preacher is 2--17 and 2 is 19. So it is 19.

Two students wanted the story repeated, and they added using their fingers to add. One girl stated: "You could tell me again. Sometimes I do that--proofread. It's kind of like that." Only one students added the character by attributes of male, female, and birds.

One girl divided the problem into two parts. She added part of the characters, remembered the total, then added the rest of the characters and added that total to the total she held in memory. She explained: "You add them all up--1 old lady and 2 boys is 3, 5 birds is 8, 1 lady is 9, 1 pot, 7 girls dancing, 1 preacher is 9--9 plus 9 is 18." She used her fingers in the addition.

One girl changed the number through the use of subtraction and then added the number back into the equation later in the problem. She explained:

> First you add 1 woman and 2 men--2 plus 1 equals 3, 5 birds--3 plus 5 equals 8 take away 1 is 7, plus 7 girls--7 plus 7 equals

> 14, add 1 more [that she took away earlier] is 15, 16, 17; just add two more--the man and crooked ladder.

The students compared their estimation with their calculation. The following statements indicate comparisons: "My estimate was two off--pretty good," "I was eight off with the estimation," and "The estimate was not really a close estimate." Two students realized their estimations were off early in their calculations. One student made the discovery: "One old lady, 5 birds, 7 girls--oh!--more than 13." He continued to count the remaining characters.

When the students were asked how they remembered all of the characters Fat Cat ate, the typical reply was: "I just remembered the story." However, five of the students were able to identify specific images that aided them in solving the mathematical word problem. The following statements illustrate their utilization of images in solving the problems:

> I listened real good and can kind of hear it in my mind.
>
> I can just see them in my head, and then I said it and counted them.
>
> I hear it like Mrs. Wolfe said it.
>
> I've got the story in my memory. I still see them. The pot is black and the cat is gray. The old lady wore black and white. The two boys wore white and orange with a hat that was red and blue. I think about it.
>
> I can see them.

The three students who stated that they did not know how to check their estimates were also unable to report any images during the discussion of the story. Two other students were confused about how to check their estimates. They explained:

> Write down a 5 for 5 birds and 9 or 11 for the rest of them. Now add.
>
> Just write 5 and stuff and 7 girls stuff.

Both of these students provided minimal image responses when they were interviewed about their reactions to the story.

In contrast, students who reported the most descriptive, rich, detailed images were confident about how to solve the mathematical word problems and could explain how they used their images in solving the problems. One boy stated: "You add--you've got to add." These students also named the characters faster than did those who reported no images.

In summary, the vast majority of the students knew what algorithm they needed to use to check their estimates of how many characters Fat Cat ate. However, the students employed many different strategies in adding the characters. Using fingers to count was the strategy used most often. Many of the students used more than one strategy to solve the problem. There is a strong correlation between the students' ability to generate images and their ability to solve the problem. Those who were unable to generate any images were unable to solve the problem. Those who reported the most descriptive images solved the problems faster, with more accuracy, and exhibited more confidence in their ability to complete the task.

More Than Word Problem

The second mathematical word problem asked the students: "Did Fat Cat eat more people or animals?" After the students responded, they were asked to explain their answers. Table XI (p. 67) illustrates the students' responses to the question.

Most of the students had no trouble in categorizing the birds as animals. They recognized that all of the other characters were people, and that there were more people than animals. All except four of the students realized there were more people than birds. One girl explained:

"Because there are more people in the story than there were animals. The only animals he ate were the five birds."

TABLE XI

MORE THAN WORD PROBLEM

Answer to the Problem	Number of Students Who Responded With That Answer
More people	17
More animals, but changed their answer to more people during their explanation	3
Guessed more people	2
Did not know	2

Only one student used her fingers to solve this problem, and explained: "Fat Cat ate more people because I added them up." Three students said that Fat Cat ate more animals, but changed their minds as they explained why:

> More birds. Because he ate the woman, preacher, girls . . . don't . . . seven girls is more than the birds. I changed my mind.

> More animals--five, but . . . seven . . . not animals, but girls. I'd changed my mind. More people . . . when I thought back, I thought it was seven girls. Well, now that I figured it out, I think there would be more people.

> . . . mmm . . . birds. Five. Lots of people. I'd say more people because he ate the seven dancers and that's more than birds.

Two students stated that they did not know and did not know how to figure it out. Two students guessed "people," but were unable to explain why they thought that. Three of these students reported no images during the discussion of the story, and the fourth student reported minimal images in response to the story.

Five of the students explained their answers with: "I remembered back in the story." However, they were unable to elaborate on how they remembered. Three students illustrated visual imagery in their explanation:

> Because he only ate five flocks of birds and all the others I saw were people.

> People, because he only ate five birds and I think he probably ate a worm because one had a worm in his mouth.

In summary, most of the students were able to complete this word problem without difficulty. The three students who answered birds were able to correct their answer during their explanation. Several students explained their answers with: "I remember back in the story," but were unable to explain how they remembered. Three students used visual imagery in explaining their responses. Those students who generated no images during the story were unable to solve the problem.

Subtraction Word Problem

The third mathematical word problem is typically considered by educators to be a subtraction problem. The problem posed to the students was: "How many more dancing girls did Fat Cat eat than birds in a flock?" However, the process employed by the students indicated that multiple strategies were used to solve the problem. Table XII indicates those different strategies.

TABLE XII

STRATEGIES FOR SUBTRACTION PROBLEM

Type of Strategy Used	Number of Students Who Used the Strategy
Subtraction	8
Addition	8
Counted up	2
More than one way	4
Did not know what to do	2
Used fingers	6
Utilized memorized fact	3

Although this problem is traditionally taught by teachers as a subtraction problem, the students used other strategies, as well as subtraction, to solve the problem. Of the eight students who subtracted, four explained the problem as seven take away five is two. Three of the students reversed the problem and explained it as: "I took two away from seven." One child was confused about the number of dancers. He thought about it for more time than his classmates and then said: "Four . . .

because you subtract the numbers. There were nine dancers and five birds, so that's four."

Eight students used addition to solve the problem. Typical was the statement: "Two more. I just went five plus two is seven." All of these students started with the number five and added two. Two students indicated that they "counted up." Both started with the number five and counted two more to get seven. One boy explained: "Seven is higher than five, and there's two more than five, counting up."

The following examples indicated that four students calculated the correct answer, but in their explanation they mixed the way they figured the problem out with the algorithm they seemed to think was expected of them:

> More girls--two more. Five and count up two more. I took away off of seven.
>
> I know how to add [laughs]. I added two more. No! I took . . . I did two more and that . . . it's two.
>
> Two more. Because five plus two is seven. Seven minus five equals two. I just know that from doing math.
>
> Seven and five . . . that's two more. I subtracted.

Students used fingers to solve the problem and to explain their answers. One boy said: "It helps me keep track." Three students indicated that they had the number fact memorized. One girl stated: "Two more, because five plus two is seven. Seven minus five equals two. I just know that from doing math. I know that from memory from doing math."

Only three students reported the following images while solving this problem:

> The numbers are in my head. I just see them in my head.
>
> I had a picture up in the air and that's how I know.
>
> I just pictured the numbers.

The two students who were unable to solve the problem or generate images in response to listening to the story made the following statements:

> I don't know. I can't figure it out.
>
> I don't know. Seven more dancing girls. He only ate five birds and he only ate seven girls, and seven girls are more than five birds . . . seven more birds, because birds are less than the seven girls dancing.

In summary, the students were inventive in solving the word problem that is considered to be a subtraction problem by most elementary teachers. With the exception of one student, all of the students who solved the problem answered correctly with the answer of two. The students demonstrated that the problem could be solved through addition and counting up as well as subtraction. Four students' explanations demonstrated confusion between the way they worked the problem and the algorithm they seemed to think was expected of them. Students used their fingers and memory of number facts to solve the problem. Only three students indicated that they used visual images in solving the problem. Two students were unable to solve the problem or to verbalize indications of any images during the discussion of the story.

Spatial Problem

The fourth mathematical problem was a spatial problem. Students were asked to draw a picture of Fat Cat. Because Fat Cat ate many characters who were much bigger than he was, the students had to determine how they would spatially place the volume. In doing so, they solved the problem of how Fat Cat would move from eating one character to eating the next character. Table XIII (p. 72) indicates how the students solved the spatial problem.

TABLE XIII

SPATIAL PROBLEM

Description of Picture of Fat Cat	Number of Students Who Drew the Picture
Standing on his back two feet like a human. The stomach protruded in front and on the sides.	9
Walking with four feet on the ground. The stomach hung down.	12
Inflated, like a balloon, floating off the ground.	1
Part of the body was pictured.	1
Stick figure picture.	1
Fat Cat was smaller than the people in the picture.	10
Fat Cat was bigger than the people in the picture.	6

Seven of the students who drew Fat Cat standing on his back feet, like a human stands, drew a front view of the cat looking straight ahead. These students drew a circle body with small limbs and a head attached. The other two students drew Fat Cat from a side view of the cat, indicating a rounded back but a large protruding stomach.

Most of the students who drew the cat with all four of his feet on the ground drew a side view of the cat. Only two of these children drew a full face view of the cat. Seven students used a large circle to illustrate Fat Cat's body. Three students had the cat's large stomach hanging down toward the ground, or touching the ground. One student indicated the volume of Fat Cat by making the cat larger at the back end of the cat's body, placing the four feet close to the front of the body.

Two students presented Fat Cat from a different point of view. One child drew a picture of Fat Cat with his chin on the ground and the rest of his circular body floating in the air, like a balloon. The other child drew four tiny lines on the left side of the picture and a picture of the lady with the pink parasol in the middle of the page. When asked about her picture, she explained: "Fat Cat is just coming and all you can see are his whiskers. The lady doesn't see him yet."

Most of the students used color in their drawings. Five students used no color, choosing to illustrate Fat Cat in pencil.

The majority (18) of the students illustrated their pictures to match their description of Fat Cat. One student's illustration did contradict her responses in the interview. She stated that she could not describe Fat Cat or any of the other characters and indicated that she had no images in response to hearing the story. However, her picture was illustrated in bright color, rich details in the dress and umbrella of the girl, and words were written on the picture. She was unable to solve the first mathematical word problem, but completed the last two problems without any difficulty. This was the only student whose illustration, interview responses, and mathematical word problem solving produced this mixed conclusion.

Four students wrote words and sentences on their pictures, indicating that an auditory image accompanied the illustration of the scene. The students wrote the following words enclosed in a circle with an arrow pointing to the speaker:

I'm going to eat you! [Fat Cat].

I [woodcutter] cut him open.

Die! [woodcutter].

Pe yu! [girl addresses Fat Cat as he approaches her].

This child had earlier stated that the cat stinks because he has gross, slimy, oily stuff on him. Her drawing illustrated her description.

The following pictures indicated a sense of motion:

1. The line of the woodcutter's arm was repeated to show a downward movement.

2. The leg of a girl was raised and bent at the knee, illustrating a step being taken.

3. The cat has eaten the front half of a character and the back half of the victim was sticking out of the cat's mouth with the knees bent and feet apparently kicking, indicating a struggle.

4. Birds were drawn in the air with their wings stretched out in a flying position.

Several pictures suggested fear, happiness, and celebration that indicated the students' efforts to express emotive images:

1. Sweat was falling from Fat Cat's face as the wood chopper's ax came down toward him.

2. There was a big smile on Fat Cat's face as he walked down the road.

3. The woodcutter smiled as he raised his hands in the air.

4. The woodcutter had one leg raised off the ground and was off balance, suggesting a dance, after he cut open the cat.

5. The hands of the woodcutter were raised in the traditional victory gesture after he cut the cat's head off.

In summary, the students solved the spatial problem of the size and shape of Fat Cat by his posture and by the distance they placed him in relationship to other characters and objects included in the picture. The children's illustrations indicated evidence of auditory images with written words and sentences on the picture. Visual images like color and movement were also demonstrated. Emotive images were displayed through gestures and facial expression of the characters.

Summary

Analyses of data indicated that most, but not all, children did generate images in response to listening to a storyteller tell a traditional folktale. In all, 145 images were reported by the 24 students who participated in the study. The images were categorized as visual, auditory, olfactory, gustatory, tactile/texture, and emotive. Visual images were reported more than the other images. Visual images were subcategorized into color, motion, three-dimensional space, and size. Descriptions of characters and objects from the story provided the majority of reported visual images. Some children indicated auditory images when they reported that they "heard" music, conversations between characters in the story, and background sounds. Olfactory images were reported in response to the food cooking and smoke from the fire, and as descriptive terms to describe the personality of the characters in the story. Only one student said that she had experience a gustatory image. Tactile/texture images were reported in the students' descriptions of fabric, structure, and exterior shapes of objects. Emotive images were indicated when the students identified with the characters in the story and experienced feelings in response to listening to the story. There is evidence that many of the students experienced more than one image at the same time. Students' uses of gesture were frequently used to communicate meaning.

To solve the mathematical word problems based on the story of "Fat Cat," the vast majority of students knew the algorithm to use but they employed many different strategies to carry it out. The use of fingers was used most often. Students who gave the incorrect answer often corrected it in their explanation of the process. Most of the students viewed the traditional subtraction problem in this study as an addition problem. The majority of students indicated that they did not use imagery to solve the problems. However, the students who reported the most vivid images in response to the story displayed the most capability and confidence for solving the problems. Those students who reported no images or minimal images were unable to solve most of the mathematical word problems.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

This chapter presents a summary of the study, conclusions drawn from the data analyses of the investigation, implications for educators, and recommendations for further study.

The purpose of this study was two-fold. It was designed: (1) to determine if second grade students generated images in response to listening to a storyteller tell a traditional folktale, and (2) if those images were used in their strategies to solve mathematical word problems based on the story. It was my intent to gain insight and understanding regarding the connection of the two functions. A qualitative research design was selected to provide rich, descriptive data about the contexts, activities, and beliefs of the participants in the educational setting (Goetz and LeCompte, 1984).

The period of observation covered two months, beginning in April and ending in May. During that time, four visits were made to the classrooms to observe the classroom teachers teach mathematics in conjunction with literature. Two additional visits were made to the classroom to tell stories to the students and to have them solve problems based on those stories. These sessions served as warm-up visits in order for me and the 24 students who participated in the study to become familiar with each other and for the students to understand their role in the study. The final visit was made to tell the story of "Fat Cat" and for the students to solve mathematical word problems based on the story. This story served as the context for the inquiry.

During visits to the classroom, detailed journal notes were recorded, teacher lesson plans and mathematical textbooks were examined, in-depth interviews were conducted, and the students' drawings were analyzed. These multiple data sources were employed to collect and analyze data. Triangulation was used in this study to verify the statements of the students with observed behaviors, records, and documents and to obtain a holistic view of the students' strategies in solving mathematical word problems to determine patterns and relationships.

The study focused on: (1) seven- and eight-year-old children's ability to create images, and (2) the use of images in solving mathematical word problems.

Conclusions

The descriptions of children's images indicated that most of the children were able to generate detailed images. The students' abilities to create images, however, revealed a wide range of capabilities.

Three of the students stated that they had no images in response to the story. The questions asked of all the students were purposefully open-ended questions so as not to interfere with their images. Earlier researchers cautioned that subjects' responses may not be an indication of their image, but inspired instead by the researcher's suggestions that the subjects describe his or her image (Eagan, 1989; Rohwer, 1970). However, at the conclusion of the interview, I chose to test this theory and asked three students specific questions about the color, size, and shape of Fat Cat. They were still unable to describe the cat. For these three particular students, the power of suggestion was not of assistance to them in generating or reporting images.

The majority of students described the characters, objects, and scenes from the story in rich detail. Visual images were the most frequently reported. These images were subcategorized into color, motion, three-dimensional space, and size. The visual images were often reported in connection with other images, such as auditory images. Students wrote words on their drawings to indicate that a character was saying those words in that particular scene. One boy wrote of the woodcutter: "I cut him open," to note the last scene in the story where the woodcutter freed all the characters Fat Cat had eaten.

There were numerous indications that students emotionally interacted with the story and that their reactions reflected personal experiences. Not only did students indicate their feelings, such as "I was scared," but many used emotive images to identify feelings of the characters in the story. One boy explained: "Fat Cat would feel grumpy with all that food in his stomach." There were also indications that students emotionally viewed the same scene differently. Some students were sad that the cat died at the end of the story. Others were happy because the characters he ate were free. Students employed emotive images as they identified with characters in the story. The vast majority of these identifications were based on traditional sex roles.

Five students indicated more ability to generate images than did their fellow classmates. These students gave longer detailed descriptions, provided more background information, and extended the story for it to make sense to them. All of these students used similes to compare the story to familiar stories, cartoon characters, and incidents that had occurred in their lives. These students used specific standard measurements to describe the height and length of a character. Each of these students used numerous gestures, both facial and body, to describe the story to the interviewers. While most of the students indicated a preference for one or two types of images, these students utilized multiple types of images and used them in connection with each other. They also were able to tell the interviewers how they imaged the characters and scenes they described. When one boy was asked how he decided what the character did, he responded:

> It's like your dream. That's how I knew. If I close my eyes for a second, I can see people I don't even know. But I can't see myself. You can't see yourself in your own dream. Whenever I want to go somewhere, I can go wherever I want and wake up, and I remember. I've been there and can be there. I can see my dreams as soon as I close my eyes. I see people moving once I close my eyes, even in color, and they talk. It's like that, like a dream.

The first mathematical word problem asked the students to estimate the number of characters Fat Cat ate and to check their estimates. All, except for the three students who were unable to generate images, were able to determine the algorithm needed and to solve the problem. However, the strategies used by the students varied greatly. The two most frequently used strategies were: (1) adding the largest numbers first and adding the remaining characters, and (2) naming the characters in order, adding as they were named. Although this problem involved many numbers and would be easily solved by using a calculator, not one student suggested that strategy. Calculators are not available in the classrooms, and the students have had no instruction in their use. Only one student used tally marks to add the characters. Most of these students used their fingers to check their estimates.

The five students who demonstrated the greatest ability to generate images were also the most confident and able to explain their use of imagery in solving the problems. One student told me: "You add. You've got to add." One girl asserted: "I know what to do." Another stated, after he named the characters in order: "Because that's how the cat ate them. I've got the story in my memory. I still see them. The pot is black and the cat is gray. The old lady wore black and white. It's like that." Three of these students indicated an understanding of the purpose of the estimation. They compared their estimations with their answers after they finished calculating the problem. In the middle of the addition, one student said: "Oh, more than 14" [his estimate].

A discussion of the students' processes was helpful to them in correcting their incorrect answers. The second problem asked the students if Fat Cat ate more animals or people. The students had to reclassify the birds in the story to animals. Of the three students who first indicated that Fat Cat ate more animals than people, all changed their minds in their discussion of how they solved the problem.

The third mathematical word problem asked the students how many more girls dancing (seven) did Fat Cat eat than birds in a flock (five). This problem was typical of problems presented in the mathematical textbook used in the classrooms. Traditionally, primary teachers teach this problem as a subtraction problem, but the students did not solve the problem that way. Of those who did subtract, only four students explained it as it would be traditionally taught: 7 - 5 = 2. Four students explained it as 7 - 2 = 5. However, most of the students in this study explained the problem as an addition problem, and they either added or counted up. One student explained: "I just went, five plus two is seven." Students regularly used their fingers to solve this problem.

There were indications that teaching the subtraction algorithm for this type of problem was confusing to students. Four students started their explanation by indicating that they had added but changed to subtraction at the end. One boy said: "I know how to add" [laughs]. "I added two more. No! I took . . . I did two more and that . . . it's two."

The fourth problem was a spatial problem that simply asked the students to draw a picture of Fat Cat. Art projects require that students consider spatial problems. Because Fat Cat ate people who were bigger than he was, the students had to determine how they would handle the volume and how Fat Cat would move from one eating to the next. Although the students were given no directions concerning the problem, the students solved the problem in a variety of ways. Some drew Fat Cat standing on his hind feet with his stomach protruding in front. Others drew Fat Cat with his stomach dragging on the ground. Some students made Fat Cat as big as the other characters in the picture, explaining the he got bigger everywhere, not just his stomach. One student drew Fat Cat like a balloon and stated that he just "rolled along."

While most of the children were able to generate images, three of the students reported no images. Two of these students were unable to solve any of the problems. One student could not solve the first problem but did solve the last two problems and drew a picture that was colorful and filled with details. When asked how they felt about mathematics, these children responded negatively. One student expressed: "I don't like it. It's too hard."

The majority of the students reported images in response to listening to the story but did not indicate that they used those images in solving the mathematical word problems. When asked how they remembered the story, many students were unable to explain.

Those students who reported the most vivid images were able to verbalize how they used their images in solving problems. These students answered questions quickly and with confidence. One student expounded on his confidence: "I'm going to a math class because I know my times, and we're not even in times yet. I taught myself the one times, and I got the hang of it. I'm good at math."

In summary, the data from this study strongly supported the conclusion that those who are least capable of generating images when listening to a story are also least capable of solving mathematical word problems based on that story. It further supported the conclusion that those who are most capable of generating rich images when listening to a story also displayed the most ability to understand and solve the mathematical word problems based on that story, and that those images were a factor in understanding and solving the problems. There appears to be a strong connection between one's ability to generate images and one's ability to solve mathematical word problems. Because the data supported this connection, it has implications for those students who solved the problem but could not identify imagery as a factor in their process of solving the problem. Many of these students solved the problems and explained that they remembered the story, but were unable to explain how. Many named all of the characters in the story, several in order, which suggested some utilization of images. The data suggested that it can be inferred that these students used imagery but, as was pointed out by Rohwer (1970), they may not have had the language development to communicate how they employ these images.

It is recognized that other factors such as the student's intelligence, developmental stage, learning style, and personal experience may have influenced this phenomena and could also account for the findings.

However, because the data in this study confirmed the strong connection between the student's ability to create images and solve mathematical word problems, the creation and utilization of imagery must be a consideration in explaining and understanding the educational phenomena.

Implications for Educators

Several implications for teaching in the primary classroom emerged from the study. These implications related to instructional practices pertaining to questioning techniques, discussions by students in literature and mathematics, integrating mathematics and traditional folktales from children's literature, teaching algorithms in mathematics, and utilization of images in the educational setting. As a result of this study, I would make the following suggestions to be considered by educators regarding the integration of storytelling of traditional folktales and solving mathematical word problems based on those stories:

1. Open-ended questions should be used in the educational setting to allow children to explore, discuss, describe, and explain their own interpretations of the stories and their processes of solving mathematical word problems taken from those stories.

The benefit of using this type of question is that it allows the child to choose the direction of the discussion, and to reveal his or her thinking and understanding to the teacher. Follow-up questions enable the instructor to not only guide the discussion, but to access the child's reasoning and personal meaning he or she brings to the story. A question like: "How would you describe Fat Cat?" allowed for a wide interpretation of the question. Some students described the physical appearance of the cat, some described his personality, and a few described both his appearance and personality. The question: "Why do you think that?" caused children to consider their answers and reveal their reasoning. The use of open-ended questions enables the educator to tap into the thinking of the student and to learn from him or her.

2. Students should be encouraged to verbally express their thinking through individual interviews and class discussions in mathematics as well as in other subjects.

While this type of communication is fairly common in connection with literature, mathematics tends to be traditionally thought of as a pencil and paper activity, and mathematical communication is less common in our schools. Children need opportunities to talk mathematics. Explaining mathematics promotes communication. It helps the students clarify their thinking and sharpen their understanding, as was demonstrated by the three students who changed their minds about their answers when they were asked to explain why they thought Fat Cat ate more animals than people. Teachers should ask all students to explain their answers, not just those who have the incorrect answers. This enables the students to learn other strategies from their classmates as they communicate. It is also a good way for the teacher to assess students' thinking and to understand their processes for solving problems.

3. Mathematics should be integrated with other subjects in the curriculum.

Mathematics should be viewed, not as a subject to be taught in isolation, but as part of the curriculum. Traditional folktales provide many problem-solving situations that enable the students to see mathematics in all aspects of their lives. This genre of children's literature reflects life. The problems of estimation, comparing, determining attributes, and making decisions concerning volume that were dealt with in the story used in this study are problems that students deal with in their lives on a daily basis. When students solve problems of this nature they are more apt to recognize those same problems in their lives and see the value of mathematics. Because the story was longer than word problems typically found in mathematical textbooks, it provided an in-depth knowledge needed by the students to understand the mathematical problems and their purpose.

4. Educators must be sensitive to the fact that children solve the same problem many different ways. We need to allow each child to solve the problem in the way that is reasonable to him or her.

The students in this study used multiple strategies to solve the problem. Children should have the autonomy to develop their strategies and carry them out in a way that makes sense to them. There were indications in this study that teaching the algorithm interfered with those strategies. When autonomy is encouraged by the instructor, children gain confidence in their ability to reason and explain their thinking.

5. Educators should provide stories and problem-solving situations that involve the emotions of students in mathematics.

The children in this study became emotionally involved as they listened to the folktale. Not only did these students express their own feelings, they also speculated about the feelings of the characters in the story. Their analyses of the characters' behaviors produced understanding and compassion. Because the students in this study were emotionally involved in the story, it made sense to them, and the problems from the story made sense to them. When teachers value the students' interpretation of a story and their process for solving problems, it results in the students building confidence in their ability to analyze stories and to solve mathematical problems.

6. Art should be used to strengthen mathematical spatial skills.

Mathematics, integrated with art projects like the drawing and sketching of Fat Cat, enables students to give concrete form to their ideas and mental images. Clay projects could enable students to develop a sense of volume as well as space. Art projects, in a variety of forms, may be of benefit to students in developing their mathematical skills.

7. Educators need to exercise caution in teaching algorithm in conjunction with mathematical word problems to students at this grade level.

Confusion was demonstrated by the students who stated they added in the problem of how many more girls dancing did Fat Cat eat than birds in a flock, but when asked to explain, they stated that they had subtracted. Teachers would be wise to interview students to discover how they would solve the problem to understand their thinking. Clearly, the majority of the students viewed the "more than" word problem as an addition problem, not as a subtraction problem.

8. Second grade students should be allowed to use their fingers to calculate mathematical problems any time it is needed.

The common practice of the students using their fingers to calculate indicates that this is a natural strategy and should be encouraged. The students employed several methods, like the finger they started with, etc., and were successful in their calculations.

9. Calculators need to be made available to students in the classroom if they are to learn how and when to use them.

When adding many numbers, as in the first problem in this study, calculators must be available if students are to think of using this valuable tool to aid in their mathematical learning.

10. Because there was support in this study for the conclusion that an individual's ability to generate images was strongly related to his or

her ability to solve mathematical word problems, educators need to consider the importance of imagery in the student's ability to learn and to remember. Imagery games should be considered to help students generate images.

Of particular concern would be those students who were unable to generate images and those students who reported only minimal images. Imagery games may be helpful to these students. Interviews and discussions concerning images with these students could provide the educator with opportunities to discover insight into their thinking and ability to generate images.

11. Educators should search for folktales and stories from children's literature that portray girls as heroines in stories and depict boys as sensitive, compassionate individuals, as well as heroes in the stories.

This finding from the study was personally disturbing, and I believe it has sobering implications for all educators. The overwhelming majority of students who participated in this study indicated identification with a character based on the traditional sex role of the character. The boys identified with the hero and the tough cat. The girls identified with the calm, pretty, nice girls in the story. There are traditional folktales available that portray females as strong and wise as well as pretty, and males as caring and sensitive. Because children identified strongly with the sex role, we need to expose them to alternate gender roles.

Recommendations for Further Research

Several possibilities for further research are proposed as a result of this study. The following recommendations are made for further research investigations:

1. To determine if this finding is typical of second grade students, the study could be replicated with a different second grade class.

This study revealed that most, but not all, students did generate images in response to hearing a traditional folktale. Students who had the greatest capability of generating images exhibited the most ability and confidence in solving mathematical word problems based on the folktale. Students who were incapable of generating images in response to hearing the folktale were also incapable of solving the mathematical word problems.

2. Further research could be conducted to determine the difference in the strategies used to solve mathematical word problems taken from traditional folktales with the strategies students use to solve textbook mathematical word problems.

Children used multiple strategies to solve mathematical word problems taken from traditional folktales. Are these strategies different from the strategies students use to solve similar word problems in the classroom mathematical textbook? If so, how are they different? How do the number and types of images generated from listening to folktales differ from images generated in response to word problems taken from the classroom mathematical textbook? Further studies that compare and contrast the findings of this proposal would provide a better understanding of the value of integrating literature and mathematics.

3. Researchers need to investigate the connection of mathematical spatial sense in connection with different art mediums in the art curriculum.

Students in this study were asked to draw a picture of Fat Cat. How would the art work and the student's explanation compare and differ if, instead, they used clay to make the figure of Fat Cat?

4. Research is needed to determine if children of this age can be taught how to generate images.

Three students in this study reported no images in response to questions based on the folktale. Can students of this age be taught how to generate images? Research on possible approaches to educational instruction in this area could prove valuable for students who are experiencing difficulty in mathematics.

5. To determine if imagery is a developmental process, the study could be replicated with different grade level students to detect any variances that may occur.

6. Further research is needed to determine the impact that traditional folktales have on the listener identifying with a character in the story. Educators need to know if a student would identify with a character of their same sex who exhibited nontraditional sex roles and behavior.

The purpose of this ethnographic study was to explore children's use of images in response to listening to a traditional folktale and to study their use of those images in solving mathematical word problems. Many of my storyteller friends and educator colleagues expressed surprise at this connection. However, the students in this study expressed no such astonishment. These young children accepted the integration as a natural exercise, and it made sense to them. The NCTM (1989) Standards remind us:

> It is particularly important to build on the wholeness of their perspective of the world and expand it to include more of the world of mathematics. This can be done in many ways, both within and outside the realm of mathematics (p. 32).

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APPENDIX A

PARENTAL CONSENT FORM

Date: March 22, 1993

Dear Parents of Mrs. ______________'s Second Graders:

My name is Peggy Wolfe and I am completing my doctoral program at Oklahoma State University in Curriculum and Instruction in Elementary Education. I recently received permission from [superintendent] and [elementary principal] to conduct educational research in [classroom teacher's class at the ________________] Elementary School. The purpose of this letter is to request your permission for your child to participate in the research study to be conducted during the spring semester of 1993.

The purpose of the study is to see the strategies second grade students use to solve mathematical word problems taken from traditional folktales. My study will be to observe and listen to your child's responses to story telling.

All information gathered will be confidential and the identity of your child will remain anonymous. If you or your child do not want to participate in the study, you are free to decline. Furthermore, your child may withdraw from the study at any time you choose.

The folktales planned for this study should provide your child with an enjoyable experience as they listen to the story told by a storyteller. In addition, they will experience solving problems in the stories that are like problems they, too, could experience. As students become familiar with solving problems in this way, they begin to see mathematics in a broader context. It is not isolated. Mathematics is part of every aspect of their lives, and their participation in the study should help them to recognize, enjoy, and appreciate mathematics.

Thank you for your consideration of having your child participate in my research study. Please feel free to call me if you have any questions.

PARENTAL CONSENT FORM FOR CHILD PARTICIPATION

I, ___________________________, give my permission for my child, ____________________, who is a student in Mrs. ______________________'s second grade class at __________________________ Elementary School, to participate in the research study: The Use of Strategies to Solve Mathematical Word Problems by Second Grade Students, to be conducted by Peggy M. Wolfe from Oklahoma State University. I understand that information gained for this study will be confidential and the identity of my child will remain anonymous. I understand 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 Peggy Wolfe, University Research Services, 001 Life Sciences East, Oklahoma State University, Stillwater, Oklahoma, 74078 at any time regarding the study.

____

Parent's Signature

____

Date

APPENDIX B

OKLAHOMA STATE UNIVERSITY INSTITUTIONAL REVIEW

BOARD FOR HUMAN SUBJECTS RESEARCH FORM

Date: 03-04-93 IRB#: ED-93-051

Proposal Title: THE USE OF IMAGERY TO SOLVE MATHEMATICAL WORD PROB LEMS BY SECOND GRADE STUDENTS

Principal Investigator(s): Margaret Scott, Peggy Wolfe

Reviewed and Processed as: Expedited

Approval Status Recommended by Reviewer(s): Approved

APPROVAL STATUS SUBJECT TO REVIEW BY FULL INSTITUTIONAL REVIEW BOARD AT NEXT MEETING.

APPROVAL STATUS PERIOD VALID FOR ONE CALENDAR YEAR, AFTER WHICH A CONTINUATION OR RENEWAL REQUEST IS REQUIRED TO BE SUBMITTED FOR BOARD APPROVAL. ANY MODIFICATIONS TO APPROVED PROJECT MUST ALSO BE SUB

Comments, Modifications/Conditions for Approval or Reasons for Deferral or Disapproval are as follows:

REVISIONS RECEIVED AND APPROVED.

Signature: /s/ Marcia L. Tilley Date: March 4, 1993
Chair of Institutional Review Board

APPENDIX C

STUDENT INFORMATION GUIDE

OUTLINE OF INFORMATION PROVIDED TO SUBJECTS

The information will be provided prior to their volunteering to participate in the study and after consent has been granted by school administrators and the subjects' parents.

I. Purpose of the Study

   A. To identify strategies used to solve mathematical word problems

II. Describe the Study

   A. Students will listen to a storyteller tell a folktale
   B. Students will discuss the story
   C. The teacher will propose word problems
   D. Students will solve problems
   E. Researcher will observe, question, and collect drawings and classify information
   F. Researcher will write up findings of the study

III. How Subjects Were Chosen

   A. Experienced with Mrs. ________'s method of integrating children's literature and mathematics
   B. Mrs. __________ and the researcher share many of the same professional interests in education

IV. Duration of the Study

   A. Spring semester, 1993

V. Confidential Statement

   A. Anonymous

VI. Subjects' Rights

   A. Free to choose to participate
   B. Free to withdraw at any time if choosing to do so
   C. All participants will be treated fairly with no prejudice

APPENDIX D

MATHEMATICAL WORD PROBLEMS BASED ON THE FOLKTALE "FAT CAT"

1. Estimate how many characters Fat Cat ate. How will you decide to check your estimation? How did you solve the problem?

2. Did Fat Cat eat more people or animals? What makes you think that? How did you solve the problem?

3. How many more dancing girls did Fat Cat eat than birds in a flock? How did you decide that?

APPENDIX E

IMAGERY INQUIRY QUESTIONS

The following proposed questions are open-ended and designed to gain access to children's abilities to create images. Neither the order nor the precise wording of the questions need to be followed exactly. Children's responses can serve as a guide for the direction of the discussion, as well as the follow-up questions.

Suggested Questions for Student Interview:

1. What did you think about while you listened to the story?

2. What were your feelings during the story?

3. Can you describe Fat Cat?

4. If you could be a character in the story, which character would you want to be and why?

5. Is there anything else about the story you want to talk about?

APPENDIX F

THE STORY OF FAT CAT

FAT CAT

Retold by Peggy M. Wolfe

Once upon a time there was an old woman who was cooking a pot of gruel. While she was stirring she remembered she had some business with a neighbor down the road. She turned to her cat and asked him if he would watch the gruel.

"Oh yes," said the cat, "I'll watch the gruel."

But no sooner had that old woman gone out the door than the cat ate the gruel and the pot too.

When the old woman got back she took one look at him and said, "What have you been eating, my little cat? You are so fat."

"I ate the gruel and the pot, too. Now I'm going to eat you," said the cat. He did. He ate the old woman.

He was so full he decided to go for a walk. As he was walking on the path he met Skohottentot.

Skohottentot said to him, "What have you been eating my little cat? You are so fat."

"I ate the little old woman, the gruel and the pot, too. Now I'm going to eat you," said the cat.

He did! He ate Skohottentot.

He went on walking down the path. He met Skolinkenlot. Skolinkenlot said, "What have you been eating my little cat? You are so fat."

"I ate Skohottentot, the little old woman, the gruel and the pot, too. Now I'm going to eat you," said the cat.

He did! He ate Skolinkenlot.

He went on walking down the path. He met five birds in a flock. The five birds in a flock all said, "What have you been eating my little cat? You are so fat."

"I ate Skolinkenlot, Skohottentot, the little old woman, the gruel, and the pot too. Now I'm going to eat you," said the cat.

He did! He ate the five birds in a flock.

He went on walking down the path. He met seven girls dancing. The seven girls dancing stopped their dancing and said, "What have you been eating my little cat? You are so fat."

"I ate five birds in a flock, Skolinkenlot, Skohottentot, the little old woman, the gruel and the pot too. Now I'm going to eat you," said the cat.

He did! He ate seven girls dancing.

He went on walking down the path. He met a lady with a pink parasol. The lady with a pink parasol said, "Oh dear! What have you been eating my little cat? You are so fat."

"I ate seven girls dancing, five birds in a flock, Skolinkenlot, Skohottentot, the little old woman, the gruel and the pot, too. Now I'm going to eat you," said the cat.

He did! He ate the lady and her pink parasol.

He went on walking down the path. He met a parson with a crooked staff. The parson leaned on his crooked staff and said, "Heavens! What have you been eating my little cat? You are so fat."

I ate the lady with the pink parasol, seven girls dancing, five birds in a flock, Skolinkenlot, Skohottentot, the little old woman, the gruel and the pot, too. Now I'm going to eat you," said the cat.

He did! He ate the parson with the crooked staff.

He went on walking down the path. He met a woodcutter. The woodcutter said, "What have you been eating my little cat? You are so fat."

"I ate the parson with the crooked staff, the lady with the pink parasol, seven girls dancing, five birds in a flock, Skolinkenlot, Skohottentot, the little old woman, the gruel and the pot, too. Now I'm going to eat you," said the cat.

"Oh no you're not!" said the woodcutter. The woodcutter raised his ax and cut open the cat. Out came the parson with the crooked staff, the lady with the pink parasol, seven girls dancing, five birds in a flock, Skolinkenlot, Skohottentot, and the little old woman. She took the pot of gruel and went home.

VITA

Peggy McDonald Wolfe

Candidate for the Degree of

Doctor of Education

Thesis: THE USE OF IMAGERY TO SOLVE MATHEMATICAL WORD PROBLEMS BY SECOND GRADE STUDENTS

Major Field: Curriculum and Instruction

Biographical:

Personal Data: Born in Porterville, California, January 25, 1944, the daughter of James and Oza Ree McDonald.

Education: Graduated from Alex High School, Alex, Oklahoma, in May, 1961; received Bachelor of Science degree from University of Arts and Science, in 1964; received Master of Library and Information Studies from the University of Oklahoma in 1987; completed requirements for the Doctor of Education degree at Oklahoma State University in July, 1993.

Professional Experience: Elementary Teacher, Windsor Public School, Windsor, Connecticut, 1964-67; District Office Director, Congressman Glenn English, 1976-81; Branch Librarian, Tulsa City-County Library System, Tulsa, Oklahoma, 1982-83; Media Specialist, Morrison Public Schools, Morrison, Oklahoma, 1985-88; Media Specialist, Perkins-Tyron Public School, Perkins, Oklahoma, 1988-90; Media Specialist, Richmond Elementary School, Stillwater, Oklahoma, 1990-92; Teaching Assistant, Department of Curriculum and Instruction, Oklahoma State University, 1992-93.