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ABSTRACT

The current period in mathematics education can be characterized as one of reform. Many feel that children in the United States are not learning enough appropriate mathematics; these critics are concerned with the specific areas of problem solving and children's conceptions of the nature and uses of mathematics. A pretest/posttest experimental design study examined the effects of SQUARE ONE TV, a television series about mathematics aimed at 8- to 12-year-old children, on the problem-solving behavior and attitudes toward mathematics of 240 fifth graders from 4 public schools in Corpus Christi, Texas. Performance and attitude data were collected from a subgroup of 24 students exposed to 30 SQUARE ONE TV programs and from 24 students in a control group having no SQUARE ONE TV contact. Reported here is children's attitudes toward mathematics and the effects of SQUARE ONE TV, presented in the third of a five volume report. Results are given on four levels of students' attitudes toward mathematics: (1) their understanding of what mathematics is; (2) their perception of the usefulness and importance of mathematics; (3) their motivation concerning mathematics and the problem solving reflected in the problem solving activities; and (4) their enjoyment of mathematics and problem solving. The analyses of change indicated that SQUARE ONE TV viewers became more motivated by engagement with problems, made a greater number of positive enjoyment statements, and derived enjoyment from thinking and figuring out solutions. Students' beliefs about mathematics and its perceived usefulness remained focused on arithmetic with viewers speaking about more advanced mathematical content and more practical and problem-solving mathematics than nonviewers. (MDH)

Children's Problem-Solving Behavior and Their Attitudes toward Mathematics: A Study of the Effects of SQUARE ONE TV

VOLUME III

Children's Attitudes toward Mathematics and the Effects of SQUARE ONE TV

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TABLE OF CONTENTS

Appendix III.E: Categories for Descriptive Analysis: Usefulness and Importance

Appendix III.F: Codebook: Usefulness and Importance

Appendix III.G: Categories for Descriptive Analysis: Motivation

Appendix III.H: Codebook: Motivation

Appendix III.I: Categories for Descriptive Analysis: Enjoyment

Appendix III.J: Codebook: Enjoyment

Appendix III.K: Interrater Reliability

Appendix III.L: Statistical Analyses Used in the Analysis of Change

PREFACE

Thi is the third of five volumes that describe an evaluation entitled "Children's Problem-So ng Behavior and Their Attitudes toward Mathematics: A Study of the Effects of **SQUARE**)NE **TV**." The study was designed to assess the effects of **SQUARE ONE TV** on children's use of problem-solving actions and heuristics and their attitudes toward mathematics. In addition, children were interviewed about their opinions of and reactions to **SQUARE ONE TV** itself.

The contents of the five volumes are as follows:

VOLUME I:	Introduction: Purpose and General Design of the Study
VOLUME II:	The Effects of **SQUARE ONE TV** on Children's Problem Solving
VOLUME III:	Children's Attitudes toward Mathematics and the Effects of **SQUARE ONE TV**
VOLUME IV:	The **SQUARE ONE TV** Interview: Children's Reactions to the Series
VOLUME V:	Executive Summary

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CHAPTER 1

CONCEPTUALIZATION

Introduction

The first volume of this report provided an overview of the entire study, including a summary description of its overall purpose, design, and methodology. The reader is referred to that volume for this basic information.

The purpose of this volume is to present in detail the part of the study that relates to children's attitudes toward problem solving and mathematics. In this chapter, we first discuss the relationship between Goal I of **SQUARE ONE TV** ("to promote positive attitudes toward, and enthusiasm for, mathematics") and recent concerns in mathematics education. Then we present relevant literature on mathematics attitude and learning. Next, we briefly describe our conceptualization of attitude for the purpose of this study. The chapter concludes with an outline of the entire volume.

Mathematics Education and Goal I of SQUARE ONE TV

Mathematics educators have long recognized that achievement and performance in mathematics do not rely on one's knowledge of mathematics alone. The research of Aiken (1970), Dweck (1975), Fennema and Sherman (1977), and Schoenfeld (1983), among others, has indicated that factors such as children's perceptions of mathematics, its purpose, and its potential role in their lives play a critical role in mathematics learning. These factors describe the social and emotional relationships that children have with the subject: in essence, children's attitude towards mathematics. Learning mathematics, as Reyes (1984) notes, is basically a cognitive or intellectual enterprise; but real success in mathematics -- a success that will help children into adulthood -- is dependent on their attitudes as well.

The insight that mathematics achievement is dependent on children's attitudes is central to the reform movement in mathematics education. Documents on mathematics education reform issued by organizations such as the National Council of Teachers of Mathematics (NCTM) and the Mathematical Sciences Education Board of the National Research Council (MSEB) present suggestions for the reform of mathematics education that involve both curricular and attitudinal components. For example, NCTM's Curriculum and Evaluation Standards for School Mathematics (1989; hereinafter "Standards") presents two attitudinal goals for students: (a) to value mathematics, and (b) to feel capable of using it. NCTM's belief is that through the attainment of these goals, children will develop the "mathematical power...to explore, conjecture, and reason logically, as well as the ability to use a variety of mathematical methods effectively..." (p. 5; emphasis in original).

SQUARE ONE TV was developed to contribute to the reform movement in mathematics education by providing a supplement to classroom instruction. Recognizing the importance of attitudes to mathematics education, SQUARE ONE TV has defined the first of its three goals as follows:

> To promote positive attitudes toward, and enthusiasm for, mathematics by showing:
>
> A. Mathematics is a powerful and widely applicable tool useful to solve problems, to illustrate concepts, and to increase efficiency.
>
> B. Mathematics is beautiful and aesthetically pleasing.
>
> C. Mathematics can be understood, used, and even invented by non-specialists.

As described in Volume I of this report, SQUARE ONE TV attempts to meet its goals by presenting ideas about mathematics and problem solving in an exciting and humorous way. The series presents its target audience of 8- to 12-year-old children with models (both children and adults) who use mathematics successfully in various contexts to achieve a wide range of purposes. Additionally, the series encourages children to participate in mathematical activities through engaging content and formats that invite children to "play along." The purpose of the present study is twofold: to explore children's attitudes toward mathematics in the absence of any treatment and to examine whether exposure to **SQUARE ONE TV** can affect those attitudes.

Mathematics and Attitude: The Research Literature

How to Study Attitude?

To determine whether **SQUARE ONE TV** had met the first of its goals, we first needed to determine how to study change in attitude. This logically led to two other questions: What, exactly, is mathematics attitude? How has it been studied? Below we present a review of the research literature on mathematics attitude as it pertains to these preliminary questions.

What is mathematics attitude? Early theoretical definitions of attitude recognized that it consists of components relating to thought, feeling, and behavior -- attitude defines some predisposition to act that is related to one's thoughts and feelings (e.g., Shaw & Wright, 1967). Kulm (1980) describes similar definitions presented by several other researchers, such as Allport (1935), Rokeach (1972), and Romberg and Wilson (1969). The importance of attitude, as so defined, to mathematics performance is clear: attitude affects one's behavior. This is consistent with our common understandings of the word. We use "attitude" to refer to a stance toward something that involves one's thoughts and feelings and that, to some extent, will guide one's actions.

More recent theory has focused less on behavior than on the roles of thoughts and feelings in attitude. McLeod (1989) theorizes that attitudes "are the end result of emotional reactions that have been automatized" (p. 249). Mandler (1989) posits that these emotional reactions "give...rise to judgments and feelings of good or bad or of some affective nature" (p. 7) about the subject matter (cf. Hart, 1989). The "judgments and feelings" that are the "end result" of these emotional reactions are relatively enduring. Thus, it seems that mathematics attitude results when the emotional (i.e., affective) content of one's experiences with mathematics develops into a routine, stable reaction to and judgment of the subject. Indeed, attitudes are sufficiently stable that Kulm (1980) notes the "ineffectiveness of most experimental treatments in producing a significant improvement in mathematics attitude" (p. 375).

Thus, it might be difficult to influence attitudes at any age. However, given that research has suggested that attitudes toward mathematics are largely formed in the late elementary-school years (see Kulm, 1980), efforts toward encouraging positive attitudes toward mathematics might best be directed at children of this age. Before attitude change can be studied, however, a detailed examination of children's attitudes prior to any intervention is required.

How has mathematics attitude been studied? Researchers studying children's attitudes toward mathematics have tried to assess the possible ways in which children may relate to the subject: Do children like or dislike mathematics? Do they appreciate its value? Do they perceive it as useful? Do they seek out mathematical challenges? The answers to questions such as these begin to present a portrait of a child's attitude toward mathematics. Different researchers have focused on different questions as most important in assessing a child's relationship to mathematics. For example, a scale developed by Aiken (1974) measures attitude by exploring only two dimensions: "value" and "enjoyment." The Fennema-Sherman Mathematics Attitude Scale, on the other hand, questions children about their confidence, their effectance motivation, their perceptions of its usefulness, their anxiety about mathematics, and their belief that it is a male domain, among other attitudinal components (Fennema & Sherman, 1977). The differences among the components of these two measures (and many others) indicate underlying differences in what the researchers deem as most critical to children's attitudes toward mathematics. This, in turn, has led to confusion as to what, exactly, mathematics attitude is.

In research on mathematics attitude, attitude has often been defined by its measurement. As Kulm (1980) states, "The...trend has been to avoid explicit definition and to settle for operational definitions implied by items of instruments measuring attitude" (p. 356). Kulm also comments that "in many studies using attitude as a variable, the assumption seems to be that attitude is defined to be the total of whatever items were used on an attitude scale" (p. 365). Hart (1989) agrees with Kulm's assessment and acknowledges that such research makes it difficult to understand the meaning of scores on attitude scales. When different researchers use different components (i.e., focus upon different dimensions of attitude) in their scales, the "attitudes" of a population of students measured by one scale may be completely different from the "attitudes" of the same students measured by another scale.

Research studies using scales as measurement devices have begun to answer certain questions about mathematics attitude but have left others unaddressed. Scales allow researchers to conduct large correlational studies with relative efficiency. For example, through the use of the Fennema-Sherman scales, research has indicated that children's perceptions of usefulness is an important predictor of whether children will elect more mathematics courses in high school and that gender stereotypes seem to affect girls' continued achievement with the subject (see Reyes, 1984, for a review of this research).

Still, such research leaves unanswered a variety of questions, particularly ones relating to the development of attitudes. Typically, scales pose difficulties for research with elementary-school children, because scales require or assume that the researcher's understanding of the concepts presented on the scale (e.g., "value") is the same as the understanding that the child brings to the scale. While this is always a potential threat to the validity of research with scales, this is particularly risky in studies with children in the elementary grades. Elementary-school-aged children may not have clear or stable definitions of the terms used on scales of attitude. Furthermore, the information obtained from scales does not allow the researcher to understand the reasons for a child's response and, thus, the sources that underlie his or her attitude toward mathematics. To fully comprehend children's attitudes toward mathematics, then, one would require a methodology that provides richer information than can be obtained through paper-and-pencil scales.

The need for a descriptive analysis. The lack of detailed information about the elementary-school children's attitudes toward mathematics suggested that we needed to undertake an in-depth, descriptive empirical study of the children's attitudes toward mathematics before assessing attitude change. Children in our target age population were said to be in the process of developing their attitudes toward the subject, but very little research on mathematics attitude existed for this age group; more information was required as to how children of this age related to mathematics. Therefore, the first step in this study was to create a "descriptive analysis" that would describe the children's thoughts and feelings about mathematics before the treatment, i.e., at the pretest. This descriptive analysis could then serve as the basis from which change in the children's attitudes would be measured.

Approaching the Study of Attitude

Once we decided to conduct both a descriptive analysis and an analysis of change, we then had to consider how best to approach such analyses. Our thoughts were guided by recent research on mathematics attitude and calls for reform in mathematics curricula.

Attitude as consisting of belief and affect. Current research in mathematics attitude has attempted to distinguish among component parts of attitude. The growing influence of cognitive psychology has led to attempts to separate thought and feeling in the study of attitude. Generally, researchers use the term "belief" to describe the cognitive aspect of mathematics attitude and "affect" to describe its emotional aspect.

"Belief" does not refer to cognition relating to mathematical content (e.g., multiplication tables), but to cognitions that describe the child's understanding of and relationship with mathematics. Various researchers have identified similar sets of beliefs as important to the study of attitude. Schoenfeld (1983) describes various "belief systems" important to performance in mathematical problem solving: about the self, the environment, the specific topic being considered, and mathematics itself. McLeod (1989) describes two categories of beliefs: "First, students develop a variety of beliefs about mathematics as a discipline...A second category of beliefs deals with students'...beliefs about themselves and their relationship to mathematics (p. 246)."

The affective component of mathematics attitude concerns the underlying emotional response inherent in beliefs about one's relationship to mathematics; "affect" describes the emotional basis of a child's beliefs about mathematics. While psychologists use the term "affect" to refer to "a wide range of concepts and phenomena including feelings, emotions, moods, motivation, and certain drives and instincts" (Corsini, 1984, p. 32), affect as a component of mathematics attitude is a long-term, low-intensity feeling toward something such as geometry (McLeod, 1989).

The construction of mathematical experience. Research has indicated that children "construct" their beliefs about mathematics in relation to their social experiences (e.g., Dweck & Repucci, 1973; Fennema & Sherman, 1977; Reyes & Stanic, 1988). In other words, sex, socioeconomic status (SES), and ethnicity make a difference in how children view mathematics. For example, in studies of sex differences, researchers have realized that the general perception of mathematics as being primarily for males has led many girls to experience conflict and anxiety about their ability to do mathematics (e.g., Dweck & Elliott, 1983; Fennema & Sherman, 1977).

This research has led to new theoretical developments and has methodological implications as well. For example, Dweck's exploration of children's understanding of the purpose of achievement has resulted in a new theory in motivation (Dweck & Elliott, 1983) that presents two patterns in children's understanding of the motivation and achievement. The theory is based on the children's perspectives. This stands in contrast to traditional approaches that have frequently assumed that there is one perspective -- usually that of the researcher -- and match children's responses with that perspective. The methodological implication here is that research on mathematics attitude (a) needs to allow children to express their own perspectives, and (b) must be sensitive to social differences among children.

The changing mathematics curriculum. The call for change in the mathematics curriculum also has implications for the study of mathematics attitude. As discussed in Volumes I and II of this report, mathematics educators are trying to change the emphasis of the teaching of elementary-school mathematics from computational arithmetic to mathematical problem solving involving many areas of mathematics (NCTM, 1989; National Research Council, 1989). The new curriculum would present mathematics in the service of problem solving rather than presenting it as focused primarily on arithmetic drill and practice. Because the new curriculum and the traditional one are very different, researchers need to make clear what aspects of mathematics they are discussing when they study attitudes toward mathematics.

Summary. The research literature relating to mathematics attitude indicates that the topic is complex and poses real challenges for study. The study of attitude toward mathematics needs to consider beliefs about the subject, beliefs about oneself in relation to the subject, and affect (emotional responses to mathematics that have become stabilized over time). Additionally, the study of attitude must take into account the fact that children of different backgrounds will have different relationships to mathematics.

Lastly, the changing subject matter of mathematics itself needs to be considered in studying attitude. School mathematics is being redefined to include a range of activities and skills that are new to the curriculum. One cannot simply study attitudes toward "mathematics" but must specify exactly what type of mathematics is under consideration.

Conceptualization of Attitude in the Present Study

In examining mathematics attitude, we used a theoretical foundation that is in keeping with recent research. We viewed attitude in terms of dimensions of belief that children hold about the subject and about their relation to the subject. Also, we assessed the positive or negative feelings underlying the children's beliefs about their relationships to mathematics (which we refer to here as "affective response" or "valence"). We also explored the distinction between traditional mathematics and mathematics as problem solving by dividing the study into three domains of mathematical inquiry: novel problem-solving activities (i.e., the Problem-Solving Activities, or PSAs, described in Volumes I and II[1]), problem solving generally, and mathematics in and out of school.

Goal I and the Development of Attitude Dimensions

As stated above, our purpose in this study was to develop an understanding of attitudes toward mathematics and to assess the effects of viewing **SQUARE ONE TV** on those attitudes.[2] In developing the dimensions of belief and affective response for our study, we were guided by Goal I of **SQUARE ONE TV**: "to promote positive attitudes toward, and enthusiasm for, mathematics."

[1] Recall from Volumes I and II that the PSAs are a range of mathematically rich, nonroutine, problem-solving situations. Each PSA allowed children to demonstrate the problem-solving actions of Goal II and to reach solutions through a variety of approaches. Three sets of PSAs were used, each at a different level of complexity. The least complex problems, PSAs A and A', were combinatorics problems involving circus performers or stripes on a shirt. PSAs B and B' were of medium complexity and involved sorting party guests or price tags into piles that met several conditions. PSAs C and C', the most complex PSAs, asked children to determine what was wrong with a mathematical game and to fix it; PSAs C and C' involved the owner of a game factory, Dr. Game (and were often referred to, by the researchers and children, as "the Dr. Game thing"). For the purposes of this report, we use, e.g., PSA A* to refer to the pair of PSAs A and A'. Further detail on the PSAs may be found in Volume II.

[2] Generally, when a reference to "mathematics" appears in the text, the term refers to the three domains of mathematical inquiry that have been mentioned above and will be discussed in greater detail subsequently.

Our division of Goal I into belief dimensions was guided both by the subgoals of Goal I and by previous research (Aiken, 1970; Eccles, 1980; Fennema & Sherman, 1976; IAEEA,1986). The research literature presented various aspects of children's attitudes toward mathematics, e.g., their enjoyment, their understanding of mathematics as a discipline, their perceptions of its usefulness, their persistence in the face of failure, and so on. These various aspects of attitude represented different dimensions of belief about mathematics and one's relationship to it.[3]

We determined that there were four specific attitude dimensions that were consistent with the goals of **SQUARE ONE TV**, particularly Goal I ("to promote positive attitudes toward, and enthusiasm for, mathematics") and its subgoals. The first subgoal, Goal IA, states that "mathematics is a powerful...tool, useful to solve problems...and to increase efficiency." This relates to children's beliefs about the usefulness and importance of mathematics. Goal IB ("Mathematics is beautiful and aesthetically pleasing") relates to children's beliefs about their enjoyment of mathematics. Finally, Goal IC states that the series should promote the concept that "mathematics can be used, understood, and even invented by non-specialists." This subgoal relates to children's beliefs about their motivation to engage in mathematical activities. Enjoyment and motivation are also related to the "enthusiasm" described by the overarching statement of Goal I. Finally, all three goals of **SQUARE ONE TV** (concerning attitudes, problem solving, and mathematics) relate to children's constructs of mathematics, i.e., their conceptions of what mathematics is.

Because the dimensions of enjoyment and motivation concern children's beliefs about themselves in relation to problem solving and mathematics, we could also assess the positive or negative affect underlying their beliefs within these two dimensions.

[3] Conversations with children during our pilot-test phase, which will be described in Chapter 2, enabled us to determine whether these dimensions were appropriate to children of this age and how to ask children questions about them.

The Development of Three Domains of Mathematical Inquiry

We decided to create three distinct areas, or "domains," of mathematical inquiry: (a) the novel PSAs, (b) problem solving generally, and (c) mathematics in and out of school. As discussed above, mathematics attitude research traditionally has posed questions about "mathematics" without any explication of what "mathematics" is (see Kulm, 1980). This has left unclear what "mathematics" the children were referring to in their responses and left unknown what "mathematics" meant to the children. Because children's conceptions of "mathematics" are apt to be limited by their limited experience with the subject, their conceptions of "mathematics" are likely to differ from those held by researchers or the creators of SQUARE ONE TV. Therefore, we wanted to capture the children's beliefs relating to "mathematics" in their own terms. What the children identified as "mathematics," and their relationship to it, became the focus of our questions in the Mathematics Domain.

We also wanted to explore the children's conceptions of problem solving. Questions relating to problem solving in general formed another domain, the Figuring Out Domain. We have named this domain "Figuring Out" because "figuring out" is the term that children often used in their discussion of solving problems. The questions in this domain asked children to identify and to discuss their experiences with solving problems (mathematical or nonmathematical) in their own lives.

A third domain, the PSA Domain, was created to continue our exploration of children's conceptions of problem solving. The children's discussion of problem solving in the Figuring Out Domain allowed each child to discuss his or her own experiences with problem solving. It seemed reasonable to expect that the experiences children chose to discuss would vary widely across the sample, which might interfere with our ability to examine data across the children. Thus, to facilitate analysis, we felt it would be prudent to ask the children about a common experience of problem solving as well; the hands-on Problem-Solving Activities used in the problem-solving portion of the present study provided such an experience. Using the PSAs as a basis for questions was also compelling because the PSAs are an example of the sort of complex problem solving that proponents of mathematics reform would like to see as part of a revised curriculum.

Summary

Using Goal I of **SQUARE ONE TV** as a guide, we conceptualized four attitude dimensions: construct of mathematics, usefulness and importance, motivation, and enjoyment. Questions were developed to elicit responses indicating children's beliefs and, in the case of motivation and enjoyment, their affective responses. We asked these questions in three domains of mathematical inquiry (the PSA Domain, the Figuring Out Domain, and the Mathematics Domain).

Outline of Volume III

After Chapter 2, on Pilot Testing and Methodology, this volume will contain one chapter dealing with each of the four belief dimensions that we have just described. Within each chapter, we will present: (a) an introduction to the theoretical and analytic framework of the dimension, (b) a detailed description and discussion of the children's responses to questions concerning that dimension, (c) the development of the analysis scheme for measuring the effects of **SQUARE ONE TV**, and (d) the results of the analysis and a discussion of the effects of the series. The final chapter will present the conclusions that we draw from our data.

CHAPTER 2

PILOT TESTING AND METHODOLOGY

Introduction

The purpose of this chapter is to present the development of the methodology used in the present study. Two instruments were created to study attitude: the Attitude Interview and the Essay. The Attitude Interview is a series of open-ended questions individually administered at the pretest and posttest to the subsample of 48 children who worked with the PSAs.[4] The Essay is a group measure given to all of the 240 children in the sample toward the end of the **SQUARE ONE TV** viewing period. This chapter will discuss the conception, pilot-testing, and initial steps in the analysis of the Attitude Interview and the Essay.

General issues regarding the instrumentation are presented in this chapter. Issues relating to a specific dimension can be found in the subsequent chapter on that dimension. The complete protocol for the Attitude Interview can be found in Appendix III.B.

The Attitude Interview

Purpose

We designed the Attitude Interview to provide in-depth information from fifth-grade children that would allow us to develop a detailed description of their attitudes and to measure attitude change. Our decision to interview was supported by two other factors: (a) the call for qualitative methods in the research literature on mathematics attitude, and (b) a desire to use

[4] Recall from Volume I that the sample of 48 children was evenly divided by sex and SES. 29% of the children were Anglo, 4% were African-American, and 67% were Latino; these percentages mirrored those found in the local school district and were nearly identical to the percentages for the larger sample of 240 children.

a method consistent with the one-on-one Problem-Solving Activities (PSAs) described in Volume II. We will consider these issues in turn.

The call for qualitative methods. Several researchers in mathematics attitude have called for qualitative methods as an alternative to traditional scales (Hart, 1989; Kulm, 1980; McLeod, 1989). Kulm, arguing for the self-reporting offered by interviews, asked rhetorically in 1980: "What better way is there to determine a subject's attitude toward math than to ask a direct question? Unfortunately, self-report has often come to mean self-report scale" (p. 362). Qualitative methods provide the opportunity for a detailed, empirical exploration of children's mathematics attitudes arising from the children's own responses rather than attempting to fit children's responses to the researcher's preconceived conceptions; an open-ended interview would allow children to respond freely to our questions and give us, as interviewers, the ability to pursue their lines of thought; this would provide the opportunity to develop as complete an exploration of the children's beliefs and affective responses as possible.

Congruence with the PSAs. There were two reasons why the choice of an open-ended interview was compelling in light of the PSAs used in the problem-solving portion of the study. First, as discussed in Volume II, the PSAs took the form of task-based interviews (Davis, 1984) aimed at exploring children's thinking in depth.[5] The use of a task-based interview for the PSAs suggested the creation of an instrument for measuring attitude that would similarly allow for an exploration of the children's ideas and reactions.

Second, an open-ended interview provided a means to distinguish between the children's attitudes toward traditional mathematics and their attitudes toward more sophisticated mathematical problem solving. Children can discuss "mathematics" because they have had years of experience with a subject called "mathematics" in school; thus, with little difficulty, we can understand their explanations of their experience. Children's explanations of problem solving

[5] In our task-based interview approach, a child was presented with a problem-solving task to solve and then asked to discuss it with a researcher.

are another matter. Without a shared context, it is difficult to interpret and to compare one child's ideas with another's. The PSAs gave us a shared context and a concrete example for discussing problem solving with the children.

Procedure

The pretest and the posttest each consisted of two 55-minute testing sessions conducted on two consecutive days. On the first day of the testing session, the children worked with two problem-solving tasks, PSAs C* and B*. The second day of testing consisted of PSA A* and the Attitude Interview.[6] Each of the 48 children in the subsample participated in an approximately 40-minute Attitude Interview administered by an interviewer who was blind as to the child's experimental condition (viewer or nonviewer). Interviewers were trained to make the children feel as comfortable as possible, to follow up the children's responses with questions, and to rephrase questions as needed; each of these points will be discussed later in the chapter. The interviews were video- and audiotaped for subsequent transcription and coding. Each child worked with the same interviewer in the pretest and the posttest Attitude Interview. Further details on the procedure employed in the study are presented in Volume I.

Issues Addressed in the Pilot-Test Phase

From June 1988 to January 1989, we developed and refined our methodology and the specific questions used in the Attitude Interview. Through an iterative process we developed and tested the Attitude Interview with small groups of children in two New York City public schools. The pilot-test phase concluded with an informal pilot test of the study that will be described later in the chapter.

[6] The reader is referred to Volume II for a discussion of the sequencing of the PSAs within the testing sessions. Due to time constraints, the children could not complete PSA A* in the same testing session as PSAs C* and B*. The inclusion of PSA A* in the second testing session also gave the children another experience with problem solving that provided continuity between the two days of testing.

In developing the Attitude Interview, we had to address many interrelated issues, such as: How should questions be constructed to ensure that children will understand them? How can we maximize the degree to which questions are parallel across the PSA, Figuring Out, and Mathematics Domains? How do we ask children fairly complex, abstract questions and obtain meaningful information? How do we prevent children from merely giving us the answers that they think "we want to hear?" How do we ask questions about the children's feelings without making them uncomfortable?

Our discussion in this chapter will focus on these issues as they related to the development of the interview as a whole. We will use specific examples to illustrate these general issues as appropriate. The development of questions within each attitude dimension will be discussed in the relevant chapter on that dimension.

Developing interview dimensions and questions. The process of developing interview questions began with a sensitivity to the differences between the interviewers and the children. These differences existed on a variety of levels: differences in the understanding of issues, in the ability to articulate, and in conceptions of mathematics, as well as possibly in ethnicity, social class, and sex. These differences made us particularly aware that the children might not interpret our questions as we intended them. We began by exploring ways of talking with the children about their thoughts and feelings relating to mathematics and the PSAs.

For this reason, our initial aim in the pilot-test phase was to explore the ways and language in which children describe their thoughts and feelings about mathematics. At this stage, we did not ask questions within individual dimensions of attitude; instead, we asked broad questions designed to provide information about children's experiences with mathematics and problem solving and the terminology that they used to describe those experiences. For example, we would ask a question about a child's experience with problem solving, such as "Can you tell me about a time when you had to solve a hard problem?" and then ask follow-up questions. By examining children's answers to these questions, we could determine what "solving hard problems" signified to the child. Would the child talk primarily about, e.g., persistence (an aspect of motivation) or about confidence? The responses obtained in this phase of the study helped us to decide upon dimensions of attitude (related to the goals of **SQUARE ONE TV**) that seemed appropriate to investigate with children of this age and to revise questions targeting those dimensions.

We also solicited the children's assistance in learning how to phrase questions appropriately. In our early interviews, we asked each child why he or she thought we were asking these questions. This enabled us to clarify our questions based on the children's rephrasing and interpretation of them.

After interviewing, we coded the children's responses by grouping them into dimensions of attitude. This allowed us to develop the attitude dimensions and, at later stages, to determine whether our questions were eliciting responses within the dimensions of interest, thus allowing us to confirm and refine our understanding of the dimensions themselves. In this way, we developed a knowledge base from which we were able to ask more specific questions targeted for each dimension.

Identifying appropriate ways to explore domains. Given our desire to collect data within three domains of mathematical inquiry (the PSAs, Figuring Out, and Mathematics), we had to be sensitive about the terms that we used to describe these domains. Two examples of how we addressed this concern follow; one relates to the use of the term "math" and the other to the use of the term "figuring out."

We did not want to use the word "math" when we were asking the children about their experiences with the PSAs and other problem solving because children's conceptions of mathematics are often confined to computational arithmetic (e.g., Kouba & McDonald, in press; Schoenfeld, 1983). We were concerned that an early use of the term "math" in the interview would shape the children's responses to all subsequent questions and constrain their discussion of problem solving to solving arithmetic problems. Thus, the term "math" was used only in the

Mathematics Domain, which was the last domain presented in the interview; the first use of the word "math" in the interview protocol occurred after two thirds of the questions had been asked.

Another way in which we attempted to make our questions sensitive to children's language involved the use of the term "figuring out." Our discussions with children suggested that children associate the term "problem solving" with the computational word problems that they are given in mathematics class. "Figuring out," on the other hand, was a term that we heard the children use to describe their thinking and process of problem solving, and so we used the children's own term to ask questions about their relationship with the PSAs and problem solving in general. For example, in order to ask the children if the problem solving that they did in PSA B* was important, we asked, "Is being able to figure out things like this important?" rather than "Is being able to solve problems like this important?"[7]

We were aware, even as we used the term "figuring out," that this more generic phrase would sometimes elicit information that was nonmathematical and not concerned with mathematical problem solving. For example, when we asked the children to describe things that they like to figure out, many children discussed a wide range of problem solving (both mathematical and nonmathematical) that they enjoy. There were some children, however, who replied that they liked to "figure out whether to do homework or go outside." While these nonmathematical responses were not particularly relevant to our study, we felt that it was preferable to collect nonmathematical responses than to collect information solely about computational arithmetic problems.

Facilitating comparisons across the domains. We also were aware that questions concerning a given attitude dimension could not be asked in the same way in each of the domains. For instance, while PSA C* is a specific task and, thus, we could ask children if they

[7] The immediacy of the one-on-one interview situation allowed us to use seemingly ambiguous referents (e.g., "things"). Use of this language also made the interviews seem casual, thus putting the children more at ease.

found it fun, we could not have asked this question about "math" because it is far too broad a term for children to be able to answer the question in a meaningful way. Thus, we asked students instead for specific experiences in mathematics that they enjoyed and specific uses that they enjoyed to narrow their mathematics responses to discrete tasks and, in so doing, facilitate comparisons with questions about the PSAs.

It should be noted, however, that we did not assume that children's responses within a given dimension would be the same across all three domains. In other words, we recognized that what children enjoy about mathematics tasks might be different from what they enjoy about the PSAs.

Asking abstract questions. Some of what we wanted to know from the children was conceptual in nature (e.g., the steps that they use in solving problems, or what they think mathematics is). We were aware that children of this age might not find it easy to articulate abstractions, but we did not wish to assume that they could not do so at all. Thus, we needed to find a way to ask these questions that would allow the children to understand and respond as competently as possible.

This process can be illustrated in the way we asked the children to define mathematics. We realized that this was a broad, abstract question that one rarely thinks about, and, as such, would probably be difficult even for an adult to answer. For this reason, we decided to ground the question in a concrete context to make it easier to answer. In our first attempt, rather than asking the children to define "math," we asked them, "If you had to explain what math is to someone who had never heard of it, how would you explain what math is?" The interviewers, when met with looks of puzzlement, followed up by asking, "What would you say, like, to a friend?"

We found that this approach did not work because the children's friends knew what mathematics was as well as they did. To avoid this assumption of shared knowledge, our next version of the question asked, "If you had to explain what math is to someone who had never heard of it, maybe someone from another planet, what would you say that it is?" This worked fairly well. The children accepted the premise and knew that they had to explain the most important aspects of mathematics. We had a few problems, however, with some children who explained, quite logically, that an alien wouldn't speak the same language as we do. Thus, in our final version of the question, we asked, "If you had to explain what math is to someone who had never heard of it, maybe someone from another planet who happens to speak English, what would you say that it is?" This question worked very well. By giving the children a concrete context, we were able to elicit what they seemed to find most relevant to communicate about mathematics.[8]

The social studies disguise. In designing the interview, we were concerned that the children might realize that our interest was in mathematics and that this could bias them toward giving responses about "math" in the PSA and Figuring Out Domains. In fact, in our early work in developing the interview, some of the children who knew that we were SQUARE ONE TV researchers mentioned "math" in response to virtually every question that we asked, apparently in an attempt to please us. While the children's knowledge of our interest in mathematics was useful in the pilot-test phase, when we were developing an understanding of how children talk about the subject, such a bias could have affected the integrity of the responses had it arisen in the actual study. Thus, we decided that we should "disguise" the intent of the interview by asking questions about social studies that would be similar to those asked about mathematics.

The "disguise" was introduced at the beginning of the Mathematics Domain questions. We stated, "Now, let's move on to something else. I'd like to talk a bit about math and then about social studies." Interviewers were instructed to ask as many of the social studies

[8] Naturally, we recognized that no child would describe everything that he or she considered to be "math" in his or her response. However, the children's responses would represent those aspects of mathematics that he or she would consider most important and relevant about the subject. For a more complete discussion of this point, see Chapter 3 (Construct of Mathematics).

questions as possible, with a minimum of three, given the time constraints of the interview. This helped dilute the mathematics focus of our inquiry.

The relationship between the interviewer and the child. Several aspects of the Attitude Interview required that we pay close attention to the relationship between the interviewer and the child. Some questions asked children to reflect upon their performance with the PSAs that they had completed on the previous day and others asked for abstractions about new topics. We were concerned that such questions might make children uncomfortable, and so, we took two steps to ensure their comfort while at the same time, enabling us to collect the information that we needed.

The first step involved using different interviewers across the two interview sessions; each child worked with one interviewer on Day 1 (PSAs C* and B*) and a different interviewer on Day 2 (PSAs A* and the Attitude Interview). If the same interviewer had been used in both sessions, then, when the interviewer asked the child questions about the PSA C* and PSA B* experience in the second testing session, the child might have interpreted this to mean that he or she answered the questions "incorrectly" in the previous session. By having a different interviewer ask the questions on the second day, this potential stigma was removed.

The second step in ensuring the children's comfort was establishing an atmosphere in which children felt free to elaborate upon their ideas. Interviewers were trained to encourage the children to speak at length and to ask follow-up questions when they did not. Interviewers were also trained to ask for clarification of ambiguous responses and key words such as "math," to rephrase interview questions when children did not understand them, and above all, to follow up each response to each question with a "why?" or a request for further clarification. Because we were investigating children's beliefs in depth, we wanted to obtain as full an elaboration of each response as possible.

The Informal Pilot Test

Toward the end of the eight-month development phase, we conducted an informal pilot test that involved children from two schools on New York City's Lower East Side. In one school the children were encouraged to view **SQUARE ONE TV**, while children in the other school were not.

The test was conducted with a total of 13 fifth-grade children (seven from one school and six from the other). These children were matched on the basis of SES, neighborhood, ethnicity, age, and sex. In broad characteristics, such as age, ethnicity, and SES, they were also fairly matched to the sample in the actual study.

Both the PSAs and the Attitude Interview were conducted with these children on a pretest-posttest basis. We also used this informal pilot test to continue to refine the questions in the interview. In addition, we were interested in three issues: (a) whether the children's interest and involvement in the interview would wane by the time of the posttest, (b) whether their responses would be stable over time, and (c) whether any effects of viewing **SQUARE ONE TV** could be detected. Our preliminary analysis consisted of reading the pretest and posttest data for each child and comparing the responses. Although there was no formal coding scheme for this analysis, we examined the children's responses for their content and complexity.

In analyzing the transcripts of the pilot data we did not notice any decline in the children's involvement with the interview. Answering the same questions twice over a six-week interval did not seem to make them bored or less responsive. We also found that the responses were basically stable from pretest to posttest, suggesting that the questions were tapping into enduring concepts relating to mathematics and problem solving. Finally, in this preliminary analysis, we detected slight positive differences in the way that the viewers of **SQUARE ONE TV** were describing mathematics. While the change was subtle, we were sufficiently encouraged to pursue the study.

The Method of Analysis

We will now turn to the issues surrounding our analysis of the Attitude Interview. Two qualitative methods of data analysis were used in the study, one pertaining to the measurement of the effects of viewing **SQUARE ONE TV**, and the other ("content coding") pertaining to the descriptive analysis of children's attitudes in the absence of any treatment (i.e., at the pretest). Specific issues relating to the coding of individual attitude dimensions can be found in the relevant chapters on those dimensions.

Coding for the analysis of change. Beginning in October 1989, researchers met in a series of "open coding meetings" to discuss the development of a coding scheme for each attitude dimension. Open coding meetings are collaborative coding sessions in which coding categories for data are discussed and debated among a group of researchers (see Strauss, 1987, for a discussion of this methodology). Such meetings ensure that a variety of perspectives are represented in the coding of the data.

Sixteen posttest interviews were selected for initial review. The interviews used in these coding meetings were equally divided between viewers and nonviewers and selected to be representative of sex, ethnicity, and SES. Selection of the interviews was also made on the basis of the change in the children's performance on PSA C* from pretest to posttest; some of these children made significant gains on PSA C* and some either did not change or declined. To preserve the integrity of the experimental design, the researchers were blind to all of these conditions.

The aim was to achieve a high degree of variety in this first subset of interviews so that the resulting schemes could capture as wide a range of responses as possible. Because the interview situation was so novel for the children, we felt that the posttest interviews would represent richer data because the children would be more familiar with the process than they had been in the pretest interviews. Additionally, we wanted to create schemes that would be sensitive to any potential changes stemming from the effects of viewing **SQUARE ONE TV**.

The most efficient way to ensure that any new or different statements made by the children in the posttest were included in an analytic framework would be to use the posttest data in the development phase.

An open coding meeting was held for each attitude dimension.[9] The researcher responsible for the dimension presented her analysis of the first 16 cases, which included an investigation of important words, concepts, and themes that appeared frequently within the responses of individual children or across the responses to particular questions. This entire research team discussed the presentation and asked for clarification, noted contradictions, and suggested alternative interpretations. From this discussion, the presenting researcher would write a memo on the discussion describing preliminary coding categories to be used in analyzing the initial 16 cases.

Through a series of such meetings, coding schemes were developed and refined. Next, the researchers reviewed the pretest interviews of the same 16 children whose posttest interviews had been analyzed previously. Pretest and posttest interviews for an additional eight children, matched according to the criteria mentioned above, were used to finalize the coding schemes.

Once the schemes were developed, the researcher who developed the scheme coded the remaining data, and statistical analyses were performed to compare the patterns of change shown by viewers and nonviewers. Another researcher also coded a randomly selected group of 16 interviews to assess the reliability of the coding scheme. The results of the analyses of interrater reliability will be presented in subsequent chapters and in Appendix III.K.

Content coding for the descriptive analyses. While the above analysis was conducted across all of the questions in a given dimension, certain questions and topics that are key to an

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[9] The team of researchers who participated in these meetings consisted of a research consultant and two staff researchers. Two of the three members of the research team interviewed children in the study. Each member of the team was given one or more attitude belief dimensions for which to develop a coding scheme.

understanding of mathematics attitude have been analyzed individually as well. These analyses, which we call the "descriptive analyses," form the basis of our in-depth description of children's attitudes as they occur naturally, i.e., in the absence of any treatment.

Pretest responses to the key questions in each dimension were collected and coded for content. Content coding, as described by Miles and Huberman (1984), simply involves grouping data into categories that are evident in the data. For example, the content analysis of the things that children enjoy figuring out collects into a "game" category all responses that have to do with games, collects into a "mathematics" category all responses that concern mathematics class or problems, and so on. The resulting categories are intended to be descriptive of the variety of responses presented by the children in the sample. All categories were examined by sex, SES, and ethnicity to determine if certain categories of response were more typical to one subgroup than another.

The Essay

Purpose

As mentioned in Chapter 1 of this volume, the Essay was developed to assess the attitudes of the entire sample of approximately 240 children using dimensions similar to those used in coding the interview.

A large-group measure. The inevitable limits on resources (i.e., personnel, time, and money) precluded the use of the Attitude Interview with more than 48 children. However, because our total sample size included 240 children (i.e., the approximate number of fifth graders in the four schools included in the study), we wanted to develop an instrument that would permit the assessment of attitude with this entire group. Such an instrument would increase our analytic power and provide a measure that could be compared with the interview responses.

A compatible method. We wanted the large group measure of attitude to be compatible with the Attitude Interview in that it would employ an open-ended question and would capture at least some dimensions of attitude covered in the Attitude Interview.

Several different methodological approaches were considered. While the most widespread method for assessing attitude in large samples is through pencil-and-paper scales, simple scales seemed inappropriate as they would have allowed too little room for the expression of any but a highly restricted range of responses. Written essays, on the other hand, provided a method that could be easily administered to large numbers of children but would provide them with a means of expressing themselves somewhat more fully than would pencil-and-paper scales. Although essay data necessarily would be less detailed than the interview data (because interviewers could, for example, ask children to clarify ambiguous responses), this sort of data appeared to be more in keeping with the approach of the Attitude Interview than pencil-and-paper scales would have been.

In addition, essay data had been used successfully in formative testing for the CTW science series 3-2-1 CONTACT (see Mielke & Chen, 1983, pp. 37-38 for a description of the method as used in that testing). Given an appropriate topic, it seemed reasonable to expect that an essay could allow the children to discuss dimensions of attitude presented in the Attitude Interview.

The Pilot-Test Phase

The main objective of the pilot-test phase was the development and testing of the questions for the Essay and the buffer essay.[10] After the questions were developed, they were tested in a pilot test involving 82 children in a public school in Long Island, New York. The

[10] Although the children in the study were accustomed to writing in-class essays on a regular basis, a second, "buffer" essay was administered one week before the essay to accustom the children to writing assignments in the particular format that we were going to use. The "buffer" essay was thus very similar in format to the Essay, but it made no reference to mathematics.

purpose of the test was to assess the feasibility of using the Essay and to collect data from which a coding scheme could be developed.

The Essay question. One of our chief concerns in developing the question was that it provide the children with an opportunity to write about attitude dimensions of interest to our study without directing the children to respond in certain ways. The two dimensions that seemed to be the most appropriate to an essay format were construct of mathematics and usefulness/importance. A question based on either of these dimensions could be made fairly concrete and provide opportunities for children to make statements regarding motivation and enjoyment as well.

Given our desire to have the children write about both mathematics and its uses, our first approach was to ask the children to write about what mathematicians do. However, this concept was discarded because it relied too heavily on the word "mathematician," which is typically unfamiliar to children of this age and very similar to the word "mathematics." As described previously in this chapter (and more fully in Chapter 3), children's concepts of "math" are often dominated by arithmetic. We were concerned that, without other support, the children might limit their responses to school-based arithmetic.

Thus, we decided to set our request for applications of mathematics in a broader, more familiar context: that of jobs in the real world. Still, we felt that children might need some encouragement if they were to write and think about mathematics beyond simple arithmetic, and so, we decided to incorporate references to different types of mathematics into the question itself. For pilot testing, the question read as follows:

> Some people have jobs where they figure things out and solve problems using shapes, numbers, measurements, or other things having to do with mathematics.
>
> Write an essay about whether you would or would not like to have this kind of job. Give reasons and examples to help explain your answer.

Circle your topic and write about it in the space below.

Why I would like this kind of job

Why I would not like this kind of job[11]

The results of the pilot test indicated that the children did not interpret the term "like" in a consistent way. Because the question spoke about "liking this kind of job" (in the sense of wanting to have it), it was often unclear whether the children's use of the word "like" in their essays reflected enjoyment of the job they described or simply their wanting to have it. Thus, the word "want" was substituted for the word "like" throughout the question; that is, children were asked to "write an essay about whether you would or would not want to have this kind of job." Despite this change, however, we found in the main study that the children still did not provide responses that could be coded clearly for enjoyment, and so we discarded this dimension from our scheme. Similarly, we discarded the dimension of motivation because responses could not be coded clearly for this dimension.

The buffer essay question. As noted above, the buffer essay was designed to appear similar in format to the Essay but to deal with a subject other than mathematics. However, we wanted the buffer essay to provide us with information on some topic that might be of interest outside the study. Several questions were considered. One potential question investigated children's perceptions of educational television. Others solicited their views on broader educational issues, such as whether the only way to learn is to memorize. The question that was finally selected asked children whether they thought that the only way to learn was by reading books. Because we had no experimental predictions related to this topic, the data from the buffer essay were not analyzed for the present study.

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[11] In order to minimize the effects of response biases, the order of topics was reversed for half of the children in the sample. For those children, the choice of topics was presented as:

Why I would not like this kind of job
Why I would like this kind of job

Procedure

Forms for the Essay and the buffer essay were sent to the schools with explicit instructions for administration by the teachers. The buffer essay was given to the children as an in-class assignment during the fifth week of the treatment and the Essay was administered one week later. The teachers were instructed not to give examples of "good" responses, not to refer to the interviews that had taken place, and not to make any reference to **SQUARE ONE TV**.

On each occasion the children were given 40 minutes of class time to write their essays. The children's essays were collected by the teacher at the end of the time period and sent to CTW for analysis.

Constructing Coding Dimensions

The pilot-test data were used to develop coding categories for the essays. All of the responses from the pilot test were read by a staff researcher familiar with the attitude belief dimensions, and categories were developed for each dimension based on the range of responses within the Essay. These categories were then used to analyze the data from the study. Each essay was read several times, twice for each attitude dimension. The final categories developed for construct of mathematics and usefulness/importance will be discussed in the subsequent chapters on those dimensions.

CHAPTER 3

CONSTRUCT OF MATHEMATICS

This chapter presents the results of our inquiry into children's understanding of what mathematics is, i.e., their constructs of mathematics. Current research indicates that children's attitudes toward mathematics are intrinsically bound up in their beliefs about what it is (e.g., McLeod, 1989; Schoenfeld, 1983). Thus, our discussion of construct of mathematics will lay a foundation for the rest of the discussion in this volume.

Two sources of data have been used in this chapter: children's responses to the construct of mathematics questions in the Attitude Interview, and their responses to the Essay. The chapter contains: (a) an introduction to our analysis, (b) a descriptive analysis of children's responses about mathematics, (c) a similar descriptive analysis for children's responses about problem solving, (d) the development and presentation of analysis schemes for assessing the effects of SQUARE ONE TV, and (e) the results of our analysis of change and a discussion of the effects of viewing SQUARE ONE TV.

INTRODUCTION

In this Introduction, we present both the theoretical framework and the methodological approach used in our exploration of children's constructs of mathematics. Although we primarily make reference to the Attitude Interview in our discussion, our rationale refers to the Essay as well.

Theoretical Approach

What is a Construct of Mathematics?

A child's construct of mathematics is his or her conception of what mathematics is: what mathematics consists of, what it is good for, and what one does with it. It seems reasonable to expect that children construct their understanding of mathematics from the "mathematics" others have presented to them, from the sense that they make of that "mathematics," and from their experiences with learning "mathematics." Our analysis of children's constructs of mathematics goes beyond what the children explicitly identified or defined as mathematics. We also interpret what the children seemed to understand as the nature and purpose of mathematics, as well as their understanding of how one learns or knows mathematics, i.e., its epistemology.

A discrete operations construct. One phenomenon that has distressed mathematics educators is illustrated by the following example taken from Schoenfeld (1988). In several studies in Europe, children were asked to solve nonsense problems such as "There are 26 sheep and 10 goats on a ship. How old is the captain?" (p. 83). The children, accustomed to formulaic word problems that require one to add, subtract, multiply, or divide, added the two numbers in the problem to get an "answer." Apparently, these children had developed an understanding of mathematics in which applying the automatic rules of arithmetic was more important than making sense of the problem. Schoenfeld uses this example to make two points that are relevant to our inquiry: (a) children's constructs of mathematics develop out of their participation in the ongoing activities (e.g., repetition and drill) that make up the "culture" of the classroom, and (b) this culture often encourages them to construct an understanding of mathematics that is fundamentally different from the construct of mathematics held by mathematicians.

Recent research on mathematics education supports Schoenfeld's critique of the predominant culture of the elementary-school classroom (Ginsburg & Asmussen, 1988; Kouba & McDonald, in press; Lave, Smith, & Butler, 1988; Resnick, 1988). This research discusses the relationships between children's understanding of mathematics as a discipline and the emphasis on drill, rote procedures, and formulaic word problems that are utilized in traditional mathematics instruction. While these methods generally ensure mastery of basic arithmetic algorithms, they also seem to ensure a rather limited understanding of what mathematics is.

The traditional classroom pedagogy promotes a belief in mathematics as a set of discrete operations: memorized, routine, rule-bound procedures usually involving numbers or counting that are applied to problems that have one correct answer. These discrete operations, by which we mean both computational arithmetic and the individual subject areas other than arithmetic that are taught in mathematics class, are "discrete" in the sense that their unity is determined by their use of numbers and/or inclusion in mathematics class rather than by their having some fundamental coherence as a body of knowledge.[12] Because the traditional classroom is the environment in which most children learn mathematics, it seems reasonable to assume that most children construct their understanding of mathematics as consisting of discrete operations.

[12] Note that for our purposes, then, we use "operations" to refer to more than the standard definition of arithmetic "operations."

A problem-solving construct of mathematics. Schoenfeld contrasts the discrete operations perspective with a concept of mathematics as "sense-making"; "sense-making" requires that children "think mathematically" and "develop the mathematician's aesthetic, a predilection to analyze and understand, to perceive structure and structural relationships, to see how things fit together" (1985, p. 87). This is a construct of mathematics as problem solving. Within the problem-solving construct of mathematics, mathematics is an active process of figuring things out for a purpose. Here, the tools of mathematics such as arithmetic or geometry are important as they help one make sense out of problems that are aesthetic or useful. As Schoenfeld puts it, "'figuring out' is what mathematics is all about" (p. 87).

Curriculum Reform and Constructs of Mathematics

NCTM and the research community. The call for reform set forth by NCTM (1980, 1989) implies the need for a shift in children's constructs of mathematics from discrete operations to problem solving. In NCTM's Standards document, a distinction is made between "doing" mathematics wherein one "creates knowledge in the course of some activity having a purpose" (1989, p. 7) and merely mastering the facts and procedures of the discipline. Mathematics as "doing" is mathematics as problem solving (p. 6) while "mere mastery" represents mathematics as discrete operations. They note that "for many nonmathematicians, arithmetic operations, algebraic manipulations, and geometric terms and theorems constitute the elements of the discipline" (p. 7) as opposed to being viewed as tools used in the process of solving meaningful problems. Researchers in mathematics education share NCTM's concern and have noted the central importance of curriculum reform to create changes in children's understanding of what mathematics is (e.g., Greeno, 1988; Lave, et al., 1988; Resnick, 1988; Schoenfeld, 1988).

Changing children's constructs. How can the reform prescribed by NCTM and others be brought about? Proponents of this reform argue that an understanding of mathematics as problem solving develops within a context where mathematics is presented as being inherently linked with meaningful problem solving. In other words, it is not sufficient for a unit on "problem solving" and other new, discrete areas of mathematics knowledge to be added to existing mathematics curriculum. Rather, the entire approach to the teaching of mathematics needs to change so that mathematical content areas (e.g., arithmetic, geometry, probability) exist in the service of teaching problem solving. For example, in the traditional curriculum children are drilled in multiplication facts, which, after mastering, they will use in stereotyped story problems (Resnick, 1988). In a problem-solving curriculum, children would invent or discover the need for an efficient algorithm for e.g., multiplication, while working on complex, contextualized problems (CSMP, 1989; Willoughby, Bereiter, Hilton, & Rubenstein, in press). The children would then learn their mathematics facts because they would understand the purpose for them.

Too, we must consider when these changes in the curriculum might best be implemented so as to change children's constructs of mathematics. Beliefs about mathematics seem to develop, in large part, in the late elementary-school years (see Kulm, 1980); once formed, they are considered to be stable over time and, therefore, resistant to change (see Hart, 1989; McLeod, 1989). Thus, efforts aimed at promoting widespread change might best be directed toward that period when children are in the process of forming ideas about mathematics -- that is, during the elementary-school years.

The Philosophy of **SQUARE ONE TV**

The philosophy of **SQUARE ONE TV** embodies an understanding of mathematics as problem solving. **SQUARE ONE TV** has been designed to contribute to reform in mathematics education, and, as part of this aim, to expand children's ideas of what mathematics is. Thus, the series attempts to supplement the classroom curriculum by exposing children to "mathematicians' mathematics": mathematics as problem solving.

Methodological Approach

Our aim in examining the data was twofold. The first aim was to describe what the children's constructs were in the absence of treatment: how similar or dissimilar they were from the construct presented on the series. Second, we were interested in determining whether viewing **SQUARE ONE TV** in the absence of any overall curriculum reform would have an effect on children's constructs.[13] In this section we will discuss our approach to analysis, from the development of the construct questions to the first steps in our analysis of the Attitude Interview and the Essay.

The Construct Questions

Our primary goal in the construct of mathematics dimension was to develop questions that would enable the children to discuss their experience with and understanding of mathematics and problem solving. Thus, we wanted to give children a variety of ways to express their understanding of what mathematics and problem solving are about. We asked the children to define mathematics, to describe problem-solving activities that they find engaging, and so on, and to explain where they get their knowledge about mathematics. Understanding the context of the children's learning made their ideas about mathematics and problem solving easier to interpret.

Questions were developed in each of the domains of the interview: PSAs, Figuring Out,[14] and Mathematics. In developing our questions within each domain, we attempted to make some of the questions comparable to facilitate analysis across domains.

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[13]Please note that within our study, we have analyzed children's beliefs about the usefulness of mathematics in Chapter 4. In that chapter we analyze the uses and applications of mathematics that the children mention. The present chapter does not contain that information.

[14] Please recall from Chapter 2 that "figuring out" is the term that we used in asking questions about problem solving in general. In the Descriptive Analysis: Problem Solving section below, we will discuss children's uses of the term "problem solving" itself.

Selecting interview questions for analysis. Numerous questions were designated for analysis within the construct of mathematics dimension. While every question in the interview makes some reference to mathematics, the PSAs, or figuring out, the only questions designated for this dimension were those to which children gave responses that directly revealed their conceptions of mathematics and problem solving. Initially, only a few questions that asked specifically for definitions of mathematics and problem solving were designated as construct questions. However, several other questions also tended to elicit responses that shed light on the children's constructs of mathematics, so these questions were included in the analysis as well.[15]

Below is a list of the questions (identified by question number) considered in the analysis of children's constructs of mathematics. The questions are divided into the three domains of inquiry.

PSA Domain

11. Would you say you learned something from it [PSA C*]? What?

12. Remember how you were thinking when you were doing this [PSA C*]? Do you think that you could use that kind of thinking in other situations? When? In school? Outside of school? Outside of school not including homework?

16. Let's say that when you're in high school you have a chance to take a class that teaches you how to figure out things like the Dr. Game thing [PSA C*]. Would you like to take it? What do you think you would learn?

18. Do you remember the other thing that you did yesterday with the clocks/party tables [PSA B*]? Do you think it's important to be able to figure out things like that? How come?

27. Is being able to figure out things like this [PSA A*] important? How come?

28. Would you say you learned something from it [PSA A*]? What?

29. Remember how you were thinking when you were doing this [PSA A*]? Do you think that you could use that kind of thinking in other situations? When? In school? Outside of school?

[15] Note that many of these questions are also being analyzed for other attitude dimensions.

Figuring Out Domain

35. What kinds of things do you like to figure out?

36. Why do you like to figure ____________ out?

38. Do you like challenging things? How come?

39. What kind of challenging things do you like?

40. Has there ever been anything that you wanted to know and figured out by yourself? Tell me about it.

42. Have you ever tried very, very hard to figure something out and not been able to do it? Tell me about it.

44. What do you feel is important for you to figure out [in life]? What kinds of things do you feel are important to figure out? What about outside of school?

45. Now, you've told me some things that you like to figure out, plus you had the [PSAs].[16] Then there are other things. Let's take a few examples, like if someone went into his/her room and found that all the money was gone from his/her piggy bank and s/he wanted to figure out how to get it back. Or if someone was going to make decorations for a party that starts at a certain time, and wanted to figure out when s/he should start preparing. Or if someone wanted to figure out the fastest way to get to a friend's house. All of these things involve figuring out even though they're very different.

    So, let's talk about figuring out for a moment. What are the different steps you would take in order to figure something out?

46. Is there anything that people usually have to do no matter what kind of thing they're trying to figure out? Anything else?

Mathematics Domain

47. If you had to explain what math is to someone who had never heard of it, maybe someone from another planet who happens to speak English, what would you say that it is?

48. Should this person who doesn't know math learn about it? How come?

49. Can you tell me where you got your ideas about math?

50. Is what you do in math class all there is to math?

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[16] In the actual presentation of this question, the PSAs that the children worked with in the pretest session were described. Also, the gender of the child in the question was matched with the gender of the child being asked the question. That is, if a girl was being interviewed, the child with the stolen piggy bank would be female.

51. Is math useful to you in your life now? Why or why not?

52. Is math useful for you in your life outside of school? Why or why not?

53. Will it be useful for you in the future? Why or why not?

55. Can you tell me about a time when you did or learned something in math that you really enjoyed? What was it? What about it did you enjoy?

60. Can you tell me some fun and interesting ways to use math?

61. Can you name some fun and interesting ways to use math outside of school? [If say homework] Can you tell me some fun ways to use math not including homework?

62. Can you tell me some fun and interesting ways adults use math?

67. Some people say that the only thing that math is is adding, subtracting, multiplying, and dividing. What do you think of that? What else is there?

Developing a Descriptive Analysis

First steps in analysis. As described in Chapter 2, the first step in the data analysis consisted of a review of 16 posttest interviews, eight viewers and eight nonviewers (unidentified as such to the research team). The second step was to review the pretest interviews of these same children. This preliminary analysis guided our approach to developing both the descriptive analysis and the analysis of the effects of viewing **SQUARE ONE TV**.

Our initial analysis supported the research literature's claim that children view "math" as a series of rule-bound, discrete operations. However, the data also revealed far more complexity than this claim would suggest. First, when the children defined mathematics, their responses were not monolithic. That is, the children did not only talk about mathematics as addition, subtraction, multiplication, and division, but spoke about different aspects and uses of mathematics as well. Second, the children's discussion of problem solving (i.e., the PSAs and figuring out) presented a very different understanding from that expressed about "mathematics." Clearly, the coding scheme for our descriptive analysis had to be able to encompass the full range of the children's responses.

Key question analysis and other sources of data. In the descriptive analysis of the pretest responses, we analyzed certain "key questions" -- those questions (in each domain of the interview) that provided a good overview to the children's beliefs about mathematics and problem solving. While no one question presented everything that the children understood about mathematics and problem solving, an analysis of the key questions could provide a composite portrait of th. ·· .ildren's construct of mathematics. The questions that were designated as key questions for this analysis were Questions 11, 16, 45, 47, 49, 50, and 67; each is given in the list of questions presented above.

The children's pretest responses to these questions were used to create categories of responses that were derived from what the children said rather than being theoretically based. For example, because many children said that what they learned from doing PSA C* was how to fix a game, a category of "fixing" responses was established. The categories w· ·; very detailed, and, although specific to a particular question, often pointed to issues that emerged in all of the key questions under investigation. The two mathematical constructs discussed earlier, discrete operations and problem solving, provided a framework within which all categorized responses were interpreted.

Two additional sources of data were used in this descriptive analysis as well: children's spontaneous uses of the terms "math" and "problem solving," and the mathematical content areas that they mentioned.

All responses were examined according to sex, ethnicity, and SES. No consistent pattern of differences was evident in the data. Descriptions of the categories used in coding, as well as the distributions within these categories according to sex, ethnicity, and SES, can be found in Appendix III.C.

Assessing Change due to SQUARE ONE TV Viewing

The likelihood of change in children's basic beliefs. As discussed above, research indicates that children typically hold a discrete operations construct of mathematics and that their beliefs are stable. These beliefs about mathematics develop gradually over time with exposure to situations that are identified for the children as mathematical. Given that SQUARE ONE TV is intended to be a supplement to the curriculum, we realized that 30 programs of SQUARE ONE TV were not likely to be of sufficient duration or intensity to alter the basic framework of children's beliefs about mathematics. While a radical shift in children's constructs of mathematics from discrete operations to problem solving might result from sustained curriculum reform across generations of mathematics learners, in analyzing the change due to viewing we needed to determine whether change might have occurred at a less global level.

Developing a scheme for the analysis of change. The preliminary analysis of 16 pretest and posttest interviews provided valuable information in the development of our scheme for assessing change. First, we recognized that each response that the children made carried slightly different information; different questions tapped different aspects of a child's knowledge and experience with mathematics. In order to examine all of the ideas that a child presented, each construct of mathematics question needed to be included in the analysis to develop a complete picture of the child's thinking about mathematics.

Second, because children's constructs of mathematics as discrete operations had developed over their years in school, we recognized that change would have to be assessed within the limits of their present constructs. That is, given that the children viewed mathematics as independent, discrete tasks or operations, we wanted to examine whether this collection of operations would expand as a result of viewing SQUARE ONE TV.

Therefore, we developed a coding scheme to assess change within the children's framework of understanding mathematics. The scheme looked for changes in the children's level of sophistication, both in the problem solving they d_scribed and in their mentions of different content areas of mathematics. This scheme allowed us to use inferential statistics to determine whether, as a result of viewing **SQUARE ONE TV**, the viewers improved. The development of this scheme, and its results, will be presented in detail later in this chapter.

The Essay. Like the Attitude Interview, the Essay was coded for the types of mathematical content mentioned by the children. The scheme used for this coding will be presented later in this chapter.

DESCRIPTIVE ANALYSIS: MATHEMATICS

In his part of the chapter, we present the descriptive analyses of children's understanding of "mathematics" in the absence of any treatment, i.e., in the pretest. These analyses will be presented in four sections followed by a conclusion. The first, "Children's Explicit Definitions of Mathematics," concerns children's responses to questions that asked them explicitly to define mathematics; these responses have been interpreted in relation to the two epistemologies (discrete operations and problem solving) that have been described previously. The second section, "Children's Spontaneous Mentions of 'Math,'" examines children's use of the term "math" in the Figuring Out and PSA Domains. The third, "Content Areas of Mathematics," presents the different mathematical content areas that children mentioned throughout the interview. The fourth, "Sources of Mathematics Knowledge," examines children's responses to two questions about the context of their mathematics learning, to determine both the sources of their mathematics learning and, more specifically, the role of school in their mathematics learning.

Overview of Results

As we expected, a discrete operations framework structured the children's constructs of mathematics. They presented mathematics as a decontextualized list of skills involving numbers that are learned in mathematics class (e.g., addition and subtraction). Both when they defined mathematics explicitly and when they used the term "math," they were referring to a discrete operations mathematics. Yet, the children's experience of struggle toward mastery of these basic (and usually arithmetic) operations was both powerful and challenging to them. This experience of struggle seemed to result in their thinking that the term "problem solving" is defined by this process of struggle, and this understanding of "problem solving" became a part of what they understood mathematics to be about.

A small group of children defined mathematics as something that is useful in different contexts of their lives. These children usually were referring to mathematics' utility in terms of fairly routine applications of the computational arithmetic that they have been taught in school. The overwhelming majority of the children, in fact, considered school to be the source of their ideas about mathematics and agreed that all there is to know about mathematics is taught in school.

Children's Explicit Definitions of Mathematics

Approach

Although we realized that few people can easily convey all of what they understand mathematics to be, we nevertheless wanted to hear what children would say in response to direct questions asking them to define mathematics. While an individual child's response may not have presented all that he or she considered important to say about mathematics, the children's responses as a group gave us insight into what they identified as most salient and important about mathematics.

We specifically asked children to define mathematics in response to two different questions. The first question, "If you had to explain what math is to someone who had never heard of it, maybe someone from another planet who happens to speak English, what would you say that it is?" (Q47) was asked as the first question in the Mathematics Domain, which occurred approximately two thirds of the way into the interview. This was the first instance where the interviewer mentioned the word "math" in a protocol question.

The other question gave children a chance to react head-on to a very restricted definition of mathematics as discrete operations: "Some people say that the only thing that math is is adding, subtracting, multiplying, and dividing. What do you think of that?" (Q67). This question was positioned at the very end of the Mathematics Domain so that this question would not influence the bulk of the children's responses.

The following discussion will concern the children's responses to these two questions, focusing alternately on each one. As described earlier, the method used to analyze key questions involved clustering the children's responses into categories. These categories were then examined according to sex, ethnicity, and SES; we did not detect any consistent differences in the data as a function of any of these. Finally, we interpreted the categorized responses according to the two constructs of mathematics presented in the literature, discrete operations, and problem solving. Details of the response categories and of the sex, ethnicity, and SES analyses for each question can be found in Appendix III.C.

Mathematics as Discrete Operations

In response to the question asking children to define mathematics to an alien (Q47), 75%[17] of the children's definitions consisted of discrete operations. To the question that presented mathematics as computational arithmetic (Q67), 85% of the responses described mathematics as discrete operations. The children described mathematics as consisting of numbers, computational arithmetic, and other content areas of mathematics. As part of their construct of mathematics, some of the children said that this arithmetic-based mathematics gave them a sense of mastery.

When the children emphasized that mathematics is numbers, computational arithmetic was often implicit in their statements. As one child said, mathematics is "numbers that you put together." Others responded similarly, explaining that mathematics is "getting numbers... taking numbers that have other numbers..." or a "whole bunch of numbers where you have to join to make one." The numbers about which children spoke were "put together," added, or joined using the basic operations and algorithms that they have learned in school. Nearly one fourth (23%) of the children made such statements in response to Question 47.

Often, children gave straightforward definitions of mathematics as basic arithmetic. Slightly more than two fifths (42%) of the children's definitions of mathematics for the alien described mathematics in this way. For example, one child stated that "it's like the basics, that mainly it's adding and subtracting..." Similarly, in response to Question 67, approximately one fifth (19%) of the children agreed with the proposition that all there is to mathematics is addition, subtraction, multiplication, and division. Occasionally, children mentioned that these

[17] Note that this and all subsequent percentages refer to the percent of the total number of codable responses given to the question. Readers are referred to Appendix III.C for more information.

tasks are conducted with numbers or they added another aspect of the basic mathematics curriculum, such as decimals or fractions.

Many of the children who spoke of mathematics as numbers or basic arithmetic also identified it as an activity that is done in school: "It's a subject, dealing with numbers, that has add, subtract, multiply, and divide." As two other children commented, mathematics is "a subject in school that you have to work out problems" where "you use numbers and you multiply by other things to find out answers." These responses emphasized the computational problem solving involved in classroom mathematics. Mathematics was identified as school-based by children's references to it as a "subject" or by their comments about "times tables" and other classroom activities. The children were very consistent both in placing mathematics in the context of school and in describing it as computational arithmetic.

When children's responses to Question 67 did go beyond computational arithmetic, they did not describe "math" in terms of more sophisticated problem solving, but listed other content areas of mathematics, such as fractions or decimals, as well as computational arithmetic (57%). Furthermore, individual children mentioned some fairly sophisticated topics: "symmetry," "square numbering," "measurements," "geometry," "algebra," "Roman numerals," and "fractions." However, the fact that they presented unconnected lists of decontextualized topics as mathematics -- rather than, for example, discussing problem-solving strategies -- is again indicative of the discrete operations construct. These children did not place these content areas in the service of figuring out problems: they were virtually unrelated, decontextualized mathematics items. The way in which the children simply listed a variety of topics indicates a lack of any real conceptual coherence to their construction of the discipline: "perimeter and measurements and graphic and, and number lines and word problems," "measurement, um, fractions, decimal numbers," "fractions and estimating."

This lack of a larger context does not mean that children found mathematics unimportant. In response to the mathematics-as-arithmetic question (Q67), almost one tenth

(9%) of the children said that there is more to mathematics because of the importance of basic skills and the competence gained from acquiring them. These children struggled to articulate the importance of the subject. As one child said, "I'm thinking -- I'm trying to think of something -- of why it just isn't divide, multiply, subtract...It's hard to think! It's hard..." The question left this child confused: While mathematics doesn't seem to be "just" the four arithmetic operations, "it's hard to think" what else it might be. The following dialogue is a good example of one child's persistence and difficulty in explaining the importance of mathematics:

S: I don't agree [that math is just adding, subtracting, multiplying, and dividing].

R: You don't agree? Why not? What else is there?

S: Well, because it is a whole lot more than adding and subtracting. It's part of your knowledge.

R: What do you mean?

S: It's -- well, you gotta know math...You gotta learn it. It's not -- it's not just -- learn it -- it's not just adding and subtracting and multiplying...Or dividing.

R: What do you mean, you gotta -- you have to learn it?

S: Well, you have to learn it.

R: Uh huh. Okay. So, um, so, when people say that it's only adding, subtracting, multiplying, and dividing, um what are they saying?

S: They're saying that it's just -- that it's just something they gotta know. It's more than what you gotta know. You gotta know it. You gotta know it real good.

This child was emphatic about not dismissing these basic operations because mathematics is "more than what you gotta know." While the opinion that the child specifically tried to articulate is unclear, he clearly intended to stress the importance of mastering the subject. As another child echoed, "It's other things than just doing [addition, etc.], it's learning things for yourself and knowing how to do it when you grow up." For this child, the importance of mastering classroom mathematics was linked to life as an adult.

Several children in the above categories indicated that learning computational arithmetic provided them with a sense of competence. A few of them adopted a helpful tone with their advice to the alien that seemed to indicate their own comfort and competence with the subject: "I'd tell 'em that it's real easy...And they could learn it real fast." Another child said that doing basic addition and multiplication is "an easier way than just, just counting, you just add 'em up and you have to memo -- mem -- memorize it."

These elements of importance and mastery do not change the structure of the children's concept of mathematics: they still spoke of mathematics as discrete operations. However, these elements elaborated upon the discrete operations construct of mathematics by indicating that, for these children, an aspect of the nature of mathematics was its importance.[18]

<u>Mathematics as Problem Solving</u>[19]

In response to the alien question, one quarter of the children (25%) gave problem-solving responses; in response to the mathematics-as-arithmetic question, over one tenth (15%) gave such responses. In all, two fifths (40%) of the children made such responses to one of the two questions.

Two elements of a problem-solving epistemology were present in the children's explicit definitions of mathematics. The first was mathematics as a process of thinking or figuring out; this is an important aspect of a problem-solving epistemology because it frees mathematics from the confines of rote memorization and an emphasis on one right answer. The second element was mathematics as useful; because a problem-solving epistemology presents

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[18] These issues begin to touch upon children's beliefs about the value and usefulness of mathematics. These beliefs will be presented more fully in Chapter 4 (Usefulness and Importance).

[19] Note that this discussion of the children's notions of problem solving refers only to the conceptions of problem solving that arose in their definitions of mathematics. Information on their broader conceptions of problem solving per se will be presented in the descriptive analysis of problem solving later in this chapter.

mathematics as useful in solving problems, spontaneous references to applications of mathematics are important.

Mathematics as thinking. One tenth (13%) of the children described mathematics to the alien in the context of thinking and figuring out. Yet, while the children seemed to place their emphasis on the figuring out itself (i.e., on the experience of problem solving), these responses were still constrained by a notion of "math" as arithmetic. What distinguished these responses from discrete operations responses was the slight emphasis given to the process of figuring out or thinking, as opposed to the specific mathematics skills used. For example, one child defined mathematics as "something that you have to figure out by numbers and um words?" Another child explained that mathematics is also "problem solving. It's the whole math class." A dialogue with a third student made a connection between the thinking involved in mathematics and what is taught in mathematics class:

S: [It's a] skill with um numbers and...thinking skills and different kinds of things and that's it.

R: Okay, let me just make sure I heard these. A skill with numbers? And thinking skills. And then you said, different kinds of things?

S: Yes...[like] fractions or division, multiplication um, barometer, order.

While these children saw a link between thinking and mathematics, the tools that one thinks with are numbers and the discrete operations taught in school.

Mathematics as useful. Across the two questions, more than one fourth (28%) of the children described mathematics as useful in their lives, typically referring to computational arithmetic.[20] Children gave examples of a variety of contexts for using arithmetic: "if somebody had to get to another house in forty minutes...[and] he had to figure out how many more minutes...they had to walk" or "[math] helps you to pay bills and see if you have much money for the grocery store or how fast that you run." Other children gave uses ranging from knowing perimeter or area so that one can build a house, to budgeting money, to reading a map.

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[20] 13% of the children said this in response to Q47 and 15% said it in response to Q67.

Sometimes the children indicated that mathematics will be useful to them in the future: "for later uses in life" such as going grocery shopping or for "whatever you do, unless it's like in writing..." This latter child continued by saying that even in "writing, if you sell a book, you may have to use math because you have to count up how much you want." Note that the children's ideas about mathematics' usefulness for the future explored uses for computational arithmetic.

Conclusion

Virtually all of the children gave a discrete operations definition of mathematics in response to one or both questions. Not surprisingly, the children seem to have based their understanding of what mathematics is on the mathematics that they have learned in the classroom (i.e., arithmetic), as we shall see later.

Indeed, even though most of the children also knew that mathematics is more than just computational arithmetic, and some of them noted that it is used purposefully in life, this knowledge never went so far as to become the basis of their constructs of mathematics. The children seemed to identify the "figuring out" of mathematics as what one does when adding, subtracting, and so forth, rather than (as Schoenfeld and others would intend) recognizing it as the process of using mathematical tools to work one's way through the uncertainty of a situation that demands a solution. Although two fifths of the children spoke about mathematics as problem solving, the problem solving that they described was not the basis of their definition of mathematics. In fact, most of the problem-solving examples that they described were fairly limited applications of the arithmetic that they had learned in mathematics class.

Children's Spontaneous Mentions of "Math"

Approach

While the previous analysis described in detail the children's explicit definitions of mathematics, we were also interested in their uses of the term "math" when mathematics was not mentioned by interviewers -- that is, in the PSA and Figuring Out Domains of the interview. We wondered if children's spontaneous uses of the term "math" in these domains might allow us to understand better the relationship that they perceived between mathematics and problem solving, as we define it.

The analysis presented below is based on the pretest responses to the questions in the PSA and Figuring Out Domains that have been designated for the construct of mathematics analysis. We analyzed the responses of 14 children who mentioned "math" in the PSA Domain.[21] In the Figuring Out Domain, we analyzed 14 children's spontaneous mentions of "math" across the responses to two questions: "What kinds of things do you like to figure out?" (Q35) and "What kinds of challenging things do you like?" (Q39).

Generally, when the children used the term "math," they were referring to computational arithmetic. For some children, "math" also carried another connotation -- one of struggle through arithmetic problems.

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[21] Note that this section is concerned only with explicit mentions of the term "math," not with mentions of types of mathematics (e.g., addition, fractions). In fact, 45 out of the 48 children made some reference to numbers, counting, or computational arithmetic in the PSA Domain, whether or not they used the term "math." Eighteen children made such references in relation to PSA C*, 37 children made these references in relation to PSA B*, and 37 to PSA A*. Thus, from a discrete operations perspective, most of the children identified at least one of the PSAs as mathematical because of some numeric or arithmetic content. It is interesting to note that these discrete operational mentions of numbers, counting and the like were mentioned more often in relation to the less complex PSAs, i.e., PSA B* and A*. Yet, PSA C* also involved numbers and required counting and arithmetic. Perhaps the complexity of the problem-solving context in PSA C* made the discrete operational elements of PSA C* less salient or important to the children.

"Math" Means Arithmetic

While roughly one fourth (27%) of the children oresented responses pertaining to "math" or "math problems" without elaborating any further, more than three fifths (62%) of the children's mentions of "math" in the PSA and Figuring Out Domains referred explicitly to discrete operations. Mentions of the mathematics in PSA C* were characterized by "the numbers and you have to times it...or plus it" or "multiplication and addition." One child described the game as "get[ting the mathematics] refreshed in my brain" by doing the multiplication. Sometimes the child described the game presented in PSA C* as "like, doing, solving a math problem...'cause a math problem you have to get times and multiply." The construct of mathematics reflected here focused on the multiplication, addition, and numbers in the PSA rather than its overall, multi-step solution process.

"Math" as an Experience of Struggle

Both in reference to PSA C* and in discussing things they like to figure out (Qs 35 and 39), nearly one fourth (23%) of the children referred to school mathematics as an experience of struggling to solve arithmetic problems, relating their experience of this struggle to their experience struggling with PSA C*. One child described the PSA C* experience as "like a hard math problem or something and you have to think, well, there's gotta be some way I can do this...gotta do something with the numbers." Another child described the experience to be "like um when I'm doin' like a, a math test or something like, think real hard to check what the answer is," which seemed to capture the intensity, importance and difficulty of the PSA. Thus, the experience that they have had of struggling to master school mathematics begins to present a more complicated picture than might be assumed from their construct of mathematics as discrete operations. One child noted that PSA C* was like mathematics word problems because "you're gonna have to start thinking about like what to do and what to think of before you can answer all the questions about it."

While responses in the Figuring Out Domain located the children's use of the term "math" in the discrete operations found in school, they also explained how the culture of the mathematics classroom creates a climate of excitement and of figuring out. A few of the children explicitly stated that challenging mathematics problems are hard or that one needs to think hard to do them, and one child described the excitement of competitive arithmetic drills. Within this climate, the children seem to have come to understand the experience of "problem solving" (i.e., uncertainty and struggle) as an experience related to doing arithmetic. The complexity or difficulty of solving complicated arithmetic problems yielded a sense of figuring out.

Conclusion

While the children seemed to identify "math" predominantly as having to do with discrete operations, "math" also seemed to signify an experience of struggling to solve classroom arithmetic problems. Mathematics, then, could easily consist of discrete operations and still be a process of figuring out, because the children, as they have learned rule-bound operations and word problems, have experienced themselves as struggling with and figuring out problems. This sense of struggle and effort is also what some children felt in working with PSA C*.

For these fifth graders, the challenges of and struggle to master double-digit dividing, multiplying fractions, and basic word problems presented an experience of the process of problem solving. The problems that they felt that they were solving, however, involved simple decoding -- in word problems -- and mastery of basic arithmetic. The uncertainty of problem solving, then, stemmed from the children's novice status rather than from the complexity of the open-ended problems themselves.

Content Areas of Mathematics

Approach

The children's responses in the two previous sections have emphasized the solidity of their belief in mathematics as discrete operations. These discrete operations, by which we mean both the basics of arithmetic and the individual subject areas other than arithmetic that are taught in mathematics class, are "discrete" in the sense that their unity is determined by their use of numbers and/or inclusion in mathematics class rather than by their having some fundamental coherence as an area of knowledge. The fact that so many of the children listed mathematical content areas and computational arithmetic to define mathematics supports this interpretation.

Given this, then, it is of interest to know what content areas of the mathematics curriculum the children acknowledged as part of mathematics. While the Attitude Interview did not ask each child to identify what is and what is not mathematics, we did collect information on the range of content areas that the children specifically identified as mathematics. This does not mean, obviously, that every child recognized these content areas to be "mathematics," but it does give us some understanding of what the group as a whole identified as mathematical content.

Content Areas of Mathematics

The description in this section is intended to be very general and to refer only to data taken from the pretest. A detailed analysis of pretest-posttest change will be presented below in the section on the effects of SQUARE ONE TV.

Goal III of SQUARE ONE TV as a content guide. The children mentioned all of the content areas of mathematics in Goal III, some considerably more than others. The content areas described in Goal III and the distribution of the children's responses are shown in Table 3.1.

Table 3.1

Distribution of children's mentions of Goal III content areas

Content Area	No. of References Made
A. Numbers and Counting	133
B. Arithmetic of Rational Numbers	112
C. Measurement	64
D. Numerical Functions and Relations	67
E. Combinatorics and Counting Techniques	69
F. Probability and Statistics	11
G. Geometry	31

While each of these content areas has a number of subareas consisting of topics that span quite a range of sophistication,[22] the children made few references to the more sophisticated, less traditional material. The vast majority of children's responses fell into two categories quite similar to a discrete operations construct: "Numbers and Counting" and "Arithmetic of Rational Numbers." These categories were evident in the children's discussions of the numbers, counting, and basic arithmetic operations found in the PSAs, in mathematics classwork, and/or in applications of mathematics. Approximately one half of the children also mentioned some aspect of "Measurement," "Numerical Functions and Relations," or "Combinatorics and Counting Techniques." In the "Numerical Functions and Relations" category, the children's discussion was limited to numerical order or "greater than or less than." "Combinatorics and Counting Techniques" responses were predominantly limited to references to PSA A* or to similar

[22] See Appendix III.A for a more detailed description of Goal III.

sequencing tasks that they had in school. While only one child overtly mentioned something about probability or statistics, references were made to graphs and chart-making as mathematical activities. In "Geometry," children's responses generally included maps and the shapes of geometric figures.

Conclusion

It seems that most of the children's responses were in line with their mathematics curriculum. The most frequent responses concerned basic arithmetic, and their mentions of other content areas were relatively limited.

Occasionally, references to algebra or, in one case, trigonometry, were given as part of mathematics; some of the children who made these responses explained that an older relative had shown them this "math." This mathematics was often closely related to school. As one child who identified algebra as the advanced part of mathematics said, "[My brother] taught me. Ever since the beginning, like when he gets a lesson, I get to do it, too." The children's general lack of familiarity with these more sophisticated topics can be summed up by one child's halting explanation of his disagreement with our statement that mathematics is only addition, subtraction, multiplication, and division: "No, that, no there's a bunch m -- there's a whole lot more things...Like all the fractions, all um words that, um, oh, what do you call it, the sentences of, that, that you, you use words to, to do it and there's a whole, and um, um, alber-ab-abra-what's, can't think of it, I can't." When the interviewer helped the child by asking, "Yeah, algebra?" the child said, "Yeah, algebra. And there's, yeah that..." Some of the more sophisticated content areas that the children mentioned seem to be words that they have heard, or misheard, rather than topics with which they had real familiarity or understanding.

Sources of Mathematics Knowledge

Approach

The children's discrete operations construct of mathematics is hardly surprising given the traditional emphasis in the elementary-school curriculum on mastering arithmetic facts through drill. To test our assumption that the children in our study derived most of their knowledge about mathematics from school, we have analyzed two questions about their sources of mathematics knowledge: "Can you tell me where you got your ideas about math?" (Q49) and "Is what you do in math class all there is to math?" (Q50). The results of this analysis are described below. Further information can be found in Appendix III.C.

Mathematics Comes from School

More than four fifths (83%) of the children responded that mathematics class was where they got their ideas about mathematics (Q49). While it is not at all surprising that school figured prominently as a source of the children's mathematics knowledge, it is noteworthy that many (37%) considered it to be their only source. Many of these responses were very simple statements, such as:

R: Can you tell me where you get your ideas about math?

S: Um, my math class.

R: Okay. Anyplace else?

S: Um, my math book.

R: Hm hm.

S: And that's it.

Some of the children elaborated on their responses and explained how mathematics class figured so prominently in their thinking. One child, in mentioning the importance of mathematics, revealed the fundamental dynamic that the children described as learning: "They always try to tell you you need to know this. They're always tryin' to tell you, 'You need to listen, and you need to know this because later in your life, you're gonna have to use it.'" When the children are told that they need to learn by listening in school, this constrains to school how and where one learns mathematics.

A few children said that they got their ideas about mathematics from kindergarten or first grade. The implication is that they had not learned anything new about what mathematics is since they first started school and learned about numbers, counting, addition, and subtraction. These statements very clearly indicate that their conceptions of mathematics developed in the early years in school. But, more importantly, it indicates that they did not feel that they encountered anything in school subsequently that expanded upon these very basic ideas.

The children also mentioned that they learn mathematics from family members and from themselves. Nearly two fifths (37%) of all of the children described working with older family members while doing their homework as a part of learning mathematics. One child said:

> Um, well my Mom's real good in math and when she helped me -- when she helps me with my homework I ask her some other hard questions that aren't even on my homework.

Another child described a father's involvement:

> ...and he's always, he's always putting a, a math problem when we talk. During dinner or something here and there and we have to guess...

Although the family was mentioned as a source of math knowledge, the "mathematics" that these children described was their homework and thus basically defined by the classroom.

Similarly, one fifth (20%) of the children mentioned that they, themselves, are a source of mathematics knowledge. For example, one child responded hesitantly, "From my brain cells?" and then added that "you have to learn it first before you know it." Thus, while children like this one pointed to themselves as sources of mathematics knowledge, their knowledge seemed to have come from first having experienced and mastered it in the classroom.

The extent to which children cited school as a source of mathematics knowledge is emphasized by the fact that, when asked if what they do in mathematics class is all there is to mathematics (Q50), nearly three fifths of the children indicated that it was. Over one quarter (26%) simply agreed by saying "I think so" or "Yes." Another one third (33%) believed that there was more to mathematics than what they were currently doing but gave reasons such as "'cause there's more harder stuff in different grades," thus placing the new material squarely in a school context as well.

Mathematics Comes from Using It

Nearly one fifth (19%) of the children's responses to these two questions included examples of uses of mathematics.[23] When asked if there is anyplace other than school where he learns mathematics, one child responded:

> Just when I go to the store. Like, if I buy a candy or something. And then in my head, I subtract and then when they always get my change, I always count it.

Another child said that there is more to mathematics than what is included in mathematics class, because "like if you're going to have a party, you need to know how much food and everything for a person." Other children mentioned buying items at the store or playing games like Monopoly as involving mathematics that isn't a part of mathematics class. One child noted, "There's a little bit of [math in] social studies like um, how much water is in the climate..." Such a response not only recognizes that mathematics is not limited to what they are being taught in the classroom but also that its use crosses disciplines. These children seemed to be aware of mathematics as a tool that could be used in a variety of settings.

[23] 15% of the children talked about uses in responses to Q50 and an additional 4% talked about them in response to Q49.

Conclusion

The majority of the children's responses indicate both that their primary source of mathematics knowledge was the classroom and that they identified the knowledge obtained from the classroom as all that there is to mathematics. Therefore, what children have learned from the classroom is extremely important in shaping and constraining their ideas about the nature of mathematics. While the prominence of school as a source of mathematics knowledge is to be expected, the lack of other real sources is disappointing.

Considering these responses in the light of Schoenfeld's point that mathematics is defined by the classroom, we find that the children seemed to think of mathematics from within a school context. Although some children articulated a view of mathematics as a purposeful activity that they could learn outside the confines of the classroom, none of the children gave this type of response to both questions, even though the questions were consecutive. Thus, these ideas were not very frequent or strong; they appeared as threads in the fabric of their mathematics knowledge rather than its substance.

Conclusion: Children's Constructs of Mathematics

The Structure of the Children's Mathematics Constructs

Repeatedly throughout this analysis, we have interpreted the children's statements as portraying a discrete operations epistemology. By this we mean that these children understood mathematics to be a collection of tasks that were largely unrelated except for the fact that they were learned in mathematics class and, perhaps, that they dealt with numbers. Learning mathematics, then, concerned mastering these specific tasks as presented in class on worksheets and tests. Because its origin was so closely tied to the classroom, it stayed by and large in the classroom.

This way of knowing mathematics is very different from the problem-solving epistemology. A problem-solving approach to mathematics would treat these basic operations as simple tools used in the broader context of figuring out rather than being the heart of the discipline. Two fifths (40%) of the children made statements that presented elements of a problem-solving epistemology wherein mathematics is presented as figuring out or as a purposeful (i.e., useful) activity. However, the kinds of figuring out and uses to which they referred were limited to the constrained arithmetic problems found in their lives -- going to the store, dividing candy -- and were often remarkably similar to word problems presented in the classroom.

When children's mathematics constructs are structured as a series of decontextualized number-based classroom activities, mathematics can easily become devoid of sense-making, as noted in the research literature (e.g., Lave, et al., 1988; Resnick, 1988). Mathematics as discrete operations may constrain to the classroom both what the children understand as mathematics and where mathematics learning can happen.

The Process of Discrete Operations

Despite their view of mathematics as discrete operations, the children's experience with these classroom activities led them to think of this as figuring out. This "figuring out" is very different from the figuring out that Schoenfeld (1988) says is the heart of mathematics. These differences can be seen in two ways. First, the children were struggling to figure out that which they hoped eventually to commit to memory; figuring out was not a mode of inquiry but a struggle to master and to memorize (e.g., Ginsburg & Asmussen, 1988). Second, the children's figuring out was constrained by the arithmetic of the classroom. Rather than being just one tool in a process of problem solving, arithmetic itself defined the figuring out.

As novices, the children often perceived these activities as difficult and challenging because doing these problems often required serious concentration. However, this concept of problem solving is not the one espoused by the mathematics education researchers mentioned previously. The children's struggle with the "problem solving" presented in the mathematics classroom involved figuring out which operation they were supposed to perform, recalling their mathematics facts, or applying numerical algorithms, rather than formulating problems or deciding between several different alternative solutions. The rules of discrete operations admit to one answer per problem that is yielded to the child when the right task is performed correctly. This basis for understanding problem solving can set up expectations of swift and certain solution as the mark of the good problem solver.

Relation to the SIMS Study

In the Second International Mathematics Study, or "SIMS" (IAEEA, 1986), eighth graders were given a "Math as a Process" scale in order to determine their constructs of mathematics. The scale presented two supposedly antithetical constructs of mathematics: "mathematics as a dynamic process," (a view consistent with a problem-solving epistemology), and "mathematics as a static set of rules" (consistent with an epistemology of discrete operations). The researchers found that children agreed with both views, or, as they said, "students seem to be torn" between the two views (p. 377).

Based on the responses of the fifth graders in our small sample, it seems likely that children, especially when presented with statements that present a process-oriented mathematics, can assimilate those statements within a discrete operations epistemology without being inconsistent. The SIMS children's "process' responses may describe an aspect of their experience with mathematics: as a struggle to master the rules. Given that children in our study understood figuring out and problem solving -- the "process" of mathematics learning -- as a step toward mastery of the rigid rules of computation, it seems apparent that children's understanding of mathematics can indeed have qualities that are both process-oriented and static at the same time. However, it is important to note that even the process-oriented aspects of the children's conceptions of problem-solving are not truly "problem-solving" in the sense intended by proponents of mathematics reform.

DESCRIPTIVE ANALYSIS:
PROBLEM SOLVING

In this part of the chapter, we present the descriptive analyses of the data relating to children's conceptions of problem solving. We have begun to discuss problem solving in our descriptive analysis of mathematics, and the information presented here will expand on the interpretation begun earlier.

This descriptive analysis is divided into four sections. In the first section, "Children's Spontaneous Uses of the Term 'Problem Solving,'" we have analyzed all spontaneous references that the children made to "problem solving." The second section, "Problem Solving in the Figuring Out Domain," presents a description of the problem-solving activities that children enjoyed figuring out and also analyzes one key question that asked children to describe problem solving. In the third section, "What the Children Said They Learned from PSA C*," two key questions relating to the most complicated PSA have been analyzed. The last section will present our overall conclusions.

Overview of Results

The children described the experience and purpose of problem solving in a variety of ways. When they spoke about "problem solving" per se, they were usually referring to multi-step computation problems or arithmetic word problems. Yet, when they described the activities that they enjoyed figuring out, the children mentioned mysteries, mathematics problems, puzzles, and games. The common element that all of these activities share is a process of figuring out that is defined by uncertainty and a requirement to think very hard; these activities seem to present the experiential basis for what the children understood to be the essence of problem solving. The children brought this understanding of problem solving to the

PSAs as well; in describing the learning experience that PSA C* offered, they essentially described a figuring-out process that can be used in the world in a variety of important tasks. Problem solving seemed to exist for the children as an activity that is of critical importance to exploring and investigating the world around them. However (and this is not surprising given their limited, discrete-operations view of mathematics), the children rarely linked mathematics with problem solving. Classroom word problems provided one of the few contexts in which children did make a link between mathematics and "problem solving."

Children's Spontaneous Uses of the Term "Problem Solving"

Approach

As discussed in Chapter 2, we used the term "figuring out" because we were concerned that the term "problem solving" would prompt the children to talk about the arithmetic problems taught in school. In this analysis, we have used children's spontaneous mentions of the term "problem solving" or "solving problems"[24] to test that assumption and determine what the children meant by "problem solving."

Uses of the Term "Problem Solving"

Approximately three tenths (31%) of the children made references to "problem solving" in one or more domains of the pretest interview. There were 22 mentions of "problem solving" in all: four in the PSA Domain, five in the Figuring Out Domain, and 13 in the Mathematics Domain. Four of these responses were ambiguous because they mentioned "problem solving" but did not elaborate upon the term; these will not be discussed here.

Problem solving is computation. Nearly two thirds (64%) of the 22 references to "problem solving" were to computational problem solving. These references seemed to indicate that the children thought of problem solving as computation. Children mentioned problem solving in connection with mathematics class, homework, and computation outside of school. Their examples of problem solving in all three contexts sounded remarkably similar. One child provided an example of problem solving that sounded as though it came straight from a textbook: "There are eight hundred and fifty cans of soup. Ben sold fifty. How many does he have left?" Another child made the link to arithmetic problems more explicitly. This child said that mathematics is "something that you solve problems wi -- with and...And something like if

[24] Note that this analysis will not include children's references to "solving" without the referent "problems."

you go to the store or something and you want to figure out how much it is, like plus and times and all that," going on to explain her use of the word "problems" as "like where you write that answers down...of the problem." Thus, while on the surface, these statements may seem to have been set outside of school, they were firmly rooted in textbook and classroom computational problems.

Noncomputational problem solving. Two children made reference to different kinds of problem solving. One child struggled between two meanings of the term. He said that PSA C* was interesting to him because "I am interested in games. Video games and alla that," thus drawing a connection between PSA C* and playing with video games. Then he said, "And the -- sometimes I like solving problems, except the word problems with numbers in 'em." In this statement, he recognized the existence of two kinds of problem solving: one with numbers and one without. While further probing revealed that he could not explain the difference between the problems that he likes better (those without numbers) and word problems (with numbers), he identified both under the term "problem solving."

Another child made a similar distinction but added a third, generic category of personal problem solving. She, too, did not like "problem solving" in mathematics class. She began by saying, "I like to figure out solving problems, but not that much...I don't like those that, the ones that go, 'Jane bought seven cookies and then she gave three away...and two away and how many was she left.' I like these ones right here [indicating the PSAs]." Later in the interview, this child referred to "problem solving" in a completely different context. She mentioned that in the future she is "going to solve problems if I have a family or something, kids or something or a husband or something." Thus, this child used the term "problem solving" in three different ways: for computational word problems, for the PSAs, and for personal problems.

Conclusion

The children's predominant meaning for the term "problem solving" referred to the solution of computation problems. While children did use the term to mean problem solving in the generic sense of having to resolve or solve a situation, this generic use of the term was infrequent. The meaning that children placed on the term in the Figuring Out Domain is particularly important; there were numbers involved in the PSAs, and the questions in the Mathematics Domain directly concerned mathematics, but nothing in the Figuring Out Domain suggested numbers or mathematics. Despite this, three of the five children who used the term "problem solving" in the Figuring Out Domain talked about computational problems from mathematics class. "Problem solving," as a term, seemed to mean performing computation more than describing a process of figuring something out.

Problem Solving in the Figuring Out Domain

Approach

The Figuring Out Domain is a rich source of information from which we can interpret the degree to which the children understood problem solving in the same way we do. Within the Figuring Out Domain, we asked the children for two related pieces of information. The first concerned the kinds of figuring-out activities that they enjoy, as reflected in the questions "What kinds of things do you like to figure out?" (Q35), and "What kind of challenging things do you like?" (Q39).

The second piece of information concerned how the children would explain their process of problem solving, i.e., figuring out. This posed a challenge in that it concerned fairly abstract information and we were uncertain as to the children's ability to respond. For this reason, we incorporated concrete examples into the question. The question read:

> Q45: Now, you've told me some things that you like to figure out, plus you had the [PSAs].[25] Then there are other things. Let's take a few examples, like if someone went into his/her room and found that all the money was gone from his/her piggy bank and s/he wanted to figure out how to get it back. Or if someone was going to make decorations for a party that starts at a certain time, and wanted to figure out when s/he should start preparing. Or if someone wanted to figure out the fastest way to get to a friend's house. All of these things involve figuring out even though they are very different.
>
> So, let's talk about figuring out for a moment. What are the different steps you would take in order to figure something out?

This question sets a broad context of "figuring out" that is intentionally set in the child's experience. To some extent, the problem solving mentioned in this question conforms to the idea of mathematical problem solving presented in SQUARE ONE TV.

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[25] In the actual presentation of this question, the PSAs that the children worked with in the pretest session were described. Also, the gender of the child in the question was matched with the gender of the child being asked the question. That is, if a girl was being interviewed, the child with the stolen piggy bank would be female.

What Children Like to Figure Out

The responses to these questions have been grouped into several categories. When children presented figuring out in ways that refer to problem solving, 11 children mentioned mysteries (in books, television, and movies), 13 mentioned mathematics, and 20 mentioned games or puzzles.[26] One child enjoyed figuring out how to make things, and another child was challenged by doing experiments.

The children's responses to these questions seemed to represent the basis of their experiences with problem solving. The children enjoyed trying to figure out "who did it" before the conclusion of a mystery. They also experienced problem solving in conjunction with mathematics worksheets, complicated problems, and word problems. Children also mentioned board games (such as Monopoly and backgammon), and arcade and video games, particularly Nintendo. Figuring out puzzles such as hidden pictures, riddles, crosswords, and anagrams provided many children with an experience of problem solving.[27] These different experiences of problem solving will appear below as we discuss the children's attempts to describe the process of problem solving and the learning provided by PSA C*.

How Children Describe Problem Solving

The children answered our question about the steps involved in problem solving (Q45) in two ways. They either used examples of problem-solving situations to demonstrate the steps that one would take to solve them or they presented generalized descriptions of the thinking used in figuring out.

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[26] Note that some of the responses (e.g., responses about figuring out nature or being challenged by foot races) did not seem to relate to the problem solving that was the focus of this study.

[27] We will describe the children's reasons for enjoying such activities in Chapter 6 (Enjoyment).

Contextualized problem situations. Nearly two fifths (39%) of the children responded by giving contextualized examples to demonstrate their problem-solving processes. In these examples, the children demonstrated their understanding that problem solving involves testing, examining, gathering information, comparing, and the like. A few of these examples were particularly inventive, as illustrated by the following example:

> Well first I would like to get faster to a friend's house, well I'd get the stopwatch and time myself. I mean like I would go first on a bike, see how fast I would get. Then I'd ask my Mom to drive me in a car, I know that'd be the fastest way but, but if umm there was really no gravity people could fly. What about that? [Laugh] Get there really fast.

This child described a process of trying and testing different approaches to solve a problem. Although such contextualized examples indicate that the children recognized that different steps are involved in solving the particular problems to which they referred, they did not abstract from these examples to make statements about problem solving more generally. Such abstraction is found in the other type of response.

Generalized problem-solving processes. Approximately three fifths (59%) of the children presented a generalized description of their "figuring-out" process. In describing the process of problem solving, the children emphasized thinking. As one child said, "You think a lot. You have to think about what you should do." Less than one fifth (15%) of the children giving these generalized responses described problem solving simply as thinking. The remaining children (44%) also emphasized the thinking that is involved but also described several general heuristics as a part of this process. For example, one child said:

> Well, first I'd figure out how it'd be done and then I'd, I'd try to find out and then I'd just try to look around for clues or and ask questions. And, and, and see what would've happened or think [about] what would've happened.

This child described a process of problem solving involving the heuristics of planning and collecting information. The children did not articulate heuristics very clearly but made distinctions between one aspect of the solution process and another.

These responses were firmly rooted in the activities that the children said they enjoy figuring out (mysteries/detective work and fixing) as well as school work. Within these responses to Question 45, some of the children used words associated with solving mysteries in their descriptions (e.g., "clues" or "find out who did it and why"). One child spoke about the process of figuring out and, in so doing, made a connection between studying in school and detective work: "First you gotta study it and stuff...Like a detective, he studies and studies, like a, like a scientist." A smaller number of the children in this category spoke of problem solving using words such as "fixing"; typically, they either mentioned fixing or figuring out "what's wrong with the thing."[28] One child mentioned that "a mechanic usually has to figure out a part of a car" to illustrate what he meant by figuring out. These responses indicate an understanding of general figuring out as based in concrete repair work on objects or machines.

Finally, some of the children used words associated with learning or doing school work to describe their process of figuring out. These children talked about reading and taking notes, following directions, and working through a problem. One of these children linked the complex figuring out mentioned in our question with doing arithmetic: "they have to multiplicate and all that, divide." This child, in this rudimentary articulation of a connection between the tools of mathematics and solving, described mathematical problem solving.

Children who recognized the power of mathematics to help them solve problems in their lives were extremely rare. Only one child other than the one presented above described mathematical problem solving. She explained that mathematics is important for all of the kinds of problem solving stated in the question. Further, she found mathematics more useful than her other subjects for working with current, real-life problems:

> I think for all these things, math [is useful]...'Cause, like you said, the piggy bank and everything, and ...the fastest way and everything. I heard those kind of stories and you have to...multiply, subtract and add and everything...but I really think it's math 'cause science and all them are about past and the future and everything. Other things that aren't really involved, multiplication and everything that I know...just math I think math would probably.

[28]Note that some of these responses may have been influenced by the fact that PSA C* concerned fixing a game.

Note that this child's application of computation to various problem-solving situations was the most powerful example of mathematical problem solving in the sample (i.e., one that extended beyond a generic sense of thinking hard or solving).

Conclusion

While it might be difficult even for an adult to describe how one goes about solving problems, the children's responses to our question were surprisingly inventive and reflected the "figuring out" experiences that they enjoyed (e.g., solving mysteries and detective stories, doing school work, and fixing things). The children described problem solving in one of two ways: (a) by giving an example of a "figuring out" (i.e., problem solving) situation, or (b) by explaining a process of figuring out.

In general, the children's descriptions of problem solving indicate that their conceptions of figuring out were characterized by an experience of thinking hard as well as by a process of investigation (e.g., looking, examining, or studying).

It is important to note that, with the two possible exceptions discussed above, the children did not describe mathematical problem solving. In other words, they did not describe using mathematical tools to solve interesting and useful problems systematically. Rather, they described problem solving as figuring out: an experience of thinking hard when confronted with a task that demands solution.

What the Children Said They Learned from PSA C*

Approach

The PSAs provided an opportunity to assess children's understanding of the kinds of problem-solving activities that are the focus of **SQUARE ONE TV** and some problem-solving-based mathematics curricula.

We asked the children to describe what they learned from PSA C* (our most complex PSA) in two ways. The first question that we asked was "Would you say that you learned something from [PSA C*]?" (Q11). Given that this is a leading question that would be likely to encourage affirmative answers, we were less interested in children's "yes" or "no" responses to this question than in what they felt they learned. In particular, because the question did not mention problem solving, we could see whether the children considered this experience to be an instance of problem solving.

The second question asked, "What do you think you would learn" by taking a course in high school that taught things like PSA C* (Q16). This question was designed to give the children a concrete way of describing the larger discipline or enterprise that the PSA might be a part of.

Children's responses to these two questions were sufficiently similar to be analyzed under the same coding categories. The percentages reported below represent percentages of the total pool of responses to the two questions.

PSA C* as Thinking, Mystery, and Invention

PSA C* is problem solving. One fifth (20%) of the responses[29] discussed PSA C* in terms that we consider to refer to problem solving. In general, this problem solving involved thinking hard to figure out something; as one child explained, learning from PSA C* was

[29] Eighteen children made these responses.

"learning more about solving things. A better way to figure them out." Another child explained the difference between "thinking kind of everyday stuff and thinking real hard" in that the latter is "harder with the things than what you usually do. 'Cause you have to try to figure it out." The problem solving described by these children involved effort toward solution although they did not make an explicit connection with mathematics.

PSA C* involves thinking. More than one fourth (28%) of the responses[30] focused on the thinking that was involved without naming the activity as figuring out or problem solving. As one child said, "like you get a better education -- you learn more" from the thinking skill that the PSAs could provide. Children mentioned a variety of thinking skills from "how to make decisions" to "kinda hav[ing] to stop...think about what you're doing" to "just concentrating" to "how to check for things that are right or wrong" to "pay[ing] attention."

Two of the children in this category discussed PSA C* in terms of their potential performance in the task. For example, one of the two children said that she learned "that I can't always be right when I want to...like the saying goes, nobody's perfect." The fact that these children discussed the PSA C* experience as something that they might not solve implies that they recognized PSA C* as a problem to be solved.[31]

Several of the children who described the PSA C* experience as problem solving also made a connection to detective work and solving mysteries. One child said that in a PSA C* class, he would learn "to figure out things...like, the way the detectives um figure out crimes, something like that." This child's response seems to connect the context of PSA C* with the figuring out that detectives do. This concept of problem solving was echoed in another child's explanation that what one would learn in a class concerning PSA C* is "um, intelligence?...Like um you really learn by doin' something like -- like goin' -- like goin' back and figuring out

[30] Twenty-three children made these responses.

[31] Note, however, that across the 94 responses to these two questions only three children responded negatively about their performance.

problems and solving mysteries and everything." In a perhaps naive way, this child articulated the hopes of many proponents of mathematics reform: that, given the opportunity to do hands-on problem solving, children will "really learn by doin'." Another child's response pointed to the difficulty of explaining what one might learn from a PSA C* class but at the same time articulated an understanding of problem solving as solving mysteries:

> I'd learn how to, how to um, how to know that, how to they'd teach me how to um pretend I can't get the words out...How to make decisions, how to, how to um, how to, I can't...How to um find out what's wrong with things by yourself and um and being in like your own mystery and all...Like um, the um, you have a mystery to solve and, and like, and you, you're supposed to solve it and it, and it's um, and then, and then after the end you solve it and you feel real good 'cause you solved a mystery and you were the one who, who solved it instead of somebody in a book.

In identifying PSA C* with solving mysteries, the children described a general process of figuring out that could lead to a sense of mastery and competence. This process is a sophisticated one, although it is not explicitly mathematical.

<u>PSA C* as fixing or inventing.</u> More than one tenth (13%) of the responses described the experience of PSA C* in terms of fixing or inventing.[32] Some of these children restricted their responses to the concept of the game that was provided for them; they referred only to solving or fixing the game. For example, one child learned that "sometimes when games look right, they're not -- that doesn't mean they're really right." Another spoke about learning "how to put games together."

Most of the children in this category spoke more generically about fixing and inventing (i.e., outside of the context of the game). The children's use of the term "fixing" to describe their engagement with PSA C* was a way of expressing practical problem solving. One child gave a description of the kinds of things that one could learn from a class about PSA C*: "all different kinds of things, like how to build cars or figure out stuff in computers and all that kind of stuff." Another child spoke of "learn[ing] better ways how to fix things and like once you think you found it, maybe there might be something else wrong, and that class will

[32] Ten children made these responses.

probably teach you about it." The underlying conception of problem solving provided by these responses emphasizes the practical utility of problem solving.

A few children elaborated on what they learned from PSA C* by describing inventing. One child explained that he could learn "when I grow up if I was a scientist or somebody, and I could make games like that...[which is why] you have to find out what's wrong with them." Another child said that he could "learn how to use my knowledge a little better or...then um on material things." He explained that he could use his knowledge

> by putting my ideas into different things that will result in a good way for me in the future...like if I was really poor and just had barely enough money to support myself in that class...then, then thought of something real big -- and it was a real big hit -- then, that's what I mean. Providing for myself.

Because of their emphasis on invention, these responses seem to have gone beyond the practical aspects of fixing expressed by the other children.

PSA C* and Mathematics

Less than one tenth (7%) of the children mentioned computational arithmetic or numbers as the learning experience to be found in PSA C*.[33] The fact that the arithmetic in PSA C* is so simple seems to have limited what these children felt that they learned (or could learn) from the activity. Two children would not take the PSA C* class in high school because they would not learn anything -- "I would probably know it" -- because they had already mastered arithmetic. One of these children would take the class even though he would learn "nothing," while the other wouldn't because "I would already know everything, so why take it?" It seems clear that these children's responses were limited to the arithmetic that they identified as salient in the PSA. Perhaps the fact that the PSAs were administered in school, that numbers were displayed prominently on the materials for PSA C*, or that our use of the word "learning"

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[33] Six children made these responses.

may have triggered an association with the subject matter of school, limited the learning possibilities that they saw for PSA C* to arithmetic.

However, one child made a somewhat different connection between mathematics and the PSA C* experience in that both involve figuring out:

> because then um these...have to figure out if he goes to the store and buy a game, and then have to figure if it's wrong or not...And like if you're doing a problem, you have to figure out what to do...And stuff. And like um, like the way you have to subtract or add or whatever...Like a word problem.

This child found the experience of figuring out PSA C* to be similar to figuring out an arithmetic problem.[34] The similarity lay in the figuring out required by both situations rather than in the arithmetic used. Thus, this child seems to have described a generic form of problem solving in which one thinks hard about what to do rather than a more specific type of problem solving that uses mathematics.

Conclusion

Overall, the children's explanations of what they could learn from PSA C* presented a wide range of descriptions of problem solving as a generic process of figuring out rather than as a logical or systematic process involving mathematics. In describing problem solving generically, the children described what they could learn from PSA C* as solving, figuring out, thinking intensely, or, more concretely, fixing; common to all of these ideas was a sense of process and the satisfaction of resolution.

Working with PSA C* gave most children an experience of problem solving through which they could make connections to the work of detectives, scientists, and inventors -- an experience that is important and purposeful. Lave, Smith, and Butler's (1988) concept that

[34] In the descriptive analysis of mathematics, we discussed similar references to "math" in the PSA Domain. These responses described the process of doing hard arithmetic problems with a struggle with uncertainty.

mathematics education should be an apprenticeship to the practice of inventing and discovering mathematics seemed to be nascent in some of these responses.

By contrast, in the previous section on "Spontaneous Mentions of Problem Solving," children's descriptions of problem solving seemed to be limited to contexts of mathematics tests and worksheets, getting change, or measuring for building. Their understanding of problem-solving processes was constrained by the arithmetic that they associated with mathematics class. Here, however, while a few children seemed to have been constrained by the arithmetic in the PSA, others expressed an understanding of problem solving that was conceptually richer than the understanding seen in the descriptive analysis of children's constructs of "math." Problem solving here seemed to be a purposeful process that could take the children into fixing, invention, and detective work.

Conclusion: Children's Understanding of Problem Solving

Problem Solving as "Figuring Out"

When asked about "figuring out," the children described rich experiences of problem solving. In describing what they learned or could learn from PSA C*, the children said that they could learn about solving in general, being a detective, inventing, fixing things, and improving their minds. Through PSA C*, the children described learning activities that are deeply connected to an exciting world where problem solving is done for a purpose -- to build, to create, or to solve crimes.

This world complements the problem-solving activities that the children said they enjoy. When asked for the kinds of figuring out that they like to do, the children named mysteries, games, puzzles and mathematics. Their experiences with these activities may have given them an experiential base for the learning that they could identify from PSA C*.

When one looks across the children's responses to all of the questions we have included in this analysis, a pattern emerges. The children described an experience of problem solving that basically involved thinking hard, figuring out, solving, fixing, or struggling to find a solution. Children used words associated with activities they enjoyed (e.g., finding clues) to describe their process of problem solving and, in some cases, made explicit links between PSA C* and these activities (e.g., some children mentioned that learning about PSA C* was similar to solving mysteries and inventing). The problem solving that emerged from their experiences with these activities did not usually involve mathematics.

Figuring Out vs. "Problem Solving"

The children's use of the term "problem solving" did not carry the richness found in their descriptions of this generic, figuring-out process. When the children used the words "problem solving," they generally meant some form of computational arithmetic. They discussed a variety of contexts for computation: mathematics class, word problems, and buying or selling. Yet, their responses and the apparent uses for this computational problem solving did not go much further than the corner store.

Relevance for the Reform Movement

The children's experiences and descriptions of problem solving as a process of figuring out provide an endorsement of the pedagogy recommended by the proponents of mathematics reform. Some mathematics educators speak of the need for a "paradigm shift" (Carter & Yackel, 1989) in the ways children think about mathematics. To accomplish this, mathematics learning must be structured so that children will realize that mathematics is inherently about making sense in the world through invention and discovery (Lave, et al., 1988; Schoenfeld, 1988). Clearly, the children in our study found PSA C* to be interesting and relevant. When the children in our study spoke of the problem solving in PSA C*, they described it as helping them to learn how to solve mysteries, fix things, create inventions, or grow intellectually. Yet, these children did not link PSA C* explicitly to mathematical problem solving.

The disparity between the children's understanding of a generic form of problem solving (as a process of figuring out) and the meaning they gave to the term "problem solving" (as computational arithmetic) suggests directions for curriculum change. The source of their limited understanding of "problem solving" may well have been that computation is often presented in the classroom as "problem solving" -- and this, in turn, may confuse and restrict children's understanding of problem solving. One way to correct this difficulty might be to capitalize on children's curiosity about mysteries, fixing, building, inventing, and figuring out games and puzzles to create a curriculum built around problem-solving activities that incorporate mathematics. The children themselves, in their discussion of PSA C*, gave evidence that this is possible. There seems to be real potential that learning mathematical problem solving in broader contexts could allow children to understand that mathematics can take them far beyond the arithmetic classroom.

THE EFFECTS OF SQUARE ONE TV:
ANALYSIS SCHEME

Where the analyses discussed above explore children's constructs of mathematics in the absence of any treatment, this section concerns statistical analyses of pretest-posttest change. The present analysis involves three measures, two of which used data from the Attitude Interview and one that used data from the Essay: (a) a content analysis of interview data on mathematics and problem solving, (b) an analysis applying the mathematical content areas of Goal III of **SQUARE ONE TV** to interview data, and (c) a similar analysis applying Goal III to Essay data.

Considerations in the Development of the Scheme

Two considerations were critical to the development of our analysis scheme. First, because the children did not have an integrated concept of problem solving and mathematics, we recognized that we would have to assess their conceptions of problem solving separately from mathematics. Moreover, whatever changes the intervention might bring about would be likely to be fairly subtle, and probably would involve change within their existing constructs of mathematics and problem solving.

As part of our analysis of change, we examined the variety of different mathematical content areas that the children named from within their discrete operations perspective. This was important both because mathematics educators have expressed the concern that children only identify computational arithmetic as mathematics and because **SQUARE ONE TV** presents mathematical content that goes beyond the traditional elementary-school curriculum.

A second aspect of our analysis concerned children's conceptions of problem solving. In discussing problem solving as a process of figuring out, children made reference to certain kinds of figuring out that relate to aspects of the problem-solving pedagogy advocated by some proponents of mathematics reform: that of mathematics as an apprenticeship of invention and discovery where meaningful problems are solved. **SQUARE ONE TV** also presents mathematical content in a variety of problem-solving contexts. While only rarely did children make an explicit connection between mathematical reasoning and the process of figuring out, we believed that it was important to assess whether their references to figuring out (often related to the problem solving of detectives, inventors, and mechanics) would change as a result of viewing the series.

Finally, both schemes needed to compile the children's responses across all of the construct questions into a composite score. The coding categories had to be general enough to use across all of the domains yet flexible enough to capture the distinctions that we felt were important.

Measures of Construct of Mathematics

Based on the above concerns, we created two different measures for construct of mathematics: (a) the Categories of Mathematics and Problem Solving Analysis, and (b) the Goal III analysis. The first analysis distinguishes between levels of sophistication in children's discussions of mathematics and problem solving in the Attitude Interview. The second analysis is designed to explore the different kinds of mathematics that the children mentioned (both in the Attitude Interview and in the Essay) via Goal III of **SQUARE ONE TV**.

Categories of Mathematics and Problem-Solving Analysis

The purpose of this coding was (a) to aggregate each child's examples of mathematics and problem solving across all questions, and (b) to rate the sophistication of those examples.[35] Within the categories of mathematics and problem solving there were several subcategories used to assess the sophistication of the responses. Also, responses could be categorized as nonresponsive if the child did not know, responded negatively, or did not give a codable construct response. Brief descriptions of each category and examples will follow. For detailed information relating to the coding, and additional examples, please refer to Appendix III.D, which contains the Construct of Mathematics Codebook.

Mathematics categories. Three subcategories were used to capture mathematics responses: non-mathematics, basic, and advanced:

Non-mathematics responses were those in which a child's response did not contain an example of mathematics or problem solving. Many of these responses discussed social relationships. These responses were frequently found in the Figuring Out Domain. Examples of such responses follow:

Q44: What do you feel is important to figure out?
S: Things that the teacher says in school...Like on different -- different subjects you have to figure out what the teacher is saying. If you can't then you have to ask the teacher. [Outside of school?] How to get away from bullies.

Q40: Has there ever been anything that you wanted to know and you figured it out by yourself?
S: Yeah...Uh um, when uh when uh like people if you wanna know people talking about you and then you're talking to your friend, and then you say their name, and then you know that they're talking about you.

Basic responses included unelaborated uses of the word "math" as well as mentions of the basic arithmetic operations, fractions, numbers, counting, and relations between numbers (e.g., order relations). Responses in which these were implicit, such as mentions

[35] Because construct responses could conceivably occur in response to any question, an analysis was conducted on 12 interviews to determine whether the Categories of Mathematics and Problem Solving Analysis was completely capturing the references to construct of mathematics. Extremely high correlations resulted from correlating the scores for the designated construct questions and the scores obtained from coding every interview question ($p < .001$ for mathematics responses and $p < .001$ for problem-solving responses). See Appendix III. L for further details. We concluded that the designated construct questions were adequate for our analysis.

of going to the store and getting the right change, also count as basic. The following examples illustrate what was captured in this category:

> Q48: Do you think this person [the alien] who doesn't know anything about math should learn about it?
> S: So, if he buys something at the store, it's less than five dollars and he gives five dollars and they don't give change, he'll have to know.

> Q47: If you had to explain what math is to someone who had never heard of it maybe someone from another planet who happens to speak English, what would you say that it is?
> S: You use numbers and you multiply by other things to find out answers.

Advanced mathematics responses were those in which the child mentioned (or implied through example) more advanced content areas of mathematics such as measurement, geometry, algebra, estimation, combinatorics, graphs, or maps. Examples of responses in this category follow:

> Q55: Um, can you tell me about a time when you did or learned something in math that you really enjoyed?
> S: ...Symmetry.

> Q58: What are the different steps you would take in order to figure something out?
> S: ...You estimate like how long you can take to dress up and do all the things you have to do, and estimate how long it's going to take you to get there and then...

Problem-solving categories. We developed four problem-solving categories: generic, computational, practical, and sophisticated. Given the children's limited ability to articulate their problem-solving processes, we coded any problem mentioned by a child as a problem-solving response if it could be solved through a systematic process, although he or she did not have to describe the solution of the process itself.[36]

Generic problem-solving responses were those that explicitly mentioned "problem solving" or "figuring out" (when "figuring out" was not mentioned in the question) with no further elaboration. Fragments of problem-solving strategies, such as looking for

---

[36] A response could also be coded for both mathematics and problem solving, if appropriate.

clues, were coded here also. Further, this category captured unambiguous references to puzzles or brain teasers that were placed only in a general context of school or recreation. Examples of generic responses follow:

Q35: What kinds of things do you like to figure out?
S: ...Riddles.

Q45: What are the different steps you would take in order to figure something out?
S: Clues.

Computation responses referred to computational problem solving in which basic computation is used to get answers or to figure out problems. Such responses could be set in the context of school or outside of school, e.g., when a child gave an example of using counting or arithmetic at the store. Examples of these responses follow:

Q35: What kinds of things do you like to figure out?
S: Hm, word problems.

Q48: ...Should this person who doesn't know math learn about it?
S: Yeah...Because, like, say that other person goes to the store, and he has ten dollars, and he buys something for, eight dollars and fifty cents. They could just give him like a dollar back.

Practical responses discussed or mentioned fixing, figuring out, or problem solving in reference clearly to practical, concrete problem situations. Practical responses were usually real-life situations that involved step-by-step solutions and a process other than computation but were concrete, e.g., fixing a bike. These were "hands-on" illustrations of a problem-solving process. The following are examples of this category:

Q67: Some people say that the only thing that math is, is adding, subtracting, multiplying, and dividing. What do you think of that?
S: Area -- the area of something. Somebody moves -- comes to their house and...how to build it -- how much space you can use.

Q11: Would you say that you learned something from it [PSA C*]?
S: ...I learned, I learned a lot of stuff from it...Like um, um, just fixing it, like fixing it so, like I just said...that to, so when I get big and I have to fix a car and stuff I just, I just do it myself.

Sophisticated problem-solving responses described situations that involved abstract thinking or complicated, logical processes. While there may have been mathematics underlying this problem solving, often there was not. Mysteries, inventions, and science experiments were considered as belonging to this category, as were designing something or creating a map. Below are examples of sophisticated responses:

> Q16: Let's say when you're in high school you take a class that teaches you to figure out things like the Dr. Game thing [PSA C*]. Would you like to take it? What do you think you would learn?
>
> S: How to make decisions...How to find out what's wrong with things by yourself and um and being in like your own mystery and all. Like um, the um, you have a mystery to solve and, and like...you're supposed to solve it...
>
> Q16: Uh, let's say that when you're in high school you have a chance to take a class that teaches you how to figure out things like the Dr. Game thing [PSA C*]. Would you like to take it?
>
> S: Well if well, when I grow up if I was a scientist or somebody, and I could make games like that. [That's why] you have to find out what's wrong with them. You had to find out what's wrong with them.

Scoring. A child was given two scores at the pretest and two scores at the posttest. The child's mathematics score was equal to the proportion of advanced mathematics statements that he or she made (out of all statements coded for mathematics). The child's problem-solving score was equal to the proportion of practical and sophisticated problem-solving statements that he or she made (out of all statements coded for problem solving). Note that for the purposes of analysis, we chose to merge the categories of practical and sophisticated problem solving because, although the two categories were different, both represented a high level of thinking about problem solving.

Goal III Analysis

The Attitude Interview. Goal III of SQUARE ONE TV was used as a coding guide, to identify the specific content areas of mathematics that the children mentioned as part of their constructs of mathematics. Because no child could be expected to list all of the mathematical content areas that she or he knew of, no inferences can be made about what they did not mention. That is, because we were not asking them to identify content areas of mathematics, the exclusion of an area does not imply that a child considered the excluded area to be nonmathematical.

Scoring. Children needed to mention or describe an item in one of the categories of Goal III for the response to be considered in this analysis. A complete list of Goal III content areas can be found in Appendix III.A.

Children were awarded one point for mentioning an item in one content area; for example, a mention of Roman numerals would receive one point under "Numbers and Counting." Each child could receive a maximum of one point for each content area of mathematics. Children's responses were analyzed according to the number of content areas mentioned as well as for the distribution of their responses across the content areas. More specific coding guidelines for this analysis are presented in Appendix III.D.

The Essay. Chapter 2 discussed our large-group measure of attitude, the Essay. As was mentioned, the Essay was developed to enable us to assess the attitudes of the entire population of children (n = 240) in the four fifth-grade classes from which the subsample was drawn. The Essay asked the children to write about whether they would or would not want to have a job "figur[ing] things out and solv[ing] problems using shapes, numbers, measurements, or other things having to do with mathematics."

While the Essay did not explicitly ask the children to define mathematics, the question did present them with an opportunity to discuss a variety of content areas of mathematics. As in the Attitude Interview, we did not expect that any one child's response would provide an exhaustive portrait of his or her knowledge of mathematical content. However, because different children would be likely to mention different content areas of mathematics, we believed that we could obtain some idea of the breadth of the viewers' and nonviewers' conceptions of mathematics by tallying the different content areas of mathematics mentioned by each group of children. Thus, we decided to use Goal III of SQUARE ONE TV as the guide for coding the content areas of mathematics mentioned by the viewers and nonviewers. Counts were made of the number of mentions of each content area defined as subgoals under Goal III.

Interrater Reliability

After the schemes were developed, reliability was assessed by having a second researcher code for the three types of scores used in these analyses. The correlations between the two researchers' scoring of these cases were highly significant ($p < .001$ in all cases). Further information is presented in Appendix III.K.

THE EFFECTS OF SQUARE ONE TV: RESULTS AND DISCUSSION

Overview of Results

Viewers' and nonviewers' responses in the Attitude Interview did not differ significantly[37] at the pretest, but differences between the two groups emerged after the viewers were exposed to 30 programs of **SQUARE ONE TV**. Viewers made statistically significant gains in the proportion of practical and sophisticated problem solving that they mentioned, while nonviewers did not. In addition, there was a marginal trend among viewers toward producing a higher proportion of advanced mathematics responses.[38] Looking at the performance on the Essay, viewers mentioned statistically significantly more examples than nonviewers in one of the seven Goal III content areas: measurement. The viewers also demonstrated a marginal trend to mention more geometry than the nonviewers.

Categories of Mathematics and Problem-Solving Analysis

The analysis of the Attitude Interview explored the following pretest-to-posttest differences between the viewers and nonviewers: (a) their proportions of advanced mathematics statements, (b) their proportions of practical and sophisticated problem-solving statements, and (c) the numbers of Goal III content areas they mentioned.

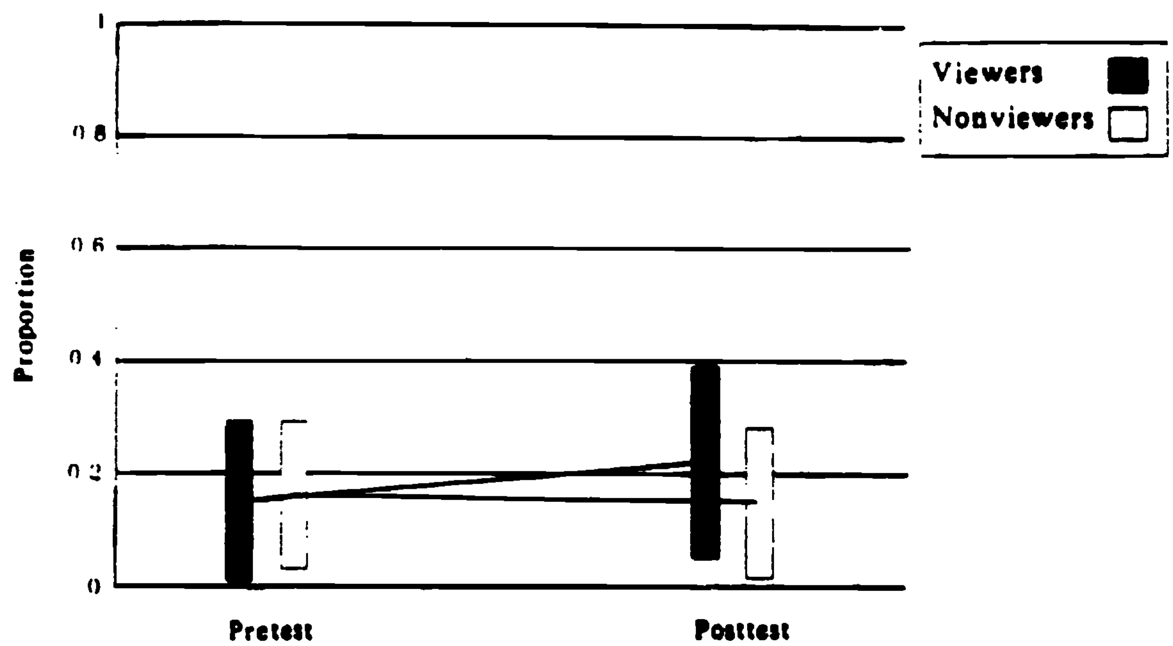
Advanced mathematics. Figure 3.1 shows the average proportion of advanced mathematics statements made by viewers and nonviewers in the pretest and posttest with

[37]Note that we have set our alpha level for significance at $p < .05$. All results reported as significant have reached at least that level of significance.

[38] Specific information on the statistical tests used can be found in Appendix III.L.

Figure 3.1

Mean proportion of advanced mathematics statements ± 1 SD



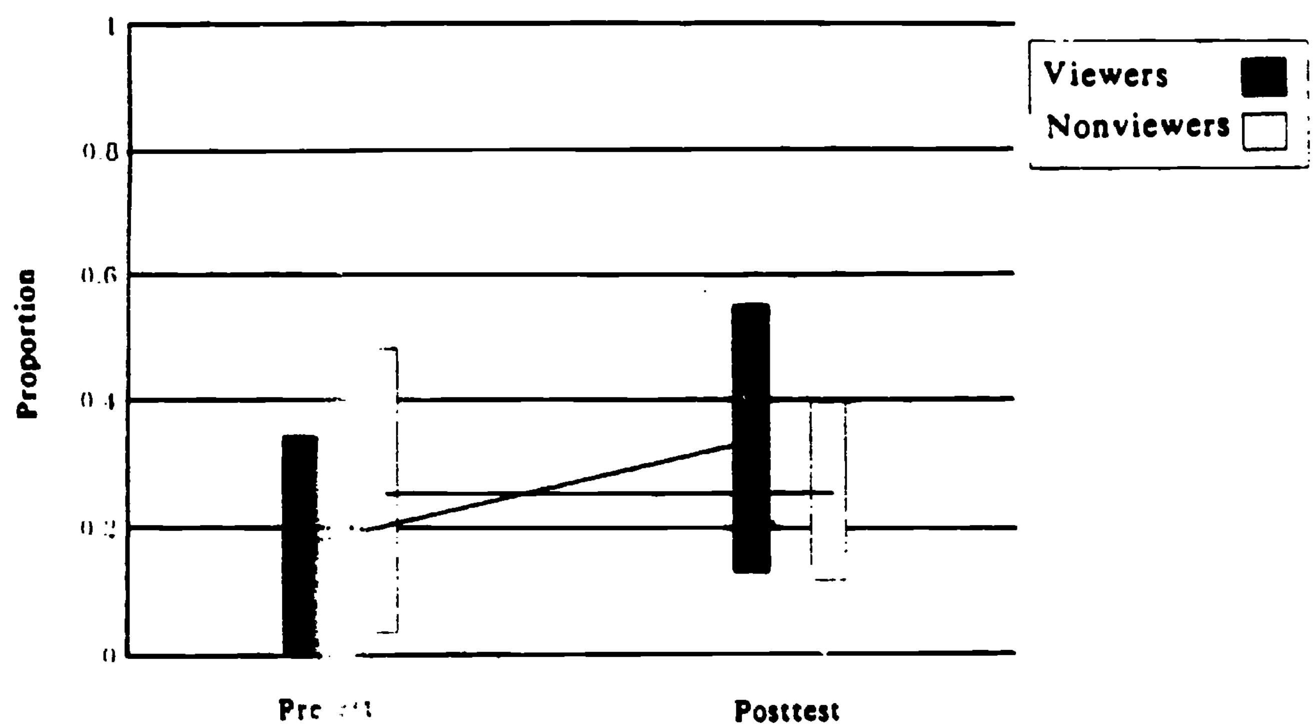
one standard deviation above and below the mean. We expected that viewers would show a greater increase than nonviewers in the proportion of advanced mathematics statements made.

As this figure suggests, there was no significant difference between the groups at the pretest. The viewers' pretest-to-posttest increase was marginally greater than that of the nonviewers ($p < .10$); the viewers improved significantly from pretest to posttest ($p < .05$), and produced a significantly greater proportion of advanced mathematics statements than the nonviewers did in the posttest ($p < .05$). There were no significant main effects of sex, ethnicity, or SES, nor did these factors interact significantly with the effects of viewing SQUARE ONE TV.

Practical and sophisticated problem solving. Figure 3.2 shows the average proportions of practical and sophisticated problem-solving responses given by the viewers and nonviewers in the pretest and posttest with one standard deviation above and below the mean. We expected that viewers would show a greater increase than nonviewers in the proportion of practical and sophisticated problem-solving statements they made.

Figure 3.2

Mean proportion of practical and sophisticated problem-solving statements ± 1 SD



As the figure suggests, viewers showed a significantly greater increase than nonviewers in the proportion of practical and sophisticated problem-solving responses they produced ($p < .05$). The two groups did not differ significantly at the pretest, but the viewers increased significantly from pretest to posttest ($p < .01$) while the nonviewers did not. There were no significant main effects of sex, ethnicity, or SES, nor did these factors interact significantly with the effects of SQUARE ONE TV.

Interrater Reliability

After the schemes were developed, reliability was assessed by having a second researcher code for the three types of scores used in these analyses. The correlations between the two researchers' scoring of these cases were highly significant ($p < .001$ in all cases). Further information is presented in Appendix III.K.

No significant differences were found between viewers and nonviewers in the number of types of mathematics (i.e., Goal III subgoals) mentioned.[39] While the difference in the means was not significant, the pattern of change in the means was in the expected direction in that the viewers' scores were higher at the posttest. No significant effects were found as a function of sex, ethnicity, or SES, either as main effects or interactions with the effects of SQUARE ONE TV.

The distribution of the children's responses across the subgoals is shown in Table 3.2.

Table 3.2

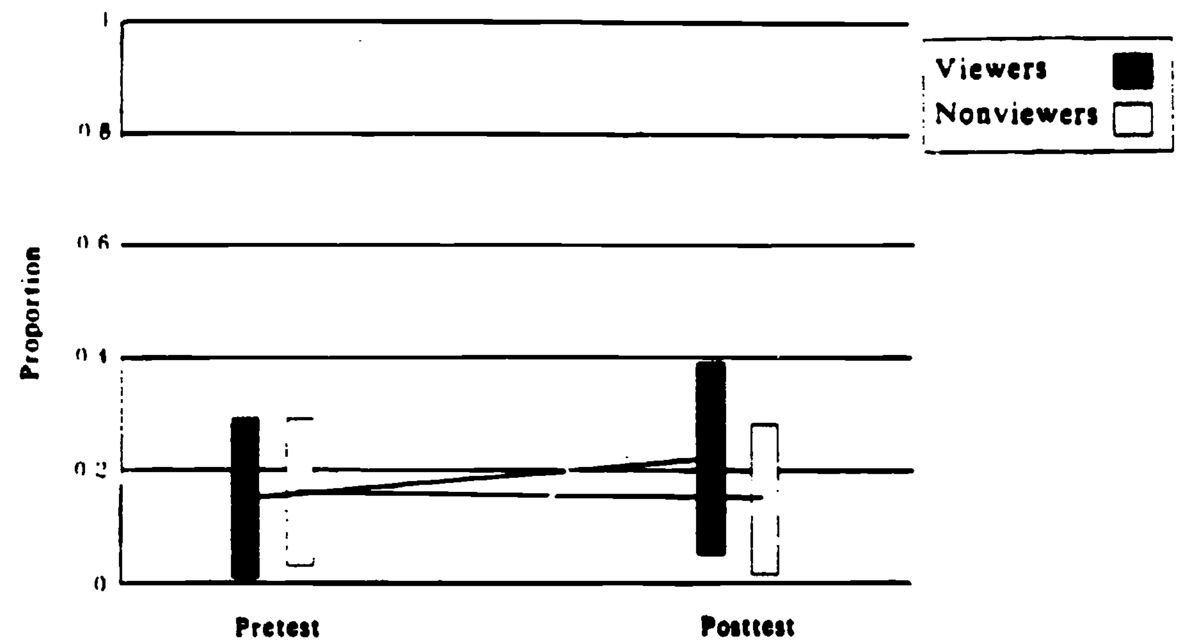
Distribution of children mentioning Goal III content areas in the Attitude Interview

	Pretest		Posttest	
	Viewers	Nonviewers	Viewers	Nonviewers
A. Numbers & Counting	33	33	35	32
B. Arithmetic of Rational #s	25	28	30	29
C. Measurement	14	13	22	15
D. Num.Functions & Relations	20	18	16	13
E. Combinatorics	14	14	23	18
F. Probability & Statistics	0	3	2	6
G. Geometry	9	5	12	5

[39] Analysis done using scores based on the number of specific content areas mentioned in the subgoals -- the sub-subgoals -- also revealed no differences.

Figure 3.1

Mean proportion of advanced mathematics statements ± 1 SD



one standard deviation above and below the mean. We expected that viewers would show a greater increase than nonviewers in the proportion of advanced mathematics statements made.

As this figure suggests, there was no significant difference between the groups at the pretest. The viewers' pretest-to-posttest increase was marginally greater than that of the nonviewers ($p < .10$); the viewers improved significantly from pretest to posttest ($p < .05$), and produced a significantly greater proportion of advanced mathematics statements than the nonviewers did in the posttest ($p < .05$). There were no significant main effects of sex, ethnicity, or SES, nor did these factors interact significantly with the effects of viewing SQUARE ONE TV.

Practical and sophisticated problem solving. Figure 3.2 shows the average proportions of practical and sophisticated problem-solving responses given by the viewers and nonviewers in the pretest and posttest with one standard deviation above and below the mean. We expected

Table 3.3

Distribution of children mentioning Goal III content areas in the Essay

	Viewers	Nonviewers
A. Numbers & Counting	58	59
B. Arithmetic of Rational #s	69	78
C. Measurement	104	69
D. Num.Functions & Relations	1	0
E. Combinatorics	0	0
F. Probability & Statistics	3	4
G. Geometry	64	45

Discussion

Together, the results of the above analyses suggests that **SQUARE ONE TV** can have an impact on several aspects of children's constructs of mathematics within a discrete-operations framework. In the Attitude Interview, viewers made significantly greater gains than nonviewers in the proportion of statements mentioning more complex problem solving and made marginally greater gains in the proportion of mentions of advanced mathematics. Viewers mentioned significantly more examples of Measurement than nonviewers did in the

<u>Goal III Analyses: The Intervie\ 1d The Essay</u>

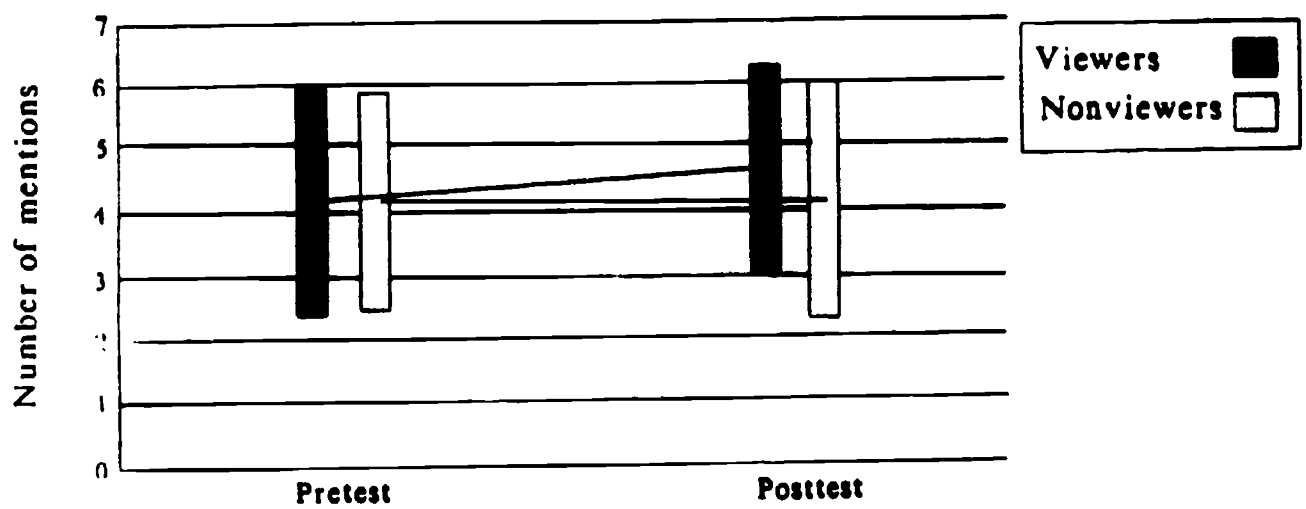
In our analyses of the content areas presented in Goal III, we examined both (a) the number of content areas (i.e., subgoals) mentioned by the children in the subsample (as reflected in their responses in the Attitude interview, and (b) the number of responses made within each subgoal by the children in the full sample (as reflected in the Essay).

<u>Goal III Analysis in the Interview</u>

Figure 3.3 below shows the mean number of Goal III subgoals that viewers and nonviewers referred to. We expected that viewers would show a greater increase than nonviewers in the number of Goal III content areas they mentioned.

<u>Figure 3.3</u>

Mean number of Goal III subgoals mentioned ± 1 SD



[1] Maximum score = 7.

The problem solving that these children described in their references to practical and sophisticated problem solving does not depend on their acknowledgement of mathematics as inherent to the solution. Rather, this problem solving is characterized by thinking hard to figure out something. As discussed above, **SQUARE ONE TV**, in combination with the PSAs, may have encouraged children to make the connection between problem solving and mathematics.

Changes in References to Mathematical Content

Viewers made significant gains in the proportion of advanced mathematics statements made in the interview. Also, in the Goal III analyses of both the Attitude Interview and the Essay, the viewers mentioned examples of Geometry and Measurement more often than nonviewers; these differences were marginal for Geometry and, in the case of the Essay, statistically significant for Measurement. The results for measurement may have been stronger in the Essay than in the Attitude Interview because of the considerable difference in sample size rendering a slight change in the small sample (n = 48) significant in the larger sample (n = 240).

How might these changes be related to the content of **SQUARE ONE TV**? When we examine these differences in relation to the content of the segments of the series that the children viewed, the results suggest there is no simple proportional, quantitative relationship between the degree to which some particular mathematics subgoal was represented in the series and the number of children who mentioned examples of that subgoal. For example, 29% of the segments included in the 30 programs of **SQUARE ONE TV** that were shown to the viewers contained geometry. Geometry comprised 21% of the viewers' responses in the Essay and 9% of the viewers' responses in the posttest Attitude Interview. It seems clear that the degree to which children discussed specific content areas may have been a function of three factors: the effectiveness of particular segments, the children's prior mathematical knowledge, and their

Both in the pretest and posttest, viewers and nonviewers most frequently mentioned examples of mathematics classified as Numbers and Counting or Arithmetic of Rational Numbers, a finding that is not surprising given their constructs of mathematics as discrete operations. However, while the number of viewers and nonviewers mentioning examples of Geometry did not differ significantly in the pretest, marginally more viewers than nonviewers mentioned Geometry after their exposure to 30 programs of **SQUARE ONE TV** ($p < .10$). Similarly, while marginally more nonviewers than viewers gave examples of Probability and Statistics in the pretest ($p < .10$), this difference was not present in the posttest; however, because few children in either group mentioned examples of Probability and Statistics, the results for this subgoal should be interpreted with caution.

Goal III and the Essay

In our analysis of the Essay (administered to the entire sample of 240 children during the sixth week of the treatment), we compared the average number of content areas mentioned by the viewers to the number mentioned by the nonviewers. We found that the two groups did not differ significantly; viewers mentioned 2.50 subgoals on average, and nonviewers mentioned 2.28. However, the two groups did differ significantly within individual subgoals. Table 3.3 presents the distribution of the viewers' and nonviewers' responses across the content areas described in Goal III.

As this table suggests, viewers and nonviewers differed within two of the Goal III subgoals; viewers mentioned significantly more examples of Measurement ($p < .01$) and marginally more examples of Geometry ($p < .10$).

Essay. Also, viewers mentioned marginally more examples of Geometry than nonviewers, both in the posttest Attitude Interview and in the Essay.

<u>Changes in References to Problem Solving</u>

The viewers made significant gains in the proportion of the practical and sophisticated problem solving that they mentioned in response to interview questions. This is particularly encouraging. The problem solving that is demonstrated on **SQUARE ONE TV** involves people figuring out interesting problems; "Mathnet," for example, presents two detectives using mathematics to solve crimes. The children's descriptions of practical problem solving (e.g., building and fixing things) and of sophisticated problem solving (e.g., solving mysteries and creating inventions) are very much in line with the contexts for problem solving shown on the series. Exposure to the series resulted in the children's naming more of these examples.

However, the children did not generally link this kind of problem solving with mathematics. The descriptive analysis indicated that, in general, the children made connections between mathematics and computational problems but they did not connect more sophisticated problem solving with the mathematics that they were most familiar with. However, in five posttest interviews children mentioned "math" and spoke of practical or sophisticated problem solving in response to the same question; four of these five children were from the viewer group. While this is not a large enough sample to test statistically, it is suggestive.

These five children spoke of the thinking in mathematics and the thinking in PSA C* as similar. They referred to situations such as house break-ins and mysteries in books as similar to both PSA C* and mathematics. As one child summed up after noting that the PSA C* is like mathematical problem solving, "[PSA C* is] like just figuring out [arithmetic] problems. Figuring out what's wrong." These children seem to have made the leap in associating the problem solving in PSA C* with the process of problem solving in mathematics.

INTRODUCTION

In this Introduction, we present the theoretical framework and methodological approach used in our exploration of children's perceptions of the usefulness and importance of mathematics, both in the Attitude Interview and in the Essay.

Theoretical Approach

Problem Solving, Usefulness, and Importance

The current emphasis on problem solving among proponents of reform in mathematics education highlights the need to enhance children's perceptions of the usefulness of mathematics. Lave, Smith, and Butler (1988) suggest that teaching mathematics via a hands-on approach involving purposeful problems would result in children's gaining a greater appreciation of the importance of mathematics to their lives. It is further hoped that teaching mathematics by "doing" (i.e., through applications of mathematics) would help to mitigate against the development of beliefs similar to those currently held by some students: that mathematics is not useful to them by virtue of their sex, class, or race (Fennema, 1989; Lave, et al., 1988; Reyes, 1984; Reyes & Stanic, 1988). In other words, it is presumed that teaching children about the uses of mathematics would teach them to use it.

Research on Perceived Usefulness

Reyes (1984), in her review of current research on mathematics attitudes, reports that perceptions of the usefulness of mathematics are related both to mathematics achievement and to continued election of mathematics courses in the high-school years. Reyes cites the research of Fennema and Sherman (1977), which found that middle- and high-school students who scored higher on mathematics achievement tests also found mathematics to be more useful than experience with PSAs. Despite this, the evidence from these measures suggests that viewers became more likely to speak about examples of Geometry and Measurement -- two areas other than arithmetic -- in the context of discussing mathematics and problem solving.

The results presented throughout this chapter ou children's constructs of mathematics indicate how pervasive and enduring the children's discrete operations perspective on mathematics were. The emphasis that the children placed on arithmetic, placing it right in the center of their conceptions of mathematics, limited their understanding of and ability to integrate mathematics and problem solving. Despite this, persistent viewing of **SQUARE ONE** TV enabled viewers to expand on their constructs of mathematics. While the structure of the children's beliefs could not be expected to change in so short a time and without the benefit of curricular reform, qualitative differences were found in viewers' responses at the posttest. After their 30-program exposure to the series, viewers began to talk more about complex problem solving and advanced mathematics in their discussions of the PSAs, figuring out, and mathematics.

goals, characters on **SQUARE ONE TV** are shown discussing, exploring, and using mathematics in a wide variety of situations to accomplish a wide variety of purposes. The diversity embodied in these portrayals points to the more general importance of mathematics in our lives.

Methodological Approach

The Use/Importance Questions

Our aim in developing questions about this dimension was to capture the aspects of perceived usefulness discussed above: children's ideas of both current and future uses of mathematics and problem solving, and their conceptions of the importance of mathematics and problem solving. Although "usefulness" and "importance" are somewhat abstract concepts, we found that this was not problematic; both concepts were easily understood by the children with whom we worked during the pilot-test phase, and children produced meaningful responses to our questions. In addition, while many of the questions asked for simple, generalized, and, therefore, abstract evaluations of the discipline (e.g., whether mathematics is important), we asked the children for specific reasons and examples in follow-up questions to help clarify their responses to the more abstract questions. As in all of the attitude dimensions, we developed questions to probe similar issues in the PSA and Mathematics Domains of the interview so that comparisons could be drawn across the domains.

Below is a list of the questions considered in the present analysis of children's perceptions of the usefulness and importance of mathematics and problem solving. The questions are divided by the two relevant domains of mathematical inquiry, the PSA and Mathematics Domains.[40]

[40] Originally, two Use/Importance questions were included for the Figuring Out Domain as well: "Why do you like to figure out [the activity you mentioned in Q35]?" (Q36), and "What do you feel is important for you to figure out? What kinds of things do you feel are important to figure out? What about out of school?" (Q44). However, the topics that the children discussed in this domain were too diverse to relate to their PSA and Mathematics Domain

CHAPTER 4

USEFULNESS AND IMPORTANCE

In this chapter, we will present the results of our inquiry into children's perceptions of the usefulness and importance of mathematics. This attitude dimension is concerned with the ideas that children hold about the value and potential applications of their mathematical knowledge. Proponents of mathematics reform (e.g., NCTM, 1989) have recommended placing a greater emphasis upon the usefulness and importance of mathematics within the elementary curriculum.

The two sources of data for our analysis were the questions in the Attitude Interview designated for usefulness and importance and responses regarding usefulness in the Essay. This chapter contains: (a) an introduction presenting our approach to this dimension, (b) a descriptive analysis of key questions, (c) the development and presentation of the analysis scheme for assessing the effects of viewing SQUARE ONE TV, and (d) the results of our analysis of change and a discussion of the effects of viewing SQUARE ONE TV.

Developing a Descriptive Analysis

First steps in analysis. Our preliminary analysis guided us in the development of analysis schemes for the descriptive analysis and the analysis of change. As described in Chapter 2, the first step in data analysis consisted of a review of 16 posttest interviews, eight viewers and eight nonviewers (unidentified as such to the research team). From this preliminary analysis, we came to two conclusions that guided our analytic strategy: first, that the children valued those things for which they could find practical uses in their lives, and, second, that they produced specific applications of problem solving and mathematics in response to all of the questions -- even those that asked about the general importance of mathematics. Thus, the children typically responded to questions targeted for use and those targeted for importance in basically similar ways: they provided applications for the use of mathematics and problem solving. This pattern was seen in the preliminary analysis of 16 pretest interviews as well. Clearly, then, our coding scheme for the descriptive analysis would have to capture the applications of mathematics that the children described.[42]

Still, we also wanted to examine children's statements relating to the importance of mathematics, because such an analysis would lend further insight into what the children valued about mathematics and problem solving. While it was likely that children would say that they valued being able to use mathematics and problem solving, we wanted to see if there were other aspects of mathematics and problem solving that they valued as well. A similar approach was taken for the development of coding for the Essay, which was analyzed for various applications of mathematics, as will be discussed more fully below.

Key question analysis. As in the other dimensions, certain "key questions" were particularly effective in eliciting informative responses; these questions formed the basis of our descriptive analysis. Questions 10, 17, 48, and 54 were selected as key to understanding the

[42] This is not to say that we believe mathematics to be important only to the degree to which it is useful in practical applications. However, because the children's responses centered primarily on uses, our coding schemes focused on uses as well.

did their lower-achieving peers. Research by Armstrong and Price (1982) indicates that the perceived usefulness of mathematics also seems to be a more powerful predictor of continued enrollment in mathematics classes than whether the children liked mathematics. Reyes suggests that "a better understanding of the importance of mathematics in a wide range of careers and in education beyond high school is important for students as they make decisions about how much mathematics to take in high school" (p. 571).

The concept of perceived usefulness presented by Reyes and Fennema and Sherman holds several implications for reform in mathematics education. First, perceived usefulness concerns how useful mathematics is to the children currently. Because research has indicated that the foundation of mathematics beliefs are set in the elementary-school years, if children do not find mathematics useful in these years, they may not ever find it so. Second, attempts to enhance children's perceived usefulness should also focus on their perceptions of its usefulness in the future. If a child does not perceive mathematics as necessary to a chosen career or to any other aspect of her or his future life, then it may be likely that she or he will not perceive mathematics as a vital part of her or his education. Third, mathematics also needs to be seen as inherently valuable for reasons beyond its usefulness in specific situations. All three elements, understandably, are interrelated. Successful mathematics curricula would give children a sense of the current and future usefulness of mathematics as well as of its general importance.

Goal I of SQUARE ONE TV

As a part of the movement for mathematics reform, **SQUARE ONE TV** has as a goal the enhancement of children's perceptions of the usefulness and importance of mathematics. One of the goals of **SQUARE ONE TV**, Goal IA, is to show that "mathematics is a powerful...tool, useful to solve problems..." Goal IC further states that the series should promote the concept that "mathematics can be used...and even invented by non-specialists." In keeping with these

DESCRIPTIVE ANALYSIS: WHAT CHILDREN VALUE ABOUT MATHEMATICS AND PROBLEM SOLVING

This descriptive analysis investigates what the children valued (i.e., what they deemed to be important) about mathematics and problem solving (as reflected in PSA C*) in the absence of any treatment, that is, in the pretest. Our discussion will incorporate issues pertaining to both importance and use. In this section, we will: (a) describe what the children found important about mathematics, (b) describe what they valued about the problem solving in PSA C*, and (c) conclude by relating this analysis to our previous analysis of the children's constructs of mathematics.

Overview of Results

We found several similarities and differences between what the children valued about mathematics and what they valued in PSA C*. In both domains they discussed the value of being able to use mathematics and problem solving, and they described the intrinsic and extrinsic rewards that caused them to value these activities. However, most of the uses that the children described for mathematics were based in computation, and some children based the importance of the subject upon extrinsic rewards (e.g., good grades). By contrast, they found PSA C* important because of the intrinsic value of learning how to figure things out, and described uses involving fixing and problem solving in general.

PSA Domain

10. Do you think it's important to be able to figure out things like this -- the Dr. Game thing [PSA C*]? How come?

12. Remember how you were thinking when you were doing this? [PSA C*] Do you think that you could use that kind of thinking in other situations? When? In school? Outside of school? Outside of school not including homework?

17. Is that [i.e., what one would learn from a PSA C* class] important?

18. Do you remember the other thing that you did yesterday -- with the clocks/party tables? [PSA B*] Do you think it's important to be able to figure out things like this? [PSA B*] How come?

27. Is being able to figure out things like this [PSA A*] important? How come?

29. Remember how you were thinking when you were doing this [PSA A*]? Do you think that you could use that kind of thinking in other situations? When? In school? Outside of school?

Mathematics Domain

48. Should this person who doesn't know math learn about it? How come?[41]

51. Is math useful to you in your life now? Why or why not?

52. Is math useful for you in your life outside of school? Why or why not?

53. Will it be useful for you in the future? Why or why not?

54. How important is math to you? How come?

60. Can you tell me some fun and interesting ways to use math?

61. Can you name some fun and interesting ways to use math outside of school? What about fun ways to use math, not including homework?

62. Can you tell me some fun and interesting ways adults use math?

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responses, and so, the data from these questions were not analyzed.

[41] This is a companion question to Q47, the alien math question: "If you had to explain what math is to someone who had never heard of it, maybe someone from another planet who happens to speak English, what would you say that it is?" The alien math question was discussed and analyzed in Chapter 3.

know mathematics because "someone could cheat him out of his money..." Most of these money-based responses referred to the transactions that the children considered to be important in fairly simple terms: "go to the store to buy something," "buying things," or "how to count money." A few children described more complex ways of using money, e.g., in terms of comparing the weights and prices of things or budgeting.

Important uses of mathematics without money. Approximately one tenth (11%) of the children explained that the alien should learn mathematics for reasons unrelated to money (Q48). These responses described, among other things, the importance of mathematics in using a map.

Important uses for the future. Less than one fifth (19%) of the children's responses described the importance of mathematics to their future lives.[45] Most of these future-oriented responses were concerned with monetary transactions. The monetary transactions that the children mentioned ranged from paying bills to working at a store to knowing how much to pay one's employees.

Other future-oriented responses (i.e., those not related to money) described uses of mathematics in one's work. In these responses, the children did not speak about specific jobs and the requirements of mathematical knowledge on those jobs. Instead, they asserted that mathematics is important "to get a good job and things." As the following response indicates, the children were also vague about how mathematics would be used in a job setting:

> It's gonna be very useful when I get a job. And they're gonna give me lots of paperwork...And I'm gonna use math when I'm doing the paperwork, like they give me.

With the exception of working in a store, only two children mentioned specific occupations, one talking about bookkeeping and the other about using estimation in the practice of law.

Generic importance relating to usefulness. In response to Question 54 ("How important is math to you?"), nearly one quarter of the children (24%) stated that mathematics was

[45] Sixteen children gave these responses.

children's perceptions of the usefulness and importance of mathematics: these key questions were content analyzed according to the children's responses. For example, when the children mentioned that mathematics or PSA C* was important in the context of school, this was categorized as a "school" response. The coding categories were derived from themes articulated by the children and, as such, are largely self-evident. A scheme was developed for each of the two domains in order to categorize the range of responses presented by the children.

The children's responses within these descriptive categories were then examined for differences by sex, ethnicity, and SES. We found no consistent patterns of differences related to any of these characteristics. The coding categories themselves, and the distribution of responses according to sex, ethnicity, and SES, can be found in Appendix III.E.

Assessing Change due to SQUARE ONE TV

The Attitude Interview. Given that in our preliminary analysis the children's responses consisted primarily of applications of mathematics, we constructed our analysis to focus on these applications. We examined applications in several ways, each of which will be discussed in detail in the section on the effects of SQUARE ONE TV.

The Essay question. As described in Chapter 2, the question presented in the Essay asked children to write about careers involving mathematics. Like the Attitude Interview, the Essay was coded according to the applications that the children mentioned, as well as the mathematics used in those applications. The coding schemes for the Essay will be discussed at greater length in the section on the effects of SQUARE ONE TV, later in this chapter.

> highest multipli -- um, if you multiply and whoever gets the num -- highest number, he could join that and they could win for instance a thousand dollars or something...So that he'll learn about dividing, multiplying, subtracting, and adding so they'll learn more about it.

Or, as another child explained, mathematics would be important for someone to learn because:

> It's a challenge...That proves that you know something. That proves that you -- you can do whatever you're trying [to] go for...Well, you're trying to get a hundred on the paper...Well, you try real hard and you make it, you're happy. If you just flop some stuff down on the paper, you're not gonna be happy...It's a goal...That you can get what you're looking for done.

These two children did not speak of applications of mathematics to specific problems but rather saw mathematics as a means of showing that one is smart and capable and "that you can get what you're looking for done."

Important learning not in school. While one tenth (9%) of the children spoke of the importance of mathematics in terms of learning without explicitly placing this learning in the context of school, the influence that their experience in school had on their responses is evident nonetheless.[48] The children talked about the importance of knowing how to do arithmetic, how to use numbers, and how to count. As one child said, one should learn mathematics "'cause, there's lots of things here that you have to learn and that use numbers and all that kind of stuff." Another child stated that the person from another planet should learn mathematics

> 'cause if they come back to Earth again [Laugh] then, then they're gonna have to know it a lot or they're gonna be stuck in the hole...'Cause like if somebody asks, ask some math problem or something 'cause they don't know, know it totally, I mean 'cause say I don't know. I mean it'd be kind of silly to say "I don't know. I'm not from here" and stuff.

Note that this child presented a hypothetical situation that seems to stem from the classroom -- namely, being asked a mathematics problem. The value of mathematics seems to reside in being able to respond to questions about it.

Mathematics is important because it is fun. In response to Question 54 ("How important is math to you?"), 16% of the children framed their responses in terms of their enjoyment of

[48] Eight children made these responses.

What Children Value about Mathematics

Approach

We asked children about the importance of mathematics in two ways. First, we asked them, "Should this person who doesn't know about mathematics [i.e., the alien] learn about it? How come?" (Q48). Phrasing the question in this way enabled the children to present their general beliefs about why mathematics is important to learn. Our second way of asking about importance was to ask children, "How important is mathematics to you? How come?" (Q54). Together, the two questions allowed us to determine what the children felt was important about mathematics in general and in relation to themselves personally. The discussion below focuses on children's responses to both questions, unless otherwise indicated.

Mathematics is Important Because it is Useful

Approximately two thirds (65%) of the children's responses indicated that mathematics is valuable because of its usefulness.[43] These responses demonstrated an appreciation that mathematics is useful in a variety of contexts relating to the children's lives, now and in the future; many were related to money or uses in the classroom. These children who said that mathematics was not important also pointed to these types of uses but felt that they were not particularly important.

Important uses involving money. Approximately three tenths (29%) of the children's responses to the two questions focused exclusively on monetary transactions as a reason for the importance of mathematics.[44] It was important to these children to know how to use money so that one is not cheated or doesn't waste one's money. As one child explained, a person should

[43] Thirty-nine children made these responses.

[44] Twenty-four children made these responses. Note that an additional 17% of the children's responses also mentioned money, but it was not the focus of these responses.

What Children Value about PSA C*

Approach

Our analysis of the importance of problem solving is based on the children's reactions to the PSAs. Because PSA C* is the most complex PSA, we have analyzed the children's responses to two questions relating to its importance. The first question asked for the children's assessment of the importance of PSA C* itself: "Do you think it's important to be able to figure out things like this? How come?" (Q10). The second question asked the children to evaluate the importance of a hypothetical high-school class that "teaches you how to figure out things like the Dr. Game thing [PSA C*]" (Q17).

The Importance of Learning and Doing

The children's responses to these key questions emphasized the value that they place on learning how to solve or fix things. While some of the children appreciated this learning in ways closely related to the task at hand (i.e., fixing games), most explained that what they could learn from PSA C* was important to them in the present and for the future. Most saw intrinsic value in this learning; that is, they had a sense that such learning was valuable and benefitted them in some way. Only a few saw the importance of the task as dependent on their performance, i.e., as a means to get answers right.

The value of learning. Almost one half (44%) of the children's responses indicated that the PSA C* experience was important to the degree that one could learn from it.[49] Sometimes this was stated simply: "Because you could learn more." (In fact, one of these children stated that such a class wouldn't "really" be important because "you wouldn't learn too much from it.") Other children described this learning process in more detail; for example:

Yes, because it helps you learn more...It helps you think hard...It challenges your

[49] Twenty-seven children made these responses.

important to them because of its general usefulness. For example, one child said: "Because you leave -- you -- you need it um about all -- all your life and you usually need math." The majority of the responses in this category related mathematics to its use in school. However, most of the children in this category indicated that mathematics is not important, or not particularly important, because they did not find it useful. These children seemed to equate importance with usefulness so that when they perceived mathematics as not very useful, it was also not important. These children understood the applicability of mathematics to monetary transactions, yet this particular use did not seem sufficient to make mathematics generally useful or important to them, as the following response illustrates:

> Yes, [it's important], 'cause I go to the store sometimes and then no [it isn't], because I don't go to the store that often and at home, I don't really have use for math. Outside, I don't really have use for math, either.

The Importance of Learning

Less than three tenths (28%) of the children's total responses described the importance of mathematics in terms of the value they derived from learning it.[46] Typically, perceptions of value were related either to school or to the fun (or lack of fun) of learning mathematics.

The value of mathematics in school. More than one tenth (12%) of the children's total responses discussed the importance of mathematics in terms of school learning.[47] These responses referred to mathematics as important because it enables children to respond to questions about mathematics and to achieve in mathematics. Several of these children said that mathematics was important to them to "keep my grades up" or because "I get a lotta good grades." As one child explained, someone should learn mathematics

> so they'll know about, so they don't have to um, like just in case somebody goes to ask him what math is, they'll know about it and they'll, they might be smart at, they might be smart um if they learn math and some people can get smart. And join things about mathematics like, a mathematics club, whoever gets the

[46] Twenty-three children made these responses.

[47] Ten children made these responses.

school." Another said that the activity was not important because it wasn't for a "real real big grade."

The importance of PSA C* for the future. While one of the two key questions asked the children to think about a hypothetical high-school class and, thus, all of those responses might be considered future-oriented on an implicit level, nearly one fifth (19%) of the children's responses explicitly stated that learning how to figure out things like PSA C* would be important to their futures.[51] Most of these responses arose from the question not set in the future. Several of these responses indicated that knowing how to solve problems will be important to the children as they grow up. Approximately one half of the responses explained that this skill would be helpful in a range of occupations -- from teaching, to police or detective work, to "game fixer," or mechanic. One child who envisioned herself becoming a "worker off and on" made a clear connection between the fixing required in PSA C* and what she saw herself doing in the future:

> 'Cause in the future when I grow up, I might have a job or I might, it depends...[or if I was a] worker off and on, not one of those that you're like a teacher and you stay here forever, probably I would be one of those workers that...just like a little kid goes and says, want me to wash your windows or something, just like that, off and on, and she works for rest of the day or till Monday through Friday something. Probably somebody would ask me to repair something for them or something and that would, all this would probably help me in, in the future and make me earn some good money.

This child's recognition of the PSA C* experience as relevant to her future work made that experience important to her. The children in this category indicated that the PSA C* experience was important because they could use the skill they learned from it in the future.

The importance of fixing and playing games. Less than one fifth (16%) of the children's responses related the importance of the problem solving in PSA C* to figuring out or playing games (responses that are in keeping with the game that is the focus of PSA C*) but did not present a larger sense of the importance of hands-on problem solving.[52] These children

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[51] Fifteen children made the responses.

[52] Thirteen children made these responses.

mathematics. That is, for these children, mathematics was important to the degree that they found it enjoyable. As one child stated:

> [Math is] really important...It's my most favorite subject...It's just interesting... Because, like we were learning today where you can change an um um improper fraction into a proper fraction...And you change one number to a totally different number...And you can -- it's just weird the way you have two numbers and it could be a ten or something. Could be another number.

By contrast, four of the children cited issues relating to enjoyment as reasons for not liking mathematics. As one child stated:

> Well, I don't really think it's important but...Because mmm, 'cause it's not fun... You could be play -- um -- like playing my Nintendo instead of doing math in school or something.

The remaining three children disliked mathematics because they found it difficult or do not do well in mathematics.

Conclusion

The children described two basic ways in which they valued mathematics. First, and predominantly, they found mathematics important because of its usefulness in their present and future lives. The uses that the children described were very limited; most mentioned transactions involving money -- buying and selling. Indeed, a few children found mathematics unimportant because these monetary transactions did not seem useful enough to make the subject important. While there is no doubt that being proficient with money is important, the uniformity of the children's responses is striking. The only areas of mathematics beyond counting and arithmetic that the children mentioned in connection with these questions were estimating and using a map, each of which was mentioned by one child apiece.

A smaller number of children valued mathematics for the rewards of good grades and the pleasure of the activity itself. These children derived a sense of the importance of mathematics from their enjoyment of it. They took satisfaction from being competent in mathematics, which they saw as an indication that they were smart.

Conclusion: What Children Valued about Mathematics and PSA C*

The children discussed a similar range of sources for the importance of PSA C* and mathematics: usefulness, learning, and enjoyment. Yet, these values were expressed differently and were represented in different proportions in each domain. The two domains differed also in the proportion of statements indicating that the children did not find the subject important: 16% of the responses about mathematics were negative, in contrast to only 7% of the responses about PSA C*.

The Usefulness of Mathematics

The analysis suggests that the children assessed the importance of mathematics in terms of its usefulness; the two concepts, importance and usefulness, appear to have been inextricably linked. At the same time, the children's beliefs about the importance of mathematics seemed to have been constrained by their construct of mathematics. While the children found the usefulness of mathematics to be a compelling reason for its importance, the uses that they described were based in arithmetic. Simultaneously, several children did not find -- or no longer found -- these routine arithmetic uses to be enough to justify the overall importance of mathematics.

The children who did find mathematics useful spoke primarily about applications of arithmetic. The limitations placed on their uses for mathematics by their arithmetic-based understanding of mathematics raises serious questions. If these children can only identify the usefulness of the subject via computation, then what happens as children notice that computation is increasingly automated? The responses of a few of the children suggested the potential vulnerability of children's perceptions of usefulness to technological advancement. One child stated that the alien should know mathematics

> 'cause when he um comes to earth or something, he's gonna have to learn it because he's not gonna know what to do. He's gonna have to get a job. He's

mind...It gives you more practice on thinking hard...'Cause it helps you learn...So you can have a good education, and not be dumb like other people.

Some of the children mentioned that the problem solving involved in PSA C* was or would be important to learn. A smaller number of the children said that it was important to learn (in one child's words) to "do good and fix things." Similarly, some children said that learning how to fix things is important in order to be able to use things and to save money on repairs.

Most of the responses in this category concerned learning as having intrinsic value. The importance of the task seemed to rest in the know-how that one gets, the fun of doing it, and the ability to "figure out stuff." The children spoke about this learning as something that they themselves valued, rather than something that they valued because they are rewarded for it by a parent or teacher.

Within the discussion of learning, one tenth (11%) of the children's responses were more explicit about the intrinsic value of the PSA C* experience.[50] These responses explained that the experience was important "so you can be proud of yourself...You figured out something." Two children said that they felt that PSA C* was important because it gave them an opportunity to work hard and to feel good about themselves for making an effort. One stated that the PSA C* experience made "[me] feel that I'm independed [sic]" which is important, as another child said:

> because um, cause um, that'll, that'll show you that you know how to do things by, by yourself and um, and that um you're good for something and you, and um, that you know how to do something well and um, you're o -- and um, and you're always good at something and all.

Another child said that the task was "like a challenge to your -- towards yourself."

A few of the children expressed the importance of learning in terms of the extrinsic rewards given for performing well. These children felt that what was important was to "answer all the questions on it." One child explained that the task was important in order to "beat my other friends...by getting the things right." This child also said that he was "doing this...for the

[50] Eight children made these responses.

understanding of the importance of mathematics to various careers and higher education. Such concerns may not be germane to the lives of fifth graders.

The Usefulness of Problem Solving: PSA C*

The children's perceptions of the usefulness of problem solving, exemplified by their reactions to PSA C*, present a different picture in two ways. The children made fewer responses relating to uses of PSA C*. However, while in relation to mathematics the children predominantly spoke of monetary transactions, the children's important uses for PSA C* covered a range of occupations (e.g., teacher, detective, policeman, and game inventor) as well as solving problems and fixing things.

Whether the children eventually choose to pursue careers associated with PSA C* or not, the range of possibilities that this one task opens for them, in contrast to the limited horizons of the store clerk or cashier, is striking and positive. Similarly, the children's perception that the general ability to solve and fix things is an important aspect of the PSA C* experience (both in the present and in the future) contrasts with the limited and repeated references to buying and selling that the children mentioned as a reason for mathematics' importance. Both the kind of thinking required by the problem and the meaningful context in which it was set appear to have had an impact on the children.

Value and Motivation

In response to the questions relating to mathematics and those relating to PSA C*, the children discussed the value of each of these activities in terms of the benefit gained from their involvement. In relation to mathematics, the children expressed both extrinsic and intrinsic reasons for considering mathematics to be important. The children considered the reward of being competent to be a source of their enjoyment and a reason for finding mathematics important; competence stemmed from being seen as smart and being able to give discussed the problems presented in PSA C* (e.g., "you just keep on finding a winner") to be what made learning how to fix the game important: The importance of fixing the game was simply to learn how to fix games.

The importance of helping others. Nearly one tenth (9%) of the children's responses mentioned that PSA C* was important "so you can help other people."[53] These children felt that "if people need help, then it's -- they really need, then I think it's important." While this is related to the context of PSA C* (in that PSA C* was presented in the context of helping Dr. Game, the owner of a game factory, to discover how one of his games had been sabotaged), the help that the children described was not limited to stopping crime but included helping other children with games, solving people's problems in life, and assisting elderly people.

Conclusion

The children described the importance of figuring out things like PSA C* in a variety of ways. They felt that it was important for them to learn the skill of figuring out. While this skill could help them fix things and save money, the accomplishment of being able to solve problems also made them feel good about themselves and, thus, was considered important. While a few children spoke of the task as important insofar as it allowed them to perform well, the vast majority of the children's responses about learning referred to the intrinsic value of the experience.

The children also described several possible applications of the PSA C* experience as making this sort of problem solving important. Some thought that this skill would help them in the future by allowing them to solve problems more skillfully in their lives an: on the job. Others saw value in the task as it related to fixing and playing games. A few children felt that the PSA C* experience was important because it enabled them to help others.

[53] Six children made these responses.

THE EFFECTS OF VIEWING SQUARE ONE TV: ANALYSIS SCHEME

In this section of the chapter, we will present the analysis scheme that was devised to assess the effects of viewing **SQUARE ONE TV** on children's perceptions of the usefulness and importance of mathematics. Two sources of data were used: (a) the designated Use/Importance questions in the Attitude Interview, and (b) the Essay. We will present, first for the Attitude Interview and then for the Essay, considerations in the development of the analysis scheme and the scheme as it ultimately emerged.

Considerations in Developing the Interview

During the iterative process of open coding meetings described in Chapter 2 of this volume, we realized that the children's responses to our questions about the usefulness and importance of mathematics and problem solving were primarily concerned with uses, i.e., applications. Even in the four questions that were designed to target children's perceptions of importance, a large percentage of their responses described applications of mathematics or problem solving. Thus, we decided to focus our analysis of the effects of the series on the applications of mathematics and problem solving that the children mentioned.

We were also interested in making certain distinctions among the applications mentioned by the children. These distinctions concerned the types of applications mentioned by the children and the ways in which children presented them. First, as the previous descriptive analysis indicated, many of the children's applications mentioned simple computation involving money -- buying, making change, or counting. Because these applications were so prevalent, we wanted to distinguish between these basic responses and those that extended beyond them (what we term "unique" responses). Second, because research has pointed to a link between older children's perceptions of the future usefulness of mathematics and their continued gonna have to know to do everything...Like he's got -- he's gotta have a [college degree] or something. [R: And why would he need to learn math? For that?] Because, if you want to be a cash register person, you'd have to know math because you have to press all these buttons. And make change.

While this child indicated that mathematics is important for work and implied that one would take mathematics courses through college, the mathematics that he described simply involves identifying numbers. Another child explained that the alien would have to know mathematics for banking only if "there wasn't no them things [automated tellers] to get the money out. They would just get a piece of paper and do the math problem by a pencil and paper and they would figure out the, how much money they need, or how much money they get back in the change they gave." But of what use is knowledge of computation if cash registers only require the ability to identify numbers and if automatic tellers do computation? Given the increasing role of automation in banking and in other aspects of everyday life, it is doubtful that these children would consider mathematics to be important.

Concern over the relationship between arithmetic and technological advances in the elementary curriculum has been a focus of the reform movement in mathematics education. Kulm (1980) notes that the increasing use of automation for basic computation challenges the emphasis placed on computation in the elementary mathematics curriculum. NCTM (1989) and other proponents of reform in mathematics education encourage the development of curricula wherein children learn not only arithmetic skills but other content areas of mathematics as well.

The limits on the children's ability to discuss uses of mathematics may have been due to their lack of experience with and exposure to other uses. The jobs that the children spontaneously mentioned in response to these questions (cashier, bank teller, and store clerk) may have been the jobs that they most frequently come in contact with as they accompany their parents. As these children grow older and their understanding of the world expands, they may be able to articulate a greater variety of uses for mathematics. Reyes (1984) suggests that as children make decisions about what courses to take in high school, they need to have a better

Q12: Could you use the thinking in [PSA C*, which involved fixing a game] in other situations?
S: Like a game that's broken...Or it's all mixed up.

Q18: Do you think it's important to figure out things like [PSA B*, which concerned arranging clocks on shelves]?
S: Because if you worked in a store you could put the clocks in order.

Q61: Can you name some fun and interesting ways to use math outside of school?
S: Wherever you go. At home I ask my dad to tell me math problems so I can answer 'em.

Basic applications were often slight abstractions from the context given by the question, and they were not particularly inventive. They often generalized beyond the context but were vague, e.g., "arranging things." In the Mathematics Domain, all of the responses that had to do with buying things and going to the store were coded as basic. Examples of statements within this category follow:

Q12: Do you think you could use that kind of [PSA C*] thinking in other situations?
S: Like if you get a game and -- and you lose some stuff and -- Then you could like make your own rules.

Q27: Is being able to figure out things like this important?
S: If you have something and you need to put it in order.

Q5.: Is math useful to you in your life now?
S: They go to the store and gonna have to know how much it's gonna cost.

Unique applications were abstracted from the context of the question in such a way that the response was a different application entirely from the original question context. We tried to be particularly sensitive to the subjects' references to problem solving or to using mathematics in contexts other than the ones given in the interview. Examples of these responses follow:

Q12: Do you think you could use that kind of [PSA C*] thinking in other situations?
S: Like if your dog takes something but you don't know who took it, and you're looking for it.

engagement with it (see Kulm, 1980; Reyes, 1984), we wanted to focus both upon applications that the children identified as presently useful and those useful to them in the future.

The Interview Analysis Scheme

The purpose of this analysis scheme is (a) to aggregate the applications presented by the children across all designated questions, and (b) to make distinctions among the applications by "type" (i.e., basic or unique) and "time" (i.e., present- or future-oriented). A child could give more than one codable response per question asked. Each distinct application was categorized, and subcategories were established within each category.[54] Brief descriptions of each category and examples will follow. For detailed information on coding guidelines, and additional examples, please refer to the Use/Importance codebook in Appendix III.F.

Type of application. Types of applications were categorized as repeat, basic, or unique. Each distinct application was coded for only one of these categories.

Repeat applications were applications where the children merely parroted or repeated an application virtually as it had been framed by the context of the question. This was particularly evident in the PSA questions. For example, when an interviewer asked if PSA A* is important and the child responded that it was because you can put circus people in order (i.e., gave the exact context of the PSA), then this was coded as "repeat." However, the "repeat" category was not limited to the PSA questions. In the Mathematics Domain, if a child responded by giving an application that merely consisted of doing school-like mathematics problems in another context (e.g., at home), this would also be categorized as "repeat." Examples of these applications follow:

---

[54] To determine whether numbers of applications were related to the number of follow-up questions that the interviewers posed, we correlated the number of applications with the number of questions asked. The result indicated that the number of applications given was significantly related to the number of questions asked ($p < .01$). For further information on this point (and our means for dealing with it in our analysis), see Appendix III.L.

the right answers. Similarly, some students who stated that they do not do well in mathematics found it unimportant. A few children pointed to a different type of intrinsic value; these children determined the importance of mathematics by how much fun it is to do.

The children's responses to the PSA C* experience dealt primarily with the intrinsic value of learning how to solve and fix things. Further, some of the children gave elaborate descriptions of the benefits of the problem-solving task: they felt good, they realized their own worth, and they were proud of themselves. A few responses, however, indicated that the children judged the importance of the PSA C* experience by its extrinsic value. One child found this problem-solving experience unimportant because it lacked an extrinsic reward -- a grade. A few also spoke of the value of knowing how to solve problems in terms of their ability to achieve.

While it is important to consider these results in light of the fact that the children encountered PSA C* in a context devoid of grades or other academic rewards, the discrepancy between their responses concerning PSA C* and mathematics is striking. In both domains children spoke of the importance associated with learning the subject matter at hand; however, the importance of learning mathematics was typically associated with grades while the importance of learning associated with PSA C* lay in the intrinsic value of learning how to figure things out. Although we cannot state conclusively what would happen if contextualized, hands-on activities such as PSA C* were set in the classroom, where grades are stressed, the present data suggest that such tasks have the potential to show children the intrinsic value of learning how to solve problems.

know how much you're gonna -- you're gonna sell for it.

Like if -- like if I get a job like this or something? So they might hire me and I have to figure something out like that.

Scoring. More than one codable response could be given to each question. The scoring for this measure was based upon proportions of responses. Proportions were created by dividing the number of unique or future and conditional responses by the total number of codable responses that the child produced.

Considerations in the Development of the Essay Scheme

In developing the Essay coding, we wanted to create coding schemes that were parallel to the attitude dimensions investigated in the Attitude Interview. As discussed earlier, the question used in the Essay asked the children to write about whether or not they would want to have a job involving mathematics: a job "figur[ing] things out and solv[ing] problems using shapes, numbers, measurements, or other things having to do with mathematics."

Responses to the Essay clearly would contain information related to children's perceptions of the usefulness of mathematics because the question asked children directly about applications of mathematics. However, because the Essay asked for information that was somewhat different from the information elicited by the Attitude Interview, the coding scheme that was developed for the Essay was tailored to fit the demands of this measure. This scheme focused on the degree to which the children presented specific, as opposed to general, applications of mathematics.

Applications of Mathematics

This analysis described the degree to which each child wrote about mathematics as a nebulous, general whole or dealt with specific applications. There were two related components to this coding, each of which captured different aspects of the children's essays. The first

Q12: Do you think you could use that kind of [PSA C*] thinking in other situations?
S: Like a mystery in books and stuff.

Q27: Is being able to figure out things like this [PSA A*] important?
S: Like if you have like four pairs of jeans and then four shirts/blouses and you want to find out how many ways you could do them together.

Q52: Is math useful to you in your life outside of school?
S: 'Cause you need to know if somebody asks you how many miles it is to a place...

Time of application. Time refers to the time in which the child indicated the application could take place. The primary distinction was between the present and future and conditional. This distinction was not dependent solely on verb tenses, because children frequently used verb tenses that were grammatically inappropriate. For example, they used present tense to talk of jobs (e.g., being president), that, given their age, must have referred to the future. Sometimes this was not strictly ungrammatical because the present tense in English has an implied, ongoing sense that can also make it future-oriented.

Present time referred to all applications that, by indication of verb tense and context, took place in the child's current life. Examples of these responses follow:

> If you have a test, then you'll know how to add or something.
>
> Because then if you have a party, that way you can know where to sit people or how many people you're gonna invite.

Future and conditional time referred to the future. Conditional responses often involved words such as "could," "might," and "would." Frequently, an "if...then" construction was used. Future time was noted if the respondent used the future tense or if the child could not do the activity she or he described (e.g., having a job) until the future. Examples of these responses follow:

> 'Cause if you worked in a toy store, you can fix the games.
>
> That way when um later when you grow up and they might hire you to fix games.
>
> Well, like if you're gonna sell something to somebody, you need to

If a child gave both specific and general examples, then that child's essay would be categorized as Specific Mathematics.

Interrater Reliability

After the analysis schemes were developed for each measure, the completeness and replicability of the coding categories were tested by having a second researcher code a subset of the data. For the Interview data, 16 randomly selected interviews were coded by a second researcher; the correlations between scores given by the two raters were significant ($p < .001$ for all measures) and indicated high agreement between them.

For the Essay, a second rater coded a subset of fifteen essays. Here, too, the agreement between raters was high. Further information on interrater reliability may be found in Appendix III.K.

component, Types of Applications, concerned the specificity of the applications mentioned by the children. The second component, Types of Mathematics, concerned the specificity of the mathematics mentioned in connection with those applications.

Types of Applications. Under the Types of Applications analysis, each essay was coded as either Job-Related, Non-Job-Related or General.

Job-Related essays mentioned specific jobs as related to mathematics. For example:

> One kind of people who have this job are architects.
>
> Truck drivers need measurement to know how much gas they have.

Non-Job-Related essays described specific applications that were not related to a specific job. For example:

> It's good to have this kind of job because when you go to the store, you'll know how to figure out your change.
>
> I would be able to help my children with math.

General Applications essays presented no specific applications and instead referred to "math" in general. For example, essays containing statements such as the following were coded as General:

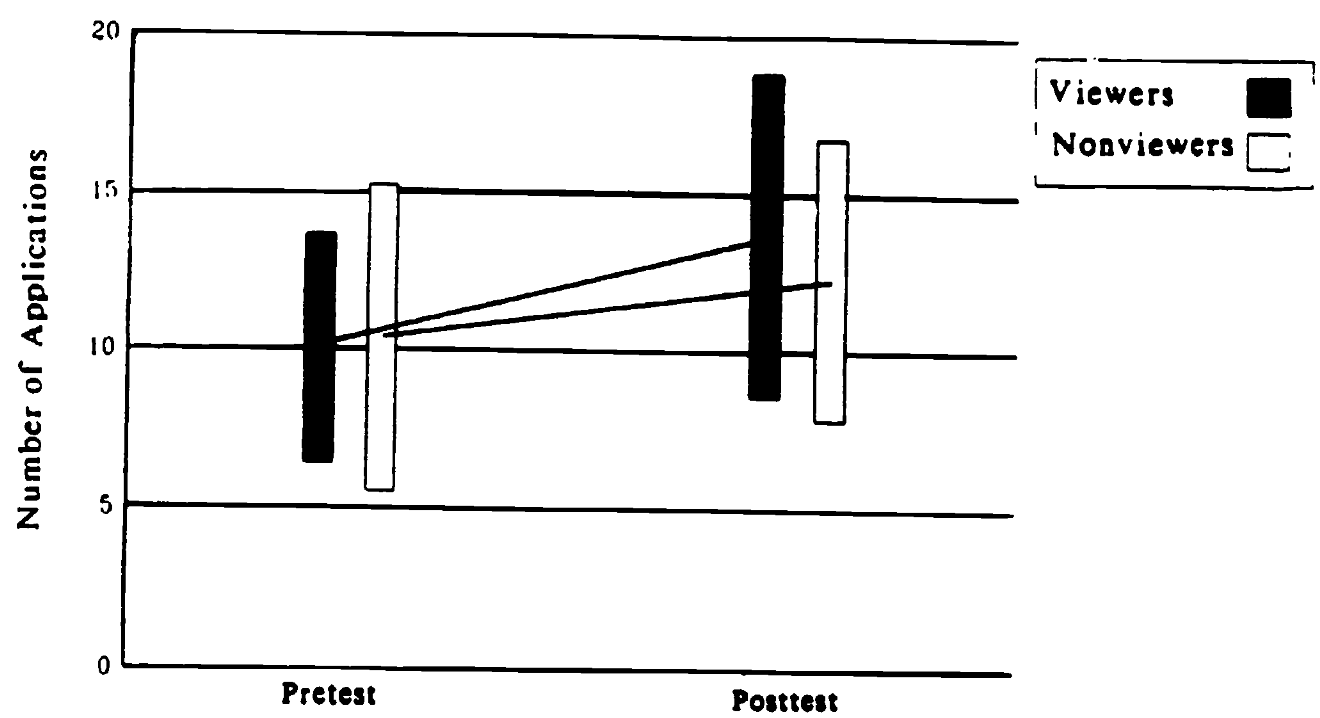
> I hate math.
>
> Math is important.

Types of Mathematics. Under the Types of Mathematics analysis, each essay was coded according to the specificity of the mathematics mentioned by the child. Essays could be coded as Specific Mathematics or General Mathematics. An essay would be coded as Specific Mathematics if the child gave examples of specific areas of mathematics in their applications. General Mathematics essays were those in which the child mentioned "math" but did not give any specific examples. The distinction might best be understood as the difference between "Architects use math," which would be an indication of General Mathematics, and "Architects have to measure how high and wide walls are," which would indicate Specific Mathematics.

significantly in either the pretest or posttest. These results did not differ significantly as a function of sex, ethnicity, or SES.

Figure 4.1

Mean number of applications ± 1 SD



Future-Oriented Responses

Figure 4.2 presents the mean proportions of future-oriented responses made by viewers and nonviewers in the pretest and posttest with one standard deviation above and below the mean. We expected that viewers would show a greater increase than nonviewers in the proportion of future-oriented responses they produced.

As this figure suggests, the viewers and nonviewers did not differ significantly in the

THE EFFECTS OF SQUARE ONE TV: RESULTS AND DISCUSSION

Overview of Results

Although viewers and nonviewers did not differ significantly in either the pretest or the posttest in their responses to the Attitude Interview, a marginal effect was observed in the data from the Essay in that more viewers than nonviewers wrote essays that described specific applications of mathematics.[55]

The Analysis of the Interview

The analysis of the Attitude Interview explored the following pretest to posttest differences between the viewers and nonviewers: (a) the number of applications children mentioned, (b) the proportion of future and conditional responses they gave, and (c) the proportion of unique applications they mentioned.

Applications

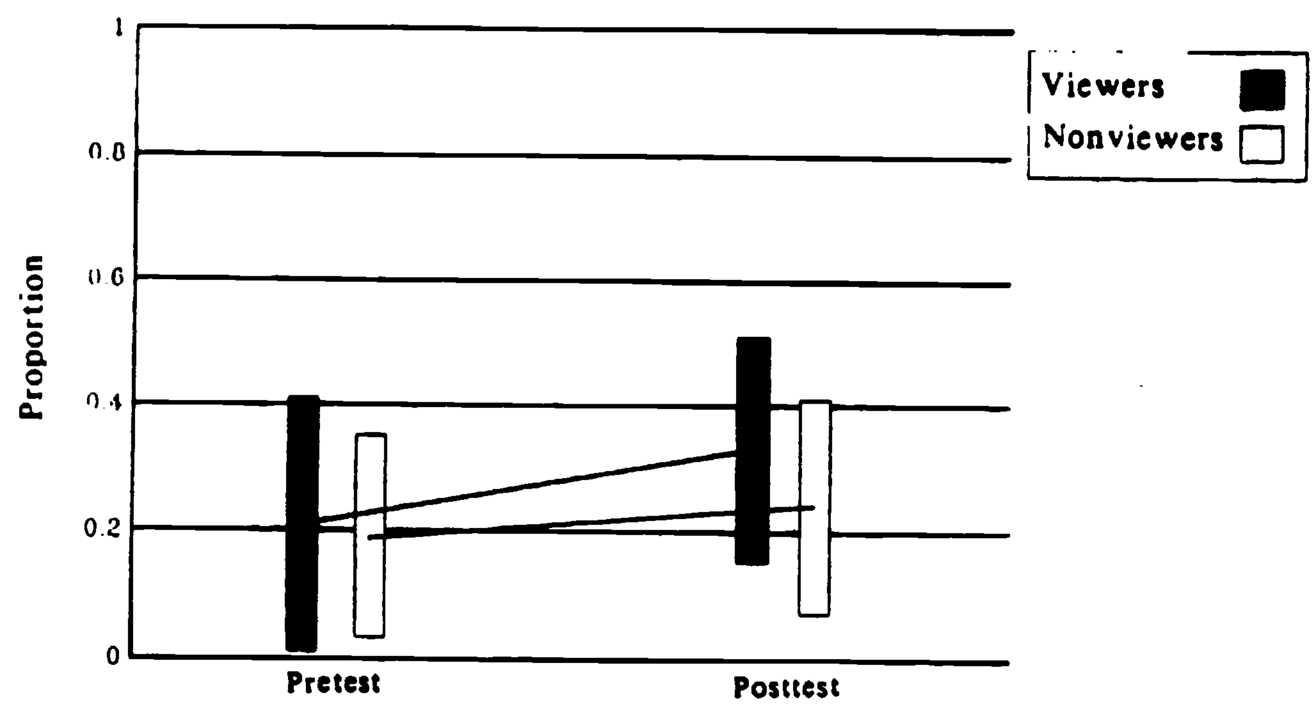
Figure 4.1 presents the mean number of applications mentioned by viewers and nonviewers in the pretest and posttest with one standard deviation above and below the mean. We expected that the viewers would show a greater increase than nonviewers in the number of applications they produced.

As the figure suggests, although both the viewers and nonviewers mentioned significantly more applications in the posttest ($p < .01$), the two groups did not differ

[55] Detailed information on the statistical analyses used in this section can be found in Appendix III.L.

Figure 4.3

Mean proportion of unique applications ± 1 SD

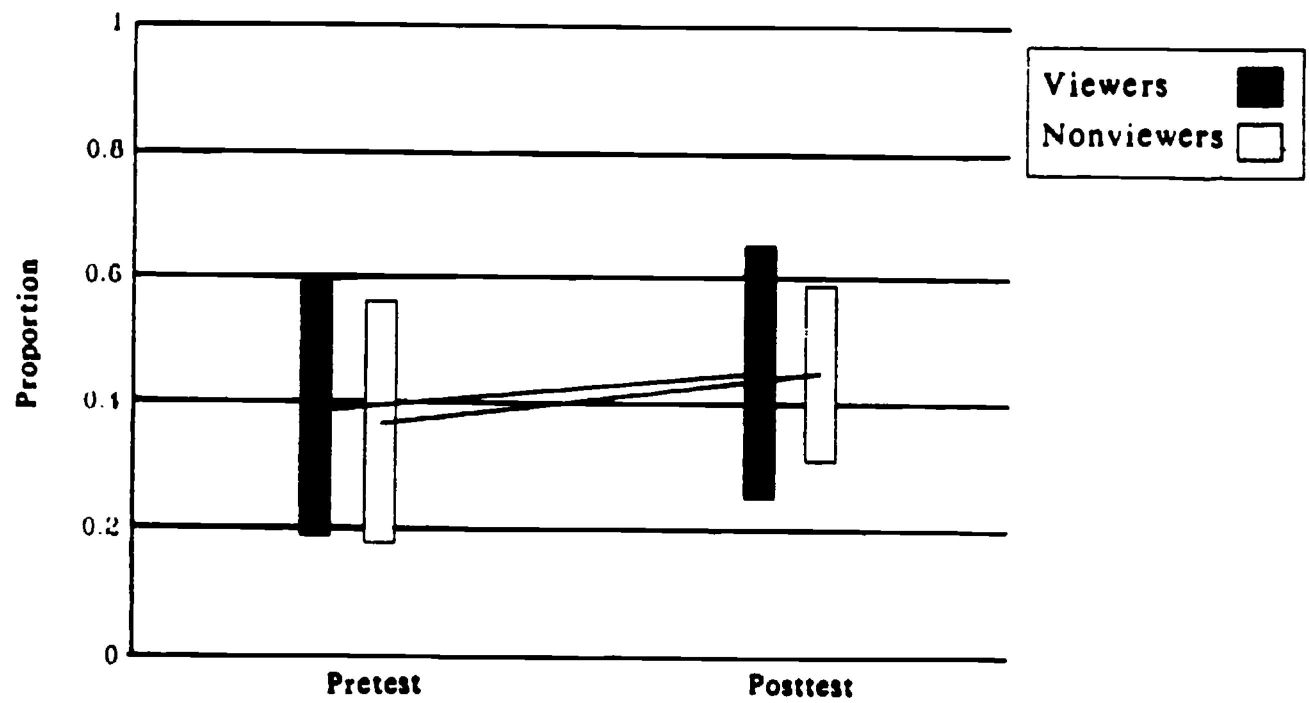


The two groups did not differ significantly at the pretest, and while the posttest average of the viewers' proportion of unique applications was higher than the nonviewers', this difference was not statistically significant. The lack of significance may be due to the high variability among the children, shown by the length of the bars representing the groups, coupled with the relatively small size of the sample (which would make it difficult to detect subtle effects). No effects were observed for either SES or ethnicity, and while a marginal effect was found for sex (in that girls produced slightly more unique applications than boys did), this effect did not interact significantly with the effects of viewing **SQUARE ONE TV**.

proportion of future-oriented responses mentioned in either the pretest or the posttest. These results did not differ as a function of either SES or ethnicity. A marg.nal main effect was found for sex ($p < .10$), in that, overall, boys produced a slightly greater proportion of future-oriented responses than girls did, but this effect did not interact significantly with the effects of viewing **SQUARE ONE TV**.

Figure 4.2

Mean proportion of future-oriented responses ± 1 SD



Unique Applications

Figure 4.3 presents the mean proportions of unique applications given by the viewers and nonviewers in the pretest and posttest with one standard deviation above and below the mean. We expected that viewers would show a greater increase than nonviewers in the proportion of unique applications that they produced.

appeared among both viewers and nonviewers ($p < .10$ in each case). The data obtained from viewers did not differ significantly as a function of either SES or ethnicity.[56]

Types of Mathematics

Table 4.2 presents a comparison of the children's essays that were coded as presenting mentions of specific areas of mathematics or merely "mathematics" in general.

Table 4.2

Proportion of children mentioning specific areas of mathematics vs. "math" in general

	Mathematics	
	Specific	General
Viewers	.55	.45
Nonviewers	.54	.45

The difference between viewers and nonviewers was not statistically significant. However, overall, marginally more girls than boys wrote about specific areas of mathematics ($p < .10$), and, overall, significantly more low-SES children wrote about specific areas of mathematics.[57] There were no significant differences as a function of ethnicity.

[56]However, a significant effect of SES ($p < .01$) was observed in the nonviewing group, in that a greater number of low-SES children produced specific applications. As a result, a significant overall effect of SES was also found ($p < .01$).

[57]Similarly, among children in the nonviewing group, a significant effect was observed for SES ($p < .01$); more low-SES children wrote about specific areas of mathematics.

The Essay Analysis

In our analysis of the Essay, we explored differences between the viewers and nonviewers in the specificity of the applications that they mentioned and in the specificity of the mathematics discussed in these applications.

Types of Applications

Each child's essay was coded as mentioning specific or general applications of mathematics. Table 4.1 presents the number of children whose essays were coded as applied or general.

Table 4.1

Proportion of children presenting specific vs. general applications

	Applications	
	Specific	General
Viewers	.60	.40
Nonviewers	.48	.52

As this table suggests, marginally more viewers than nonviewers ($p < .10$) wrote essays concerning specific applications of mathematics, as opposed to producing more general, nebulous discussions of "math." An analysis of these data by sex revealed that significantly more girls than boys presented specific applications of mathematics ($p < .05$); this difference

The Attitude Interview versus the Essay

The first question one might ask concerning these results is: Why was a marginal effect observed with the Essay and not with the Interview? Two reasons seem particularly likely. First, the Essay and the Interview approached the question of applications of mathematics in different ways. The Interview asked children to discuss the importance and uses of mathematics in fairly general terms while the Essay asked children about jobs that they were personally interested in. Perhaps the children found it easier to think about the ways that mathematics could be used in relation to jobs that they were interested in than to think about how mathematics is used generally. In a sense, the two measures approached the issue of applications from different directions: the Interview relied on their generalized knowledge of applications of mathematics while the Essay relied on their ability to apply knowledge of mathematical applications to a specific, personally interesting job. Second, the number of children in the Essay analysis was five times as large as the number in the Interview analysis. Thus, subtle patterns may have been evident among the larger sample that were not visible with only 48 children.

Discussion

The results of the above analyses suggest that sustained exposure to **SQUARE ONE TV** may have had a very limited impact on children's perceptions of the usefulness of mathematics as measured by their articulation of applications in the Essay. One marginal result occurred within the Essay, indicating that the series may have affected children's ability to articulate specific applications of mathematics, though not strongly.

The Interview Analyses

Our analysis showed no significant differences in the number, type, and future-orientation of the children's responses. Both viewers and nonviewers increased in all categories from the pretest to the posttest. The change in both groups over time may be a result of the pretest interview's encouraging the children to think about ideas that they then expressed at the posttest.

The Essay Analyses

The Types of Applications analysis suggests that the series may have had some subtle effect on the children's ability to articulate a connection between mathematics and jobs that they were interested in. While the children did not become more specific in their articulation of the kinds of mathematics used in those jobs, they did show a marginal increase in the degree to which they proposed specific applications of mathematics. Such perceptions indicate, on some level, an understanding of applications of mathematics; given the link between use and importance, this might lead children to consider a mathematics education to be worthwhile (e.g., Kulm, 1980; Reyes, 1984).

INTRODUCTION

In this introduction, we present the theoretical and the methodological approach used in our exploration of children's motivation in the Attitude Interview.

Theoretical Approach

The Concept of Motivation

Traditionally, motivation has been used to refer to factors other than ability that affect the direction, intensity, and duration of goal-directed activity. One's motivation will, in part, determine how one behaves in relation to a particular task. In a sense, motivation is the answer to the question, "why bother to do it?" In this study, we were interested in exploring the children's motivation concerning problem solving (particularly as reflected in the PSAs) and mathematics.

The Literature on Motivation

The research of Carol Dweck. The work of Carol Dweck contributed greatly to our conceptualization of motivation. She and her colleagues are concerned with children's motivation to achieve, particularly in academic settings. This research has identified two classes of goals that describe the nature of children's achievement motivation, "learning" and "performance" goals; these goals describe the underlying rationale for involvement with a particular endeavor (Dweck & Elliott, 1983). Learning goals involve "seeking to acquire knowledge or skills, to master or understand something new" while performance goals are concerned with "obtain[ing] favorable judgments of one's competence, and...avoid[ing] unfavorable judgments of one's competence" (p. 645). A child's choice of a learning or performance goal -- a "choice" that is often constrained by the environment in which the child

CHAPTER 5

MOTIVATION

This chapter presents the results of our exploration of children's motivation concerning mathematics and the problem solving reflected in the PSAs. Research in mathematics education has become more focused on motivation given the key role it plays in children's mathematics achievement (e.g., Dweck & Licht, 1980; Nicholls, Cobb, Wood, Yackel, & Patashnick, 1990; Resnick, 1988; Reyes, 1984).

Data for this analysis were taken from questions designated for motivation in the Attitude Interview. This chapter contains: (a) an introduction, (b) a descriptive analysis of children's definitions of challenge, (c) the development and presentation of an analysis scheme for assessing the effects of SQUARE ONE TV, and (d) the results of our analysis of change and a discussion of the effects of viewing SQUARE ONE TV.

ability can be devastating; performance motivation goals seem to be linked to mathematics anxiety and learned helplessness (Dweck & Licht, 1980; Reyes, 1984). When mathematics behavior is defined in terms of outcomes -- right or wrong answers -- and effort is taken as a sign of a lack of ability, then children tend to avoid areas of mathematics, such as complex word problems or algebra, that require effort or present ambiguity (Dweck, 1986; Reyes, 1984; Resnick, 1988; Schoenfeld, 1985). Even mathematically gifted students may avoid advanced or difficult mathematics if it makes them feel incompetent because they need to exert effort (Dweck, 1986). Feelings of anxiety and helplessness thus present major obstacles to higher mathematics learning.

When mathematics is constructed as a process of problem solving, however, it seems to involve a different motivational approach. Proponents of mathematics reform suggest that children who understand mathematics as a process rather than as strictly defined outcomes will make more of an effort to learn mathematics and will perceive their effort in terms of excitement rather than anxiety (Cobb, Yackel, & Wood, 1989; Ginsburg & Asmussen, 1988; Hatano, 1988; Resnick, 1988). This idea is congruent with the learning motivation goal presented by Dweck.

Goal I of SQUARE ONE TV. In Chapter 1, we described our conception of motivation and its relation to Goal I of SQUARE ONE TV. To some extent, motivation is related to the "enthusiasm" mentioned in the overarching statement of Goal I ("to promote positive attitudes toward, and enthusiasm for, mathematics"). Goal IC states that SQUARE ONE TV is to promote the concept that "mathematics can be used, understood, and even invented by non-specialists." We believe that such use, understanding, and invention are closely tied to issues relating to motivation.

attempts to achieve (e.g., the classroom) -- has serious implications for his or her achievement motivation.

Motivation and mathematics learning. Children's choices of learning versus performance goals are likely to depend in part upon the degree to which children hold a discrete operations construct of mathematics. When children come to see mathematics as a rule-governed activity in which there is one right answer per problem and in which speed is emphasized over comprehension of mathematical processes, then children are extremely likely to hold performance motivation goals (Dweck & Elliott, 1983; Ginsburg & Asmussen, 1988; Resnick, 1988; Reyes, 1984). Because this discrete operations mathematics is not typically presented as an opportunity for sense-making that has application outside of school, motivation toward mathematics becomes a matter of getting the right answers for grades on tests (cf. Carter & Yackel, 1989). This places the focus of one's competence or achievement on one's performance in testing situations; in other words, such performance becomes the goal toward which one is motivated.

One can see the effects of performance goals on the behaviors children exhibit toward doing mathematics. As Schoenfeld has observed, children "come to expect that all of the mathematics problems that they encounter will either be solvable within a few minutes or not at all...After only a few minutes of unsuccessful attempts, they quit" (Schoenfeld, 1985, p. 370). In other words, when motivation toward mathematics is constrained by an emphasis on speed and right answers, then children will avoid situations, or give up, when they are not able to exhibit what they consider to be successful behavior. Thus, only children who are extremely quick and certain of their mathematical ability will pursue mathematics learning. The emphasis on speed may also cause children to develop the belief that making an effort is an indication of a lack of ability (Dweck, 1986; Stevenson, Lee, Chen, Stigler, Hsu, & Kitamura, 1990).

The effects of these constraints on learners who feel insecure about their mathematical this question in our posttest protocol allowed us to assess the degree to which our analysis appeared to measure the same underlying constructs as Dweck's.

Below is a list of the questions used in the analysis of motivation.[58] The questions are divided by the three domains of mathematical inquiry:

PSA Domain

7. Did you think about it [PSA C*] after you left the room? What did you think?

8. Did you talk to your parents or family or anyone about it [PSA C*]? To whom? What did you say?

13. If sometime in the future you had a chance to try another Dr. Game thing [PSA C*], would you like to?

16. Let's say when you're in high school, you have a chance to take a class that teaches you how to figure out things like the Dr. Game thing [PSA C*]. Would you like to take it?[59]

22. [Re: PSA B*] Do you remember the optional part?...Did you try it?

32. Of the three things you've done with us, the thing with Dr. Game [PSA C*], the clocks/party tables [PSA B*], and the circus performers/stripes on a shirt [PSA A*] -- which did you like the best?

33. Which would you most like to work with again?

34. Which one would you say was most challenging to you?

Figuring Out Domain

35. What kinds of things do you like to figure out?

36. Why do you like to figure [the activities mentioned in Q35] out?

37. Is/are [the activities mentioned in Q35] challenging to you?

38. Do you like challenging things? How come?

39. What kinds of challenging things do you like?

---

[58] Note that Questions 32 and 36 were not originally designated as motivation questions. However, our initial analysis revealed that these questions elicited responses that were very similar to those given to the other questions in this dimension; thus, responses to these two questions were included here as well.

[59] When the "would you like to take it" question is probed "why," it becomes a motivation question.

Methodological Approach

The Motivation Questions

For the Attitude Interview, we developed open-ended questions aimed at assessing several different aspects of children's motivation, including their inclination to become involved with tasks, and the persistence and intensity of their involvement. We also developed two sets of forced-choice questions, one asking the children to choose the PSA that they would most like to work on again and the other asking them to choose between PSA C* and an arithmetic worksheet involving double-digit division. The forced-choice nature of the questions made it easy to compare the children's choices across the sample and to compare the children's assessments of the tasks with our own. For example, we considered PSA C* to be the most difficult and interesting PSA due to the complexity of the mathematics involved in it. To our minds, a child's choice to become involved with PSA C* over the other PSAs would be an indication of a high level of motivation; the forced-choice questions provided the opportunity to determine whether the children viewed PSA C* in a similar way.

We were also interested in the children's conceptions of and inclination to embrace challenge. "Challenge" is a concept that researchers have seen as central to motivation (Dweck & Elliott, 1983; Fennema & Sherman, 1977) but it was not clear that children would understand "challenge" in the same way we do. From our pilot testing we were aware that children had differing ideas of what "challenging" meant: some of the children considered the word to refer to direct competition with others, e.g., running a race or competing in time tests. Thus, we developed a series of questions, throughout the three domains of the interview, to assess the children's conceptions of "challenge."

Finally, because much of our theoretical approach stemmed from the work of Carol Dweck, our final question in the posttest interview presented children with a slightly adapted version of a question that Dweck uses to help determine a child's motivation goal. Including directed to Appendix III.G.

Analysis of change. There were two components of our analysis of change. In the first, the information provided by the forced-choice questions provided us with an opportunity to perform straightforward comparisons between the children. We did not develop interpretive categories to analyze the data from the forced-choice questions, but rather examined the degree to which children chose to pursue the tasks that were (objectively or subjectively) the most challenging. The following questions were used in this analysis:

PSA Domain

33. Which would you most like to work with again?

34. Which one would you say was most challenging to you?

Mathematics Domain

63. If you had a chance to work on another project with Dr. Game [PSA C*] or do this [arithmetic worksheet], which would you rather do?

64. Which would be more of a challenge for you?

We were interested in determining whether the children's responses to these questions would change as a result of viewing SQUARE ONE TV. Further information concerning this analysis will be presented later in the chapter.

The second component of our analysis, an assessment of the effects of viewing SQUARE ONE TV, used all of the questions designated for motivation in the interview. This analysis scheme, based on Dweck's work, will be presented later in the chapter.

Mathematics Domain

63. If you had a chance to work on another project with Dr. Game [PSA C*] or do this [arithmetic worksheet], which would you rather do?[60]

64. Which would be more of a challenge for you?

The final motivation question was the one adapted from Dweck's work on achievement goals, the text of which was presented as well as read to the children:

81. Which of these four statements comes closest to describing the kinds of things that you would most like to figure out?
    a. Things that are fairly easy so I'll do well.
    b. Things that I'll learn something from even if they're so hard that I'll make a lot of mistakes.
    c. Things that aren't too hard, so I don't make many mistakes.
    d. Things that are hard enough to show that I'm smart.

Despite the forced-choice nature of this question, we allowed the children to change the statements to make a better fit out of their response.

Considerations in Data Analysis

Descriptive analysis. As described in Chapter 2, the first step in the analysis consisted of a review of 16 posttest interviews, eight viewers and eight nonviewers (unidentified as such to the research team). This analysis, along with an earlier analysis of pilot data and our review of the literature on motivation, indicated that the children discussed ideas of persistence, willingness to be involved, task assessment, pursuit of challenge, and goals of learning and performing well. It became apparent to us that we would need several approaches to our analysis of motivation.

First, given the importance of challenge to motivation, a descriptive analysis was designed to investigate children's definitions of the term "challenge." This will be presented in greater detail in the Descriptive Analysis section below. For the categorization of responses themselves, and distributions of those responses by sex, SES, and ethnicity, the reader is

[60] The arithmetic worksheet is included with the protocol presented in Appendix III.B.

tests provided a richer pool of responses from which to draw conclusions. Because children's definitions of challenge were largely consistent from pretest to posttest, we could be certain that if children changed their choice of which task (e.g., PSA C* or the arithmetic worksheet) was most challenging, then this truly would indicate a shift in their choice and not merely in the criteria they used to determine what "challenging" meant.

The questions used in the present analysis are presented below. Note that we did not ask the children explicitly to define "challenge" but rather inferred their conceptions of challenge from their responses to the following questions:

PSA Domain

34. Which one [of the three PSA tasks] would you say was most challenging to you? Why?

Mathematics Domain

64. Which would be more of a challenge for you [PSA C* or the arithmetic worksheet]? Why?

Challenge as Pushing One's Limits

Generally, the children understood "challenge" to mean pushing one's limits through making a serious effort, mastering something new, or taking on something difficult. Nearly two thirds (64%) of the children's responses emphasized one of these core ideas in relation to the concept of challenge.[61]

Challenge as making a mental effort. The children who defined "challenge" as making an effort did so in two ways. Nearly one fifth (19%) of the children's responses presented challenge as making an effort by trying or thinking hard.[62] The selected task, as one typical child said, "made me think real hard. It made me put my mind to it." The children in this category selected their tasks as particularly challenging because they involved more effort

[61] Forty-five children made these responses.

[62] Twenty-three children made these responses.

DESCRIPTIVE ANALYSIS:
CHILDREN'S DEFINITIONS OF "CHALLENGE"

This descriptive analysis explores the children's definitions of the term "challenge" within the PSA and Mathematics Domains.

Approach

The concept of "challenge" is important to our analysis of motivation. To seek challenge is a sign of high motivation in that it indicates a willingness to expend effort in attempting something that is difficult and that would test one's abilities. The concept of challenge elegantly conveys a related group of issues that we explored in our analysis of motivation.

To us, "challenge" meant pushing oneself toward one's limits, as described above. While most of the children in the pilot test seemed to share this idea, some understood "challenge" to mean a direct competition, e.g., a race. A few children simply did not seem to understand what the term meant.

Given the importance of the term in motivational theory (e.g., Dweck & Elliott, 1983; Fennema & Sherman, 1977), we wanted to be sure that we understood what the children meant in their discussions of "challenge." Hence, a descriptive analysis of children's conceptions of "challenge" seemed to be called for.

Data sources and analysis. As the reader will recall, the data for the descriptive analyses presented in the previous chapters of this volume were taken from the pretest only. However, the data for our descriptive analysis of "challenge" were taken from both the pretest and the posttest. The reason for this departure is that the descriptive analyses for the previous dimensions concerned aspects of children's attitudes that were likely to change after viewers were exposed to SQUARE ONE TV. Here, however, there was no reason to expect that exposure to the series would change children's definitions of "challenge." As a result, we decided to include data from both the pretest and the posttest because including data from both

The difficulty of the task is either explicit, as in the previous example, or implicit as in the example of another child who chose PSA C*: "Because you had to figure out what was wrong with it. You didn't have no directions to read or anything, so you didn't really know how to play it." While these children clearly focused on difficulty, they did not appear to be concerned about their failure to do the task, but rather were expressing how challenging the task was. What is common to all of these responses is that all define challenge as pushing beyond one's knowledge.

Challenge as difficulty. While many of the previous examples mentioned the difficulty of working with the tasks, more than one tenth (13%) of the responses indicated that the child's criterion for challenge was difficulty alone (i.e., without reference to the effort required).[65] All but two of these children said that the task that was most difficult for them was the most challenging. For example, one child chose PSA C* as the most challenging PSA because "that was real hard." Another child selected the arithmetic worksheet over PSA C* because PSA C* "looks easy and this looks harder."

Across all of the above categories, the majority of children's responses presented themes of "challenge" as pushing toward the limits of their ability. The children identified tasks as challenging when they required a lot of effort, when they were new and unfamiliar, and when they were difficult. Such uses of the term imply that the children did in fact understand this concept as one related to motivation.

Challenge as Performance and Competition

Nearly one tenth (9%) of the responses defined challenge in relation to performance and competition.[66] These responses suggested a somewhat different definition of challenge from the one presented above. The majority of these responses indicated a concern about getting the

[65] Eighteen children made these responses.

[66] Fifteen children made these responses.

than the others: "Well, you had to think and think and think and had to figure out, and look everything over carefully." The effort that they described consisted of thinking, figuring out, or concentrating.

Another one fifth of the children's total responses (19%) explained challenge by describing the task, and expressing effort more implicitly.[63] These children also described the work involved in the more challenging task but did not state explicitly that it involves "working more" or "thinking harder." For example, one child selected the division problems on the worksheet as more challenging than PSA C* "because you have to think of numbers that would go into like 115..." The PSA did not involve thinking with such large numbers, and so the child implied that greater effort was required for division problems.

Challenge as mastery. In addition to effort, more than one tenth (13%) of the children's reasons for selecting a task as challenging involved mastering something new.[64] The children's responses relating to mastery were divided evenly between the two questions (Q34 and Q64). In the choice between PSA C* and the arithmetic worksheet, these children said that having the opportunity to master something new was a challenge; thus, they all selected PSA C* as more challenging. As one child explained, "Because whenever you already know your math and stuff, it's easier for you, and if you just learned how to put together a game it would be more challenging 'cause you're not used to that." As another child stated clearly, "If you already know how to do this [arithmetic] there's not that much of a challenge."

In the remaining responses, the children selected PSA C* as more challenging than the other PSAs because they had to struggle to figure it out (Q34). These responses differ from those described immediately above in that they seemed to emphasize the difficulty and uncertainty involved in mastering a challenge. For example, one child chose PSA C* "because I couldn't figure that one out? If you can't figure -- it, challenging is like when it's harder."

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[63] Twenty-six children made these responses.

[64] Nineteen children made these responses.

Miscellaneous Challenge

In the few remaining responses (7%),[67] the children described the most challenging task primarily in two ways: as fun or as important. Three children described the arithmetic worksheet as challenging because it is important to learn arithmetic. Five children selected PSA C* over the arithmetic worksheet because, as one child said, "it's fun and challenging...[the worksheet] is boring and challenging." None of the children spoke of the arithmetic worksheet as a fun challenge. These miscellaneous responses did not present "challenge" as either pushing beyond one's limits or trying to perform well.

Conclusion

Our analysis of the children's challenge responses indicated that, as a group, they shared our basic concept of the term "challenge." The children chose as more challenging the tasks that were more difficult, that gave them something new to master, and that required more effort. A willingness to embrace such "challenges" is indicative of a high level of motivation.

Even when the children made reference to external standards by which they gauged the degree to which a task is challenging (e.g., trying to get things right, to obtain excellent grades, or to compete with another), their comments reflected aspects of motivation. The distinction between these sorts of external standards (e.g., good grades) and internal ones (e.g., effort, difficulty) is important to the study of motivation. Research indicates that motivation is stronger when it is based on an intrinsic rather than an extrinsic system of rewards. While no one would deny the importance for children of doing well in school, a motivational strategy involving challenges based upon the child's desire to surpass his or her efforts or knowledge may be hardier than a strategy based upon grades (e.g., Dweck & Elliott, 1983).

[67] Twelve children made these responses.

answers right. Such responses are particularly important because they revealed the children's vulnerability to being motivated primarily by good grades rather than by engagement with the activity itself.

In the Mathematics Domain, all but one of the children who emphasized the demands of performance as challenging selected the arithmetic worksheet over PSA C*. While some of these children spoke of effort and of pushing themselves, their focus was overwhelmingly on grades. For example, one child chose the arithmetic worksheet over PSA C* because "I get to get a grade for it, and I always try to make 80's and above. It's a challenge for me 'cause I wanna get good grades, 'cause I'm an honor student. And that's all."

In the PSA Domain, fewer children spoke about performance in choosing the most challenging PSA. These children seemed to find their unfamiliarity with the task to be a source of discomfort. The novelty of the tasks made this group of children concerned about their performance: they were not sure how to do well. For example, one child selected PSA C* as the most challenging because "I thought it was gonna be obvious and I was gonna look dumb because I didn't know or something..." Only one child spoke of "challenge" simply as direct competition with someone else. This child selected the PSA C* as most challenging to "see who would get the most chips" and win the game.

In all, the children in this category used "challenge" to mean striving for good grades, trying to get things right, and beating someone in a competition. The difference between these responses and those of the children in the previous discussion is that these children seemed to rely on external standards as their guide for how well they do. That is not to say, of course, that children in the previous discussion did not care about grades or use them as indicators of performance and difficulty. For those children, grades may have been of importance, but they did not appear to be central to their definitions of "challenge."

Dweck, and (b) whether Dweck's goals could cover the range of responses given by the children in the Attitude Interview.

For Dweck, an achievement situation is one that involves activity related to the development of competence. The children's responses to motivation questions relating to the PSAs indicated that they were concerned with being competent and developing competence on the tasks. The children expressed interest in being able to solve problems and in improving their performance, thus indicating that they perceived the PSAs as an opportunity for building competence -- an achievement situation.

Given, then, that Dweck's scheme seemed appropriate to this situation, the next step was to determine whether her categories of achievement goals were well suited to the responses children gave. Dweck posits two achievement goals: a learning goal that involves seeking to acquire knowledge or skills, i.e., to master or understand something new (Dweck & Elliott, 1983), and a performance goal that is concerned with obtaining favorable, or avoiding unfavorable, judgments of one's competence. Achievement goals are assessed via a forced-choice measure (which we adapted for our interview, as discussed above):

> Put a check by the kind of problems you would like to work on. I'd like:
> (1) Problems that aren't too hard, so I don't get many wrong.
> (2) Problems that I'll learn something from, even if they're so hard that I'll get a lot wrong.
> (3) Problems that are fairly easy so I'll do well.
> (4) Problems that are hard enough to show that I'm smart.

The choice Dweck poses here is an exclusive one; only the children who select choice (2) are considered to have the learning goal.[68] Indeed, no choice presents an easy learning goal because "such a choice would not indicate a willingness to forego performance concerns in order to learn" (Dweck & Henderson, 1988, p. 6; emphasis added). For Dweck, the learning goal is demonstrated only when the child gives priority to learning over concerns with grades, mistakes, or other indices of evaluation.

[68] Choices (1) and (3) are easy performance goals. Choice (4) is a challenging performance goal.

THE EFFECTS OF SQUARE ONE TV: ANALYSIS SCHEME

We developed two schemes for assessing the effects of viewing **SQUARE ONE TV** with regard to the children's motivation. The first, the Motivation Analysis, assessed motivation across all of the designated interview questions. The second, Choices and Challenge, targeted two sets of forced-choice questions in which the children were asked to select tasks that they would like to do again and that they found challenging.

The Motivation Analysis

Considerations in Developing the Analysis Scheme

The motivation questions in the Attitude Interview were designed to capture different aspects of motivation: the children's willingness to pursue a variety of activities and their involvement with those activities. Together, the questions were designed to provide an overall picture of motivation. It was necessary, therefore, for our analysis scheme to be applicable across all of the motivation questions in the interview. A potential basis for such a scheme was found in the work of Dweck (e.g., Dweck & Elliott, 1983).

Two main issues were addressed in considering the appropriateness of Dweck's approach for our analysis. First, we needed to confirm that Dweck's achievement motivation goals were appropriate to our analysis, and if so, we then had to determine how to incorporate them into our analysis. Second, in addition to the motivation goals, we wanted to capture other important aspects of motivation, such as children's level of motivation and their tendency to approach or avoid mathematics.

The appropriateness of Dweck's achievement goals. In determining the appropriateness of Dweck's achievement motivation goals to our analysis, we considered (a) whether the children's involvement with the PSAs would constitute an achievement situation as defined by

Orientation: engagement and performance. As noted above, children's responses were classified under two orientations, engagement and performance.

Engagement is our adaptation of Dweck's learning goal. Engagement statements were process-oriented statements that indicated that the child was motivated by involvement with the activity itself and that were concerned with the expenditure of effort in order to learn.[70] These statements also described learning for the sake of learning and indicated a high tolerance for uncertainty. The following statements are examples of engagement responses:

> Yes...Well, because um what I did was uh real fun even though it was kind of a -- a thinking project, I still like to think a lot and -- and when I think a lot I think I learn a whole bunch more and kinda forget a little but I could easily gain that little that I forgot and then I could ah remember stuff about what I learned.

> Yeah things are kind of fun to just work out...Well they're like, they're not just real easy like you just ru -- run through it. You have to think about it and you have to, you have to like put your mind into it and it's, it's not just easy, you could, it's kind of fun to figure out things. In my, in my opinion I like to figure out things...Well like it it's, if it's ki -- yeah -- I like hard things to do because it's not just, I'll like, oh, like I know it and then it's just run through it. I like to it there and I like to figure out things. I don't, it's fun for me to just figure out things like that.

These responses indicate that the children valued being challenged by a situation that allowed them to figure something out and develop competence. They suggest that the children were willing to expend effort to learn and, in fact, found this to be fun. The responses below are also considered engagement responses:

> Mm hm...Because they're fun...Because you get to solve something...And you get to think about it. That's why.

> Mm hm...'Cause I like kind of hard things, I like trying new things.

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[70] Some of these statements, which describe the pleasure of doing the task, would not be considered to be achievement goal statements by Dweck because Dweck and Elliott (1983) state that they consider intrinsic satisfaction derived from a task to be a legitimate aim of achievement activity only when "the intrinsic pleasure that is sought is for competence and is not solely pleasure in the activity itself" (p. 646). However, in the present data, we found that such statements about pleasure occurred along with statements by the same child explicitly presenting the learning goal. Therefore, these appeared to indicate an aspect of the child's motivational orientation toward the activity.

In reviewing the initial 16 interviews, we observed that while children often indicated that learning was an important goal for them, they did not necessarily make an explicit choice between learning and performance concerns. This is not surprising given that only one question in the interview (the adaptation of Dweck's forced-choice question) asked them directly to make such a comparison.[69] Thus, while Dweck's requirement that learning be given priority over performance concerns may have been crucial to certain aims of her research, we felt that for our purposes, it would be best to expand the scope of her achievement goals to "orientations." An "orientation" is more diffuse than a "goal" in that it deals with a range of reasons for children's involvement with a task, including things that may not be directly related to achievement per se, e.g., enjoyment or ease of task. As one part of our analysis, then, we developed two orientations, engagement and performance, that were similar to Dweck's achievement goals, as will be described in greater detail below. In addition, for the purposes of our analysis, we felt that it would be best to examine the children's responses via the proportion of engagement statements they made rather than classifying each child in only one category.

The Motivation Analysis Scheme

In addition to orientation, our analysis scheme assessed level (i.e., involvement with a task and the explicitness of an achievement goal) and valence of affective response (i.e., approach versus avoidance). In describing these three components, we will present illustrative examples taken from the responses to Question 13 ("If sometime in the future you had a chance to try another Dr. Game thing [PSA C*], would you like to?"). For a full description of the coding guidelines, the reader is referred to the Motivation Codebook found in Appendix III.H.

[69] Note that after the children made their initial choice of one of the fixed responses to the question, they were allowed to modify it to make their selection more consonant with their feelings.

perhaps a third category representing a blend of the two dominant orientations would be appropriate. To determine whether such a category would be necessary, the responses of a subset of 16 children were randomly drawn from the data and all ambiguous statements, i.e., in which the orientations were blended, were identified. These children's proportions of engagement statements were computed in two ways: once with a denominator equal to the total number of unambiguous statements and once using all statements (ambiguous and unambiguous). The correlation between the two was highly significant ($p < .001$).[71] Moreover, when children's statements contained elements of both orientations, they usually expressed a strong priority for one orientation over the other. Thus, it seemed that a third category o ambiguous responses was not necessary.

The relationship between orientation and Dweck's goals. Given the difference between our orientations and Dweck's achievement goals, we wanted to make certain that the two were still related. Therefore, we correlated the children's choice of the learning goal in the forced-choice question (Dweck's measure) with the proportion of statements in the engagement orientation (our measure). The correlation was highly significant ($p < .001$) and indicated a positive relationship between our orientations and Dweck's achievement goals.

Level. As mentioned previously, the children expressed a range of involvement with the activities discussed in their motivation statements. Engagement statements ranged from simple expressions of enjoyment of doing the activity to more complex statements of making an effort to learn despite frustration. Performance statements ranged from simple task assessments (easy or hard) to statements expressing a desire to achieve high levels of competence to indicate one's intelligence.

Three levels of motivation statements were defined for each orientation. Level was an indication both of the child's degree of involvement with the activity, as indicated by the

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[71] For full details on this and all other statistics reported in this chapter, see Appendix III.L.

Yes...It sounds interesting.

Mm hm....'Cause they're fun.

These statements indicated a motivation to do PSA C* again based on an intrinsic quality of the task or the activity involved with the task. In these statements, an achievement goal was not articulated.

Performance orientation statements indicated a concern with the outcome of an activity, particularly in terms of accomplishment and the rewards from parents or teachers that often accompany it. These responses also indicated a willingness to be involved with the activity based on the child's perceptions of his or her ability. Often these statements expressed a low tolerance for uncertainty and frustration. The following statements are examples of the performance orientation:

It's like, 'Oh, I'm gonna be able to get it.' Because it's gonna be easy to me um it might be hard to y'all but it's gonna be easy to me...

Yeah...I like figure--figuring things out, and stuff...It makes me think...It shows that um that I'm smart, I guess.

The emphasis in these statements was often on getting the right answer to perform well in comparison with one's peers. Motivation here seemed to be less involved with the activity itself than with how the child compared with other children or how the child's solution compared with a right answer. The responses below are also considered to be performance responses:

Yes...Well I'd like to try it over again and see if I could do it this time.

Yeah...It looked easy.

The children's assessments of a task in terms of its difficulty were indications of performance concerns. These statements were often found alongside explicit references to achievement and competence based on performance.

Naturally, an important issue that had to be considered was that not every statement would necessarily be a clear expression of only one of these orientations. We considered that the engagement orientation) or as a means of demonstrating one's ability (in the performance orientation). These statements could also express an achievement goal. Engagement statements sometimes referred to wanting to learn even when the outcome was uncertain or concerned the importance of learning for learning's sake.

> Dr. Game...It had a catch to it. You had something to do. You're not really figuring out something -- well you are figuring something out but you also get to become part of it. You get to play the game, and you get into the game by playing it. That's really what it's like.

> Yeah...Because I like challenging things...Well you really don't know about it and you ain't too sure if you do know about it or not and so you just gotta sit down and try and figure it out.

Performance statements could describe the child's involvement due to the child's perceptions of his or her own competence or for the purpose of being perceived as smart.

> Yeah...I like figure -- figuring things out, and stuff...It makes me think...It shows that um that I'm smart, I guess.

> Well, I guess. Yeah. 'Cause it's kind of fun...Well, as I said, I like multiplying a lot...'Cause uh when I first -- multiplying looked easy but it got hard sort of, so I like doing it...and I would sometimes be the first one, except there's other smart guy in fifth grade -- he could beat me. I'm one of them that do fast -- working on it.

Valence. Valence indicates whether a child was motivated to approach or to avoid a given task. Statements within every orientation and level could be scored as having a positive or negative valence. Note that negative responses did not necessarily indicate that the child did not want to be involved with the activity; they could indicate that his or her involvement with the activity was driven by the desire to avoid something else. For example, if a child, asked to choose between doing an arithmetic worksheet and PSA C*, stated that she did not want to do the arithmetic worksheet and so selected PSA C*, this did not necessarily mean that she wanted to do PSA C*. She may have enjoyed working with PSA C*, but her motivation was apparently driven by the desire to avoid the arithmetic. The examples of orientation and level presented above are all positively valenced. Examples of negative statements are presented below.

amount of effort that he or she articulated, and of the explicitness of the achievement goal. Because similar criteria were used to assess level in the performance and engagement orientations, level could be considered to be independent of orientation. Examples of statements of each level within each orientation are presented below.

Low-level statements were task-based and generally concerned issues of enjoyment or ease. Within the engagement orientation, these statements concerned enjoyment of the activity with little articulation of a reason for that enjoyment or its relation to achievement.

> Yeah...Well it would be fun and that.
>
> Yes...It was fun...It was fun to play and like I spin it, and I multiply, or add the numbers -- and then to see who wins at the end of the game.

In the performance orientation, these statements often mentioned ease or speed as the reason for continued involvement with the task, or defined involvement by external standards:

> I might have to do it.
>
> Yeah...It [looked] easy.
>
> Mm hm, yes...Like if someone tells you to kind of think about it, do stuff like that.

Medium-level statements expressed a willingness to think about or solve problems. In the engagement orientation, the children discussed their involvement with the task in terms of wanting to figure it out or solve it:

> I like 'em...They're fun to work with...Thinking about what's wrong with them.
>
> Mm hm...'Cause I like kind of hard things, I like trying new things.

The performance responses described involvement with the task in terms of getting an answer or being evaluated:

> Well, I made a hundred on it, so I know I can do it again.
>
> Hm, probably, if I could do better on it.

High-level statements emphasized effort, either in the context of being challenged (in of an achievement goal, but it would not allow one to determine if, in fact, the child was motivated toward or away from the task. For this reason, we decided that an analysis of level would not be sufficient; thus, we used ratings of level and valence to create magnitude ratings.

Magnitude combined level and valence to measure the extent to which a child was motivated toward or away from the tasks presented in the interview. Magnitude ratings were assigned to every statement a child made and averaged across the questions to create a mean magnitude score for that child. Magnitude scores, rather than level, were used for the analyses of change presented later in this section.

Interrater Reliability

Reliability was assessed for each of the three variables that were coded in the Attitude Interview (orientation, level, and valence) by having a second researcher code 16 of the interviews.

The correlations between the scores given by the two raters were significant ($p < .001$ for orientation, and $p < .05$ for level and valence), and the two raters showed sufficient agreement for us to consider the coding scheme to be reliable. Further information on our analysis of reliability can be found in Appendix III.K.

The Choices and Challenges Analysis

The inclusion of questions asking the children to make choices among the three PSAs or between PSA C* and an arithmetic worksheet provided a concrete means of assessing the children's motivation, which complemented the analysis discussed above. We asked children which PSA they found to be the most challenging and which they would most like to do again. In addition, we asked whether they found PSA C* (our most complex PSA) or an arithmetic worksheet to be more challenging and which of the two they would like to do again. This

Negative, or avoidant, statements in the engagement orientation ranged from avoiding unpleasant activities (low level) to avoiding the effort of figuring things out (medium level) to avoiding challenges or anxiety about uncertainty (high level). An example of each of these follows:

> LOW: Yeah...Because I mean it gives me something to do. [Laugh] I don't like being bored.
>
> MEDIUM: Hm, not really...I don't really like to solve problems and all that.
>
> HIGH: And I usually get frustrated and everything. And I have it and I get frustrated with it and I go too far, like say [the answer to a division problem is] supposed to be like three and I go on to five...

In the performance orientation, negative responses ranged from an avoidance of hard tasks (low level) to avoiding mistakes or negative judgments (medium level) to fears of showing one's incompetence or lack of ability (high level). Examples of these statements for low- and medium-level responses follow:

> LOW: No...'Cause it's hard.
>
> MEDIUM: Probably not...'Cause I don't really know, 'cause I don't find out, I don't wan -- that I'm not gonna be able to do that one either.

No child made a high-level negative response to this question regarding PSA C*. Indeed, such statements were rare throughout the data. One child gave a high-level negative response to a question asking if he had tried an optional part of PSA B*. He said, "Didn't try...'Cause I like doing easy stuff...Easy stuff like, uh, well, when I know I'm good at it."

The Development of a Magnitude Variable

As noted above, the level of a statement did not distinguish between positive and negative valence. If a child mentioned that he or she would exert a great deal of effort to avoid involvement with a task, this statement would be designated as having the same level as a statement indicating that the child was willing to expend a great deal of effort toward the task. An analysis of level would give information about involvement, effort, and articulation

THE EFFECTS OF SQUARE ONE TV: RESULTS AND DISCUSSION

This section will present results pertaining to the effects of children's viewing **SQUARE ONE TV**. These results will include analyses of: (a) orientation, magnitude, and valence, and (b) the choices and challenge questions. The section will conclude with a discussion of the results as a whole.

Overview of Results

Viewers' and nonviewers' responses did not differ significantly at the pretest, but differences between the two groups emerged after the viewers were exposed to 30 programs of **SQUARE ONE TV**. Viewers made statistically significant gains in the proportion of engagement statements they produced. Further, nonviewers' valence declined significantly from pretest to posttest while viewers' did not.

Data on the choices and challenge responses were assessed in two ways: (a) via the children's choice of the task that was objectively the most complex (i.e., PSA C*), and (b) via their choice of the task that they found to be most challenging. Given a choice among the three PSAs, more viewers than nonviewers selected to do the most difficult PSA, i.e., PSA C*, at the posttest. From the pretest to the posttest, significantly more viewers than nonviewers changed their selection of the task that they would like to do from an easier task (i.e., PSA B* or A*), to the most difficult. At the posttest, significantly more viewers than nonviewers chose to do the task that they found most challenging.

The data on children's choices to do PSA C* versus the arithmetic worksheet showed that significantly more viewers than nonviewers selected to do PSA C* at the posttest. From the pretest to the posttest, significantly more viewers than nonviewers changed their selection from the arithmetic worksheet to PSA C*.

concrete measure provided additional insight into whether the children were motivated to pursue challenging tasks.

The Questions and Rationale

Two forced-choice questions apiece were asked in the PSA Domain and the Mathematics Domain:

PSA Domain

33. Which [PSA] would you most like to work with again?

34. Which [of the three PSAs] would you say was most challenging to you?

These questions gave us another perspective on the children's motivation by examining each child's response to Question 33 in conjunction with the response to Question 34. If a child elected to do what he or she found most challenging, then, we presume, the child was highly motivated to engage in this kind of problem solving. In addition, we were interested in whether the children would find PSA C* the most challenging and be motivated toward it, because, mathematically, it was the most difficult and complex task presented.

Mathematics Domain

63. If you had a chance to work on another project like the Dr. Game thing [PSA C*], or do this [arithmetic worksheet], which would you rather do?

64. Which would be more of a challenge for you?

These two questions allowed us to compare the children's motivation toward PSA C* and a common arithmetic task, two tasks that seemed to present very different challenges to the children. PSA C* presented a nonroutine, complex problem that had no set formula for solution. The arithmetic worksheet presented double-digit division that was approximately at a fifth-grade level of difficulty (although the children may not have been expert in applying the algorithms involved). As in the previous set of questions, we were interested in which of the tasks the children would find more challenging and which one they would like to pursue again.

significantly more engagement responses than the other children did ($p < .05$).

Dweck's achievement goals. Given the above effects and the significant correlation between orientation and Dweck's achievement goals (reported earlier in this chapter), we were interested in comparing viewers and nonviewers in terms of these goals as well. Recall that Dweck's forced-choice achievement goal question was asked only in the posttest; thus, while this did not allow us to examine pretest-posttest change, it nevertheless allowed some insight into the impact of exposure to the series.

Significantly more viewers than nonviewers selected the learning goal over the performance goal at the posttest ($p < .05$). There was no effect of the children's sex, SES, or ethnicity.

Magnitude

As the reader may recall, magnitude combines the valence and level of sophistication of children's reasons for their enjoyment of mathematics. A positive magnitude score indicates motivation to pursue a task; a negative score indicates motivation to avoid it.[72] Figure 5.2 shows the mean magnitude ratings given to viewers and nonviewers in the pretest and posttest with one standard deviation above and below the mean. We expected that viewers' motivation would increase in magnitude more than the nonviewers'.

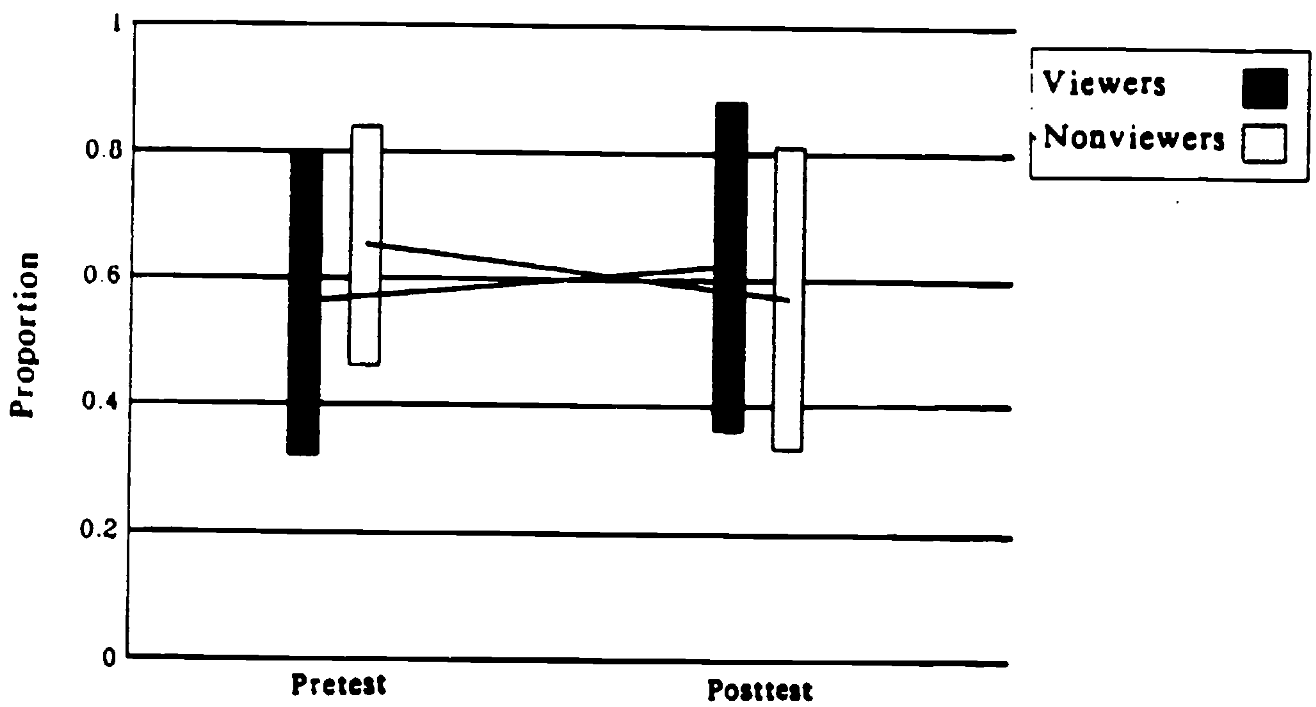
[72] Each statement was assigned a rating on a six-point magnitude scale ranging from -3 to +2. The scores were as follows: 2 = positive, high-level; 1 = positive, medium-level; 0 = positive, low-level; -1 = negative, low-level; -2 = negative, medium-level; -3 = negative, high-level. Each child was assigned a magnitude rating equal to the average of the scores given to his or her statements.

Orientation

Figure 5.1 shows the average proportion of engagement statements made by viewers and nonviewers in the pretest and posttest with one standard deviation above and below the mean. We expected that persistent viewing of **SQUARE ONE TV** would result in the children's becoming more engagement-oriented.

Figure 5.1

Mean proportion of engagement statements ± 1 SD

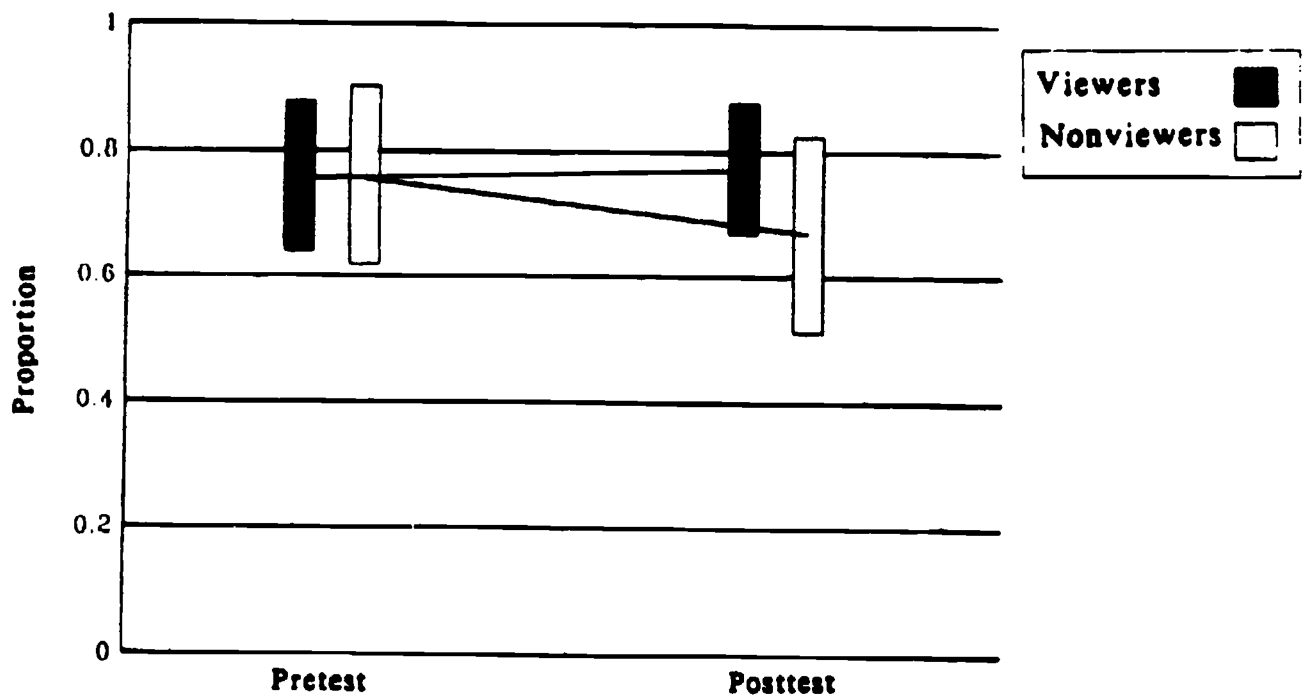


As this figure suggests, the viewers and nonviewers did not differ significantly at the pretest. However, the viewers made significantly greater gains than the nonviewers did ($p < .05$). These effects did not interact with either sex or ethnicity.

The analyses for SES showed slightly different results. SES interacted significantly with the effects of watching **SQUARE ONE TV** ($p < .05$), in that low-SES viewers were affected by the series more than any other children, and at the posttest, low-SES viewers gave

Figure 5.3

Mean proportion of positive statements ± 1 SD



As this figure suggests, there were no significant differences between the groups in the pretest. There was a marginal interaction overall ($p < .10$); while viewers did not change over time, nonviewers declined significantly from pretest to posttest ($p < .05$). These effects did not differ as a function of sex, SES, or ethnicity.

Children's Choices of Tasks

In the PSA Domain, we were interested in answering two questions. First, given that, from our perspective, PSA C* was the most mathematically complex of the three tasks (and indeed, 69% of the children found it to be the most challenging as well), we were interested in whether viewers and nonviewers would select PSA C* as the task they would most like to do again. Second, because not all of the children felt that PSA C* was the most challenging task, we were interested in whether they would choose to pursue whatever task they did find to be the most challenging.

In the Mathematics Domain, we created questions similar to those in the PSA Domain. We were curious about how the children's motivation to engage with a traditional arithmetic worksheet would compare with their motivation to do a non-traditional problem-solving task. First, we were interested in whether viewers and nonviewers would choose to pursue PSA C* over the arithmetic worksheet. Second, as in the PSA Domain, we were interested in whether children would pursue whichever task they found to be more challenging.

Selection of PSA C* vs. the Other PSAs

We approached this analysis in two ways. First, we examined the number of viewers and nonviewers who chose PSA C* in the pretest and posttest. Second, we looked at each child's pretest and posttest responses to see how many children chose PSA C* in the posttest but not in the pretest. Table 5.1 presents the number of children who selected PSA C* as the PSA they would most like to do.

As this table suggests, while viewers and nonviewers did not differ significantly in their choice of PSA C* at the pretest, the viewers were more likely than nonviewers to select PSA C* at the posttest ($p < .05$). Thus, it appears that exposure to **SQUARE ONE TV** resulted in viewers' choosing to pursue a more complex problem-solving task.

In the pretest, the children's choices did not differ as a function of sex or SES. A marginal effect was found for ethnicity in that, across the sample, marginally more minority than nonminority children selected PSA C* ($p < .10$).

In the posttest, however, there was no significant effect of ethnicity. SES exerted a significant effect ($p < .05$) in that, across the sample, more middle-SES than low-SES children chose PSA C* in the posttest. This effect was reflected in a marginal effect of SES among viewers ($p < .10$). Similarly, a marginal effect of sex was observed among the viewers ($p < .10$)

in that marginally more boys chose to do PSA C*.

Table 5.1

Number of children choosing to pursue PSA C* vs. other PSAs

	PRETEST		POSTTEST	
	PSA C*	Not PSA C*	PSA C*	Not PSA C*
Viewers	7	17	14	10
Nonviewers	11	10	5	18

A similar pattern was observed for the change shown by individual children. The first column of Table 5.2 shows the number of viewers and nonviewers who chose PSA C* in the posttest but not in the pretest. The second column indicates the number of subjects who did not change (i.e., who either selected PSA C* in the pretest or did not select it at either time).

Table 5.2

Number of children changing choice to PSA C*

	Change to PSA C*?	
	Yes	No
Viewers	10	14
Nonviewers	1	19

The difference between the two groups was statistically significant ($p < .01$) in that more viewers than nonviewers changed their choice to PSA C* by the posttest. Again, it appears that viewers' exposure to SQUARE ONE TV resulted in their choosing to pursue more complex tasks.

This effect did not differ across either sex or SES. However, overall, significantly more nonminority children than minority children showed a positive change ($p < .05$). This effect was also found within the viewer group ($p < .10$), as was a marginal effect of SES ($p < .10$).

Choosing to pursue the most challenging PSA. Table 5.3 shows the number of children at the pretest and the posttest who chose to do the PSA that they found to be the most challenging.

Table 5.3

Number of children choosing to pursue their most challenging PSA

	PRETEST		POSTTEST	
	Most Challenging PSA	Other PSA	Most Challenging PSA	Other PSA
Viewers	5	19	11	13
Nonviewers	6	13	2	12

The difference between the viewers and nonviewers was not significant at the pretest but was significant at the posttest ($p < .05$) in that, in the posttest, more viewers than nonviewers chose to do the PSA that they found most challenging. There were no significant differences due to sex, SES, or ethnicity.

A similar pattern was observed for the change shown by individual children. The first column of Table 5.4 shows the number of viewers and nonviewers who chose to pursue their (subjectively) most challenging PSA in the posttest but not in the pretest. The second column indicates the number of children who did not change (i.e., who either chose to pursue their most challenging PSA in the pretest or did not choose to pursue it at either time).

Table 5.4

Number of children changing choice to most challenging PSA

	Change to most challenging PSA?	
	Yes	No
Viewers	9	15
Nonviewers	1	17

As this table suggests, after exposure to 30 programs of **SQUARE ONE TV**, significantly more viewers than nonviewers became inclined toward pursuing problem-solving tasks that they found challenging ($p < .05$).

These results did not differ as a function of sex or SES. Similarly, there were no differences among viewers as a function of ethnicity.[73]

Selection of PSA C* vs. Arithmetic

We approached this analysis in two ways. First, we examined the number of viewers and nonviewers who chose PSA C* in the pretest and posttest. Second, we looked at each child's pretest and posttest responses to see how many of the children did not choose PSA C* in the pretest but did choose it in the posttest. Table 5.5 presents the number of viewers and nonviewers who chose PSA C* over the arithmetic worksheet as the task they would prefer to do in the pretest and in the posttest.

[73] A marginal effect of ethnicity was found among children in the nonviewing group in that marginally more nonminority children than minority children showed a positive change ($p < .10$). However, for this analysis, only five nonminority children were included in the nonviewer group; thus, this result should be interpreted with caution. For further detail on this point, see Appendix III.L.

Table 5.5

Number of children choosing to pursue PSA C* vs. arithmetic

	PRETEST		POSTTEST	
	PSA C*	Arithmetic	PSA C*	Arithmetic
Viewers	10	14	20	4
Nonviewers	11	13	13	11

While the children's selections did not differ significantly at the pretest, significantly more viewers than nonviewers selected PSA C* in the posttest ($p < .05$). No significant effects were observed as a function of ethnicity or SES. A marginal effect of sex was observed among viewers in that marginally more boys than girls selected PSA C* ($p < .10$) in the pretest. In the posttest, however, no significant differences by sex were observed for either group.

A similar pattern was observed when we looked at the change shown by individual children. The first column of Table 5.6 shows the number of viewers and nonviewers who chose PSA C* in the posttest but not in the pretest. The second column shows the number of subjects who did not change (i.e., who either selected PSA C* in the pretest or did not select it at either time).

Table 5.6

Number of children changing choice to PSA C*

	Change to PSA C*?	
	Yes	No
Viewers	11	13
Nonviewers	4	18

From the pretest to posttest, significantly more viewers than nonviewers changed their selection from the arithmetic worksheet to PSA C* ($p < .05$). No significant effects were observed as a function of SES or ethnicity. Sex had a significant effect in that, from pretest to posttest, more girls than boys changed to PSA C* ($p < .05$). An examination of viewers and nonviewers revealed that while there was no difference between boys and girls in the nonviewer group, more girls than boys in the viewer group changed to PSA C* after exposure to SQUARE ONE TV.

Selection of the most challenging task (PSA C* vs. arithmetic). Finally, we compared the number of viewers and nonviewers who selected to do the task that they found most challenging (PSA C* or the arithmetic worksheet). Table 5.7 shows the number of viewers and nonviewers who chose to pursue the task that they found to be the most challenging.

Table 5.7

Number of children choosing to pursue their most challenging task (PSA C* vs. arithmetic)

	PRETEST		POSTTEST	
	Most Challenging Task	Other Task	Most Challenging Task	Other Task
Viewers	12	12	9	7
Nonviewers	9	15	8	14

As this table suggests, viewers and nonviewers did not differ significantly in either the pretest or the posttest. Thus, this set of data does not show evidence of change as a result of viewing SQUARE ONE TV.

In the pretest, these results did not differ significantly as a function of either ethnicity or SES. Significantly more girls than boys chose to pursue the task they found most challenging in the pretest ($p < .01$ for the sample as a whole; $p < .05$ for the viewer group).

In the posttest, however, there was no significant effect of sex in either group. SES and ethnicity each exerted an effect in that, across the entire sample, more middle-SES and nonminority children chose to pursue the task that they found most challenging in the posttest ($p < .10$ for SES, and $p < .05$ for ethnicity); the effect for ethnicity was also reflected among the viewer group ($p < .05$).

A similar pattern was found when we examined the change shown by individual children. The first column of Table 5.8 shows the number of viewers and nonviewers who chose to pursue their (subjectively) most challenging task (PSA C* or the arithmetic worksheet) in the posttest but not in the pretest. The second column indicates the number of children who did not change (i.e., who either chose to pursue the most challenging task in the pretest or who did not choose to pursue it at either time).

Table 5.8

Number of children changing choice to most challenging task

	Change to most challenging task?	
	Yes	No
Viewers	4	12
Nonviewers	3	19

There was no significant difference between viewers and nonviewers in this set of data, nor did these results differ significantly as a function of sex. A marginal effect of SES ($p < .10$) and a significant effect of ethnicity ($p < .05$) were observed in that, across the sample, more middle-SES and nonminority children changed from pretest to posttest; each of these effects was reflected among viewers ($p < .10$ for SES and $p < .05$ for ethnicity).

Summary. In all, six of the eight Choices and Challenge analyses provided evidence that significantly more viewers than nonviewers chose to pursue complex and challenging problem-solving tasks after the viewers were exposed to 30 programs of **SQUARE ONE TV**. Moreover, an analysis of the change shown by individual children revealed that, from pretest to posttest, significantly more viewers than nonviewers changed their choices to the PSA that they found to be the most challenging. In the remaining two analyses, no significant differences were observed between viewers and nonviewers, and while two significant and one marginal effect were observed due to background variables, no consistent pattern was evident.

Within the six analyses for which significant improvements for the viewers were observed, few significant effects were found for sex, SES, or ethnicity; those that did exist did not form a consistent pattern across the analyses. A marginal effect of SES was found in the analyses of viewers' choices to pursue PSA C* over the other PSAs, but no SES differences were observed in their choices to pursue the PSA that they found most challenging. A significant effect of ethnicity was found in the analysis of viewers' change toward pursuing PSA C* over other PSAs; however, this effect was not present in the complementary analysis of viewers' choices in the posttest. Finally, marginally more viewer boys than viewer girls chose PSA C* over the other PSAs in the posttest, but the analysis of change in children's choices of PSA C* versus an arithmetic worksheet revealed a difference in the opposite direction: significantly more viewer girls than viewer boys changed their choices to PSA C*. Thus, it appears that across these analyses, no consistent patterns of differences were observed as a function of sex, SES, or ethnicity, although a more consistent pattern of differences was seen as a function of the viewers' exposure to **SQUARE ONE TV**.

Discussion

The results of the above analyses suggest that **SQUARE ONE TV** had an impact on several aspects of children's motivation toward mathematics. The analysis of change in the children's orientation indicates that the treatment can have some effect on sustained viewers. Further, significantly more viewers than nonviewers selected to pursue complex problem-solving tasks over easier tasks as well as over an arithmetic worksheet. This discussion will explore these effects in greater depth.

The Engagement Orientation

Viewers of **SQUARE ONE TV** became more engagement-oriented over time. The series seems to have been effective in encouraging an orientation toward mathematics that was learning- and process-focused (and, indeed, was significantly related to the learning goal described by Dweck). This effect was observed particularly with low-income children.

Engagement and the reform movement. The goals of **SQUARE ONE TV** are consonant with those of the reform movement in mathematics education, and such reform implies the need for a shift in children's motivational goals toward learning goals; thus, the increase in the proportion of engagement statements by the viewers is important. The problem-solving mathematics espoused by proponents of mathematics reform places an emphasis on figuring out and making sense of open-ended, nonroutine problem situations in which the solutions are not always readily apparent. Dweck and Elliott (1983) have suggested that children who exhibit learning goals (i.e., goals of mastery and understanding) are able to persist through the uncertainty and difficulty of figuring out difficult problems with less debilitation in performance than children with performance goals. **SQUARE ONE TV** presents a variety of individuals working with complex, meaningful problems and often struggling with a problem through many different attempts at solution. Perhaps for this reason, it seems that sustained viewing of the series encouraged children to adopt a motivational orientation that would enable them to engage with mathematics and problem solving for the sake of learning and involvement in the process of figuring out.

Orientation and choice of tasks. Given the effects observed with respect to orientation, one might expect that viewers would be more motivated than nonviewers to pursue complex problem-solving tasks. In fact, this turned out to be the case. More viewers than nonviewers selected PSA C* (the most complex problem-solving task presented to them) as the task that they would most like to do when given a choice of PSA C* versus easier problem-solving tasks or an arithmetic worksheet. Similarly, when comparing the three PSAs, significantly more viewers than nonviewers chose to pursue the task that they found most challenging themselves. These findings make sense in light of the fact that on **SQUARE ONE TV**, the emphasis is not on decontextualized arithmetic problems but rather on more complex problem solving such as that presented in the PSAs.

The children voiced a range of reasons for finding PSA C* challenging and for selecting it as the PSA that they would choose to pursue. While the number of children to whom we are referring here is small, the reasons that the viewers and nonviewers gave for their choices of tasks seemed to differ qualitatively. The viewers' reasons related to the engagement orientation: that the task was fun and required thinking or figuring out. By contrast, the only nonviewer child who changed in his choice of PSA A* to C* did so because "it takes up I guess most of my school time" -- that is, it allowed him to avoid school.

Six nonviewers and two viewers made the opposite, i.e., a negative, choice from our standpoint. These children selected PSA C* at the pretest and PSA A*, the least difficult, at the posttest. The nonviewers made their choice of PSA A* at the posttest either because it was fun or easy. The two viewers selected PSA A* because, in one case, the child liked to put things in order, and, in the other, the child liked to figure out patterns. Both of the viewers' responses indicate that they were motivated by the demands of problem solving itself.

At the posttest, more viewers than nonviewers chose to do PSA C* over the arithmetic worksheet. The reasons for the children's choices across the two groups were largely the same, however. Eleven of the children who chose PSA C* at the posttest were from the viewer group, and four were from the nonviewer group. Seven of the 11 viewers and two of the four nonviewers gave reasons that indicated negative feelings toward the arithmetic worksheet. They preferred working with fewer numbers, not having to write the answers down, or not having to do division problems. The remaining six children presented positive approaches to PSA C* itself. They found division too easy and wanted a challenge, or found figuring out PSA C* to be more interesting and compelling.

Another examination of the children's responses to the challenge questions indicated that the reason why some of the children found PSA C* more challenging also had to do with avoiding certain aspects of mathematics. Many children stated that the arithmetic was easy, boring, or routine and, thus, not challenging, and five children stated that the worksheet was less fun than PSA C*. The novelty and the sense of adventure provided additional reasons for selecting PSA C* as more challenging. Several of the children noted that the arithmetic on the worksheet is daily work for them -- work that may become boring or repetitive. As one child put it, "I've done it so many times, I mean I just automatically know the answers." These responses, coupled with the avoidant responses above, suggest that for some children the motivation to do traditional elementary-school mathematics may have been limited by the worksheets and drills that are usually found in the curriculum.

The children's "challenge" responses discussed above also indicate that children's motivation toward PSA C* stemmed, in part, from novelty and, perhaps, from the fact that PSA C* is not like school mathematics. While this may appear to indicate that the arithmetic is fundamentally less interesting than PSA C*, this may not be the case. Some children may simply have been selecting the more novel task. As we learned from the discussion of what the children understood mathematics to be, none of these children described the problem-solving aspect of PSA C* as mathematical.

Sex, SES, and ethnicity differences. In the analysis of children's orientations, one important finding was that low-SES viewers showed the greatest increase in the proportion of engagement statements they made. Perhaps the difference in the nature of the two orientations is key here. The performance orientation emphasizes seeking positive and avoiding negative judgments, as reflected in grades and similar academic achievement. The engagement orientation is concerned with mastery and learning. While the low-income children did not differ from middle-income children in their mathematics achievement scores, perhaps their different economic background may have given them a different perspective on what is worth knowing and learning. These children may have been more inclined to develop competence in situations that are intrinsically motivating to them rather than in situations where the rewards are academic (for a discussion of a similar phenomenon, see Carraher, Schliemann, & Carraher, 1988). These children may have found that **SQUARE ONE TV** validated the real-life problem solving that they valued, so that the series, and the PSAs, could have seemed more relevant to them.

In the Choices and Challenges analyses, we saw no consistent patterns of significant differences as a function of sex, SES, or ethnicity. In three of the six Choices and Challenge analyses in which significant differences existed between the viewers and nonviewers, these effects did not differ as a function of sex, SES, or ethnicity. Of the remaining three, there were marginal effects of SES in two of the analyses, and there were marginal effects of sex and ethnicity in one analysis apiece. However, as was discussed earlier, these effects were not reflected in the viewers' other choices across the analysis. Indeed, while there was a marginal effect of boys' more frequently choosing PSA C* over the other PSAs in the posttest, there was also a significant effect of girls' showing a greater change toward choosing PSA C* over an arithmetic worksheet. Similarly, although marginally more middle-SES viewers chose to pursue PSA C* over the other PSAs, our analysis of orientation toward motivation (discussed above) showed low-SES viewers as having a greater increase than middle-SES viewers in the proportion of engagement statements that they made.

Thus, it appears that while viewers and nonviewers differed significantly in several ways throughout these analyses of motivation, these effects did not vary in any consistent way as a function of their sex, ethnicity, or socioeconomic background.

Valence

A marginal difference between the change shown by viewers and nonviewers was found for valence. Yet, further analysis indicated that the effect was due to the nonviewers' becoming more negative over time. This result may have been partially due to the predominance of positively valenced statements at the pretest; at the pretest, slightly more than three quarters of the viewers' and the nonviewers' statements were positive.

The decline in the nonviewers' proportion of positive statements suggests how the series may have been motivating the viewers. The proportion of negative statements increased overall from the pretest to posttest, indicating that the children were generally more negative at the posttest than at the pretest. Overall, the children may have felt more comfortable giving negative responses at the posttest because they were more familiar with the interview process. At the pretest, in which the children were first exposed to the PSAs and a novel interview situation, the children gave positive responses. Further, dealing with unfamiliar adults in a testing situation may have led some children to give more socially desirable responses. The nonviewers' responses at the posttest may be a more accurate reflection of the children's valence than the pretest responses. Thus, it is important to note that the proportion of positive statements by the viewers did not decline. At the posttest, the viewers stayed at a very positive level.

The second factor that might explain the nonviewers' decline may have to do with the problem solving shown on SQUARE ONE TV. By presenting children with many examples of nonroutine problem solving, the series may have provided a framework for the viewers to maintain their positive approach. The series presents a variety of complex, nonroutine problems as exciting and interesting mathematics. The nonviewers, when confronted at the posttest with tasks that were very similar to the ones that they had previously seen at the pretest, may not have understood the point of being involved with the tasks. This supposition is supported by an analysis of statements that the children made at the posttest about the pretest activities. A tally was made of the children's spontaneous mentions of the similarity between the pretest and posttest. Sixty-eight percent of these responses were made by nonviewers. This may indicate that these children considered the posttest to be less interesting and meaningful than the pretest. Perhaps without the framework of problem solving modeled on **SQUARE ONE TV**, the nonviewers could not appreciate the value of engaging with similar problem-solving tasks a second time, whereas the viewers approached the posttest problems as fresh problems (see Volume II, pp. 98-99, for a further discussion on this point).

Magnitude

No significant effects were observed for magnitude. This is somewhat disappointing, but is understandable in light of the results found for valence. Recall that magnitude ratings are combinations of valence and level. Given that valence was quite high in the pretest (i.e., the children were overwhelmingly positive), the six-point magnitude scale was largely restricted to the positive half of the scale. Thus, there was relatively little room for growth. By the posttest, nonviewers had dropped to the negative half of the scale (parallel to the effect seen for valence), although this drop was not great enough to be statistically significant. By contrast, viewers remained positive, although they, too, did not change significantly.

Motivation and Problem Solving

Finally, let us consider the results that we observed in Volume II in light of what we have seen here. In Volume II, we reported that viewers made significant gains in the number and variety of problem-solving actions and heuristics they used. This finding seems very much in line with our results regarding motivation, i.e., that viewers became significantly more engagement-oriented and were significantly more likely than nonviewers to want to pursue the PSA that they found most challenging. If viewers did become more engaged with the process of solving problems and chose to pursue challenging problems, then it is not surprising that they would also explore more avenues in attempting to find solutions. Together, these results indicate that **SQUARE ONE TV** can exert an effect upon sustained viewers -- both in their inclination to pursue problem-solving tasks, and in the behavior they exhibit while attempting to find solutions.

CHAPTER 6

ENJOYMENT

This chapter presents the results of our inquiry into children's enjoyment of mathematics and problem solving. This attitude dimension is concerned with what the children liked and disliked, what they found pleasurable and interesting about mathematics and problem solving, and the reasons they gave for their dispositions. Researchers often consider children's enjoyment to be an essential component of their attitudes toward mathematics (e.g., Aiken, 1974; Ginsburg & Asmussen, 1988).

Our analysis is based upon data from two sources within the Attitude Interview: responses to questions designated for enjoyment of mathematics and problem solving and spontaneous statements of enjoyment that appeared throughout the interview. This chapter contains (a) an introduction to our analysis, (b) a descriptive analysis of what children did and did not enjoy about mathematics and problem solving, (c) a description of the analysis scheme for assessing the effects of SQUARE ONE TV, and (d) the results of our analysis of change and a discussion of the effects of viewing SQUARE ONE TV on children's enjoyment of mathematics and problem solving.

INTRODUCTION

In this Introduction, we present both the theoretical framework and the methodological approach used in our exploration of children's enjoyment of mathematics and problem solving.

Theoretical Approach

Within the literature on mathematics attitude there is some debate regarding children's enjoyment of mathematics. First, it is not entirely clear whether children typically like or dislike elementary-school mathematics. Second, the relationship between enjoyment of mathematics and continued learning of mathematics is unclear. These two points suggest two avenues of inquiry: one into the nature of children's enjoyment of mathematics and the other into the relationship between children's enjoyment and their motivation toward mathematics.

Do Children Like Mathematics?

Many researchers discuss children's liking of mathematics as an essential component of their attitudes toward the subject (e.g., Aiken, 1974; Ginsburg & Asmussen, 1988; Kulm, 1980; McLeod, 1989). In fact, these researchers often refer to children's like or dislike of mathematics as positive or negative attitudes toward the subject. Given this link between liking mathematics and more general attitudes about mathematics, it is no wonder that researchers and educators are concerned with this issue.

Despite the consensus about the importance of children's liking of mathematics, there is less consensus as to whether children do or do not like it. While Ginsburg and Asmussen (1988) assert that "by the third grade or so, children often say they 'hate' math...and some children feel that mathematics is the dullest of school subjects" (p. 90), other researchers are less conclusive about children's dislike of mathematics. In fact, Saxe (1971) reported mathematics to be one of children's top choices of school subjects in the early grades. A recent CTW-commissioned study of the interests of 988 elementary-school children showed that more children selected mathematics as their favorite subject (39%) than any other single subject (Research Communications Limited, 1990). Other research has indicated that children's feelings about mathematics are neutral rather than negative (Kulm, 1980).

Even if there were greater agreement as to whether children in elementary school like or dislike mathematics, what would this mean? Would it mean that they like or dislike arithmetic or word problems? their teacher? worksheets and drills? or numbers themselves? A given child may say he or she likes mathematics, but, in fact, enjoy word problems and dislike -- or even be anxious about -- timed drills on arithmetic facts. Ten years ago, Kulm (1980) noted that very little research on attitudes toward mathematics had explored what it is that children specifically do or do not like about it. This still seems to be true.

Thus, although researchers and educators agree that children's enjoyment of mathematics is an important factor to consider in their attitudes, there is some disagreement as to whether children do or do not like it. An exploration of whether, what, and why children enjoy mathematics is warranted. With this study, we attempt to contribute to such an effort.

Enjoyment and motivation. Various researchers have explored the relationship between enjoyment and motivation. Enjoyment is a significant predictor of high-school students' decision to take mathematics courses although it is not as significant a predictor as other attitude dimensions, such as usefulness (Reyes, 1984). In their assessment of achievement motivation, Dweck and Elliott (1983) describe the intrinsic satisfaction or pleasure that one attains from mastering a task; this pleasure is a reward that may come from achievement activity, and is therefore a part of achievement motivation.

Thus, there are two ways in which motivation and enjoyment may be linked. First, enjoyment of mathematics may motivate older children to elect to take mathematics courses.

Second, enjoyment can, in turn, be related to achievement and may provide an intrinsic reward that then motivates further success in mathematics.

Goal I of SQUARE ONE TV. In Chapter 1, we described our conception of enjoyment and its relationship to Goal I of **SQUARE ONE TV**. To some extent, the "enthusiasm" described in the overarching statement of Goal I ("to promote positive attitudes toward, and enthusiasm for, mathematics") is concerned with enjoyment. More specifically, Goal IB promotes the notion that "math is beautiful and aesthetically pleasing." We believe that such notions relate to issues of enjoyment.

Methodological Approach

The Enjoyment Questions

During the pilot-test phase, we realized that expressions of enjoyment[74] were very prevalent in the children's responses to all of our questions. To the children, enjoyment was a reason for wanting to do something, for its relevance, and even, sometimes, for its usefulness. In fact, statements indicating enjoyment were woven throughout the children's responses. Based on the ubiquity of these statements, we thought that an understanding of enjoyment was particularly critical to an overall understanding of attitude among children in elementary school. In creating questions, then, we realized that we needed to develop: (a) a thorough understanding of what enjoyment of mathematics and problem solving meant to the children, (b) a clear conception of the activities that the children found enjoyable within mathematics and problem solving, and (c) a way of comparing enjoyment in the PSA Domain with enjoyment in the Mathematics Domain. Each of these is discussed in turn below.

[74] When we refer to "enjoyment" as an attitude dimension, we are incorporating both positive and negative into the dimension. That is, in assessing enjoyment, we examined what the children found fun and not fun, what they liked and disliked, etc.

Clarifying what enjoyment means. During pilot testing, we became aware of different ways that the children spoke about enjoyment, and developed questions accordingly. The children sometimes described their emotional reactions to the PSAs and mathematics (e.g., "I was nervous at first") and sometimes explained the reasons for their enjoyment (e.g., "It was fun because I like playing games"). This led to the development of two different types of questions. The first type asked the children to describe their feelings in different situations. The second type of question asked the children to explain their reasons for finding a task "fun" or "interesting." Our choice of the words "fun" and "interesting" was guided by our observation that the children frequently used these words to describe two important -- and different -- ways in which they experienced enjoyment. "Fun" was more ubiquitous, while "interesting" seemed to be the word that the children used to describe intellectual enjoyment.

Identifying and facilitating comparisons between activities. In order to understand what the children found enjoyable about mathematics and problem solving, we adopted a straightforward approach and simply asked them to tell us. In the PSA Domain, using the PSAs as examples of problem solving, we asked the children to explain their enjoyment of the tasks. In the Mathematics Domain, we asked them to describe what they found enjoyable about mathematics and why. However, to facilitate comparisons between the two domains, we asked the children not about "mathematics" in general but rather about specific mathematical activities that they have enjoyed or have not enjoyed, an approach that was similar to asking children about specific PSAs.

Below is a list of the questions designated for our analyses of enjoyment. The questions are divided into the domains of mathematical inquiry.

PSA Domain

14. Was the Dr. Game thing [PSA C*] interesting to you? How come?

15. Was the Dr. Game thing [PSA C*] fun? What made it fun?

20. Was [PSA B*] interesting to you? How come?

21. Was [PSA B*] fun? What made it fun?

30. Was [PSA A*] interesting to you? Why/Why not?

31. Was [PSA A*] fun? What made it fun?

Mathematics Domain

55. Can you tell me about a time when you did something in mathematics that you really enjoyed? What was it? What about it did you enjoy?

56. Do you usually enjoy doing math? How come?

60. Can you tell me some fun and interesting ways to use math?

61. Can you name some fun and interesting ways to use mathematics outside of school? What about fun ways to use mathematics not including homework?

Considerations in Data Analysis

Our preliminary analysis of 16 interviews guided us in the development both of a descriptive analysis and of ways to assess the possible change in enjoyment that might result from viewing **SQUARE ONE TV**. The data from this preliminary analysis suggested three distinct approaches to analysis.

Descriptive analysis of what children enjoy. Our descriptive analysis of children's enjoyment focused on what they enjoyed about mathematics and what they found fun and interesting about the PSAs. Data for this analysis was taken primarily from responses to Questions 14, 15, 55, and 56. Categories were developed from the data to capture the most salient themes in the children's responses. In addition, categories were established for the types of mathematical activities that the children enjoyed (e.g., word problems, mathematics games). For the categorization of the responses themselves, and distributions of these responses by sex, SES, and ethnicity, the reader is referred to Appendix III.I.

Analysis of change in the target questions. The children's responses to the target questions indicated that their enjoyment stemmed from a variety of sources, ranging from the pleasure of writing down answers to the excitement of puzzling out an answer. Thus, we used the data to develop a "reasons-for-enjoyment" scheme to assess whether children's sources of enjoyment might be affected by viewing **SQUARE ONE TV.**

Analysis of change in general enjoyment. The third analysis suggested by our preliminary review concerned the appearance of statements of enjoyment throughout the interview, i.e., in response to questions other than those designated for enjoyment. We refer to this as the "general enjoyment analysis." Analyzing these statements seemed to be a reasonable strategy for three reasons. First, as mentioned above, we found that the children made a number of such statements throughout the interview. Second, several questions were developed to elicit information concerning children's feelings, but not their reasons for enjoyment of mathematics and problem solving. Clearly, the information on children's feelings is important in assessing their reactions to mathematics and problem solving, and thus needed to be included in our analysis. The questions are as follows:

PSA Domain

5. How did [doing PSA C*] make you feel?

6. When we finished [with PSA C*] and you left the room, how did you feel?

Figuring Out Domain

41. How did you feel [when you tried hard and figured something out]?

43. How did you feel [when you tried hard and couldn't figure something out]?

Mathematics Domain

58. How did [realizing or discovering something in math] feel for you?

59. Is there anything in mathematics that makes you feel good?

Third, because some of the designated enjoyment questions asked children for evaluations of issues that we had presented to them, we felt that their responses might have been overly positive because some children might tell us what they thought "we wanted to hear." For all of these reasons, we realized that we should develop a scheme that would allow us to examine all of the statements of enjoyment that occurred in response to questions other than the ones designated for enjoyment.

DESCRIPTIVE ANALYSIS: WHAT CHILDREN ENJOY ABOUT MATHEMATICS AND PROBLEM SOLVING

This descriptive analysis presents what the children find enjoyable about mathematics and problem solving. In this analysis, we (a) describe mathematical tasks that the children found enjoyable, (b) present the children's explanations of the ways in which they found mathematics enjoyable, (c) explore the children's responses to questions about why PSA C* is fun and interesting, and (d) present what the children dislike about mathematics and the PSAs.

Overview of Results

In relation to both mathematics and problem solving, the children spoke of enjoyment in terms of novelty and the potential for involvement. In mathematics, children identified tasks that they enjoyed, and, in particular, seemed to enjoy the novel parts of the curriculum, such as geometry. However, when children spoke of their enjoyment of "mathematics" per se, they talked about working with numbers and figuring out problems. Their disenchantment with mathematics came from repetition, as well as the difficulty that some children had in learning it.

With respect to problem solving, the children enjoyed PSA C* because it was novel, fun to play with, and interesting to figure out. When the children did not enjoy PSAs B* and A*, they did so because the tasks did not seem, in their perceptions, to offer enough of an opportunity for engagement.

What Did Children Enjoy about Mathematics?

Our analysis of what children enjoyed about mathematics is based upon their responses to Q55: "Can you tell me about a time when you did something in mathematics that you really enjoyed? What was it? What about it did you enjoy?" Only five children, 11%, could not name a task in mathematics that they enjoyed. Most of the activities named by the children involved the computation that they do in the classroom.

More than two fifths of the children (43%) responded that they enjoyed some aspect of computation. Children mentioned multiplication, adding, and double-digit division, as well as making more generic references to worksheets and word problems. In ex,'aining why they enjoyed these activities, the children spoke of the ease with which they could perform these tasks, feelings of competence from having mastered the tasks, and, sometimes, the challenge that the tasks presented. The children's reasons will be discussed in more detail below.

Another two fifths of the children (40%) mentioned other areas of mathematics that they enjoyed. Of this 40%, over one third stated that fractions, decimals, or least common fractions were enjoyable. The remaining two thirds of these children described other, less typical aspects of their mathematics curriculum (e.g., measurement, geometry, symmetry, and graphs) as enjoyable. The children who presented these less typical mathematical tasks often explained their enjoyment in terms of how interesting these tasks were.

The few remaining responses were less easy to classify within one category. One child spoke of a mathematics trick, finding "hidden triangles" in a picture. Two other children spoke of the enjoyment of teaching someone else how to do mathematics; the source of enjoyment here seemed to be the teaching of mathematics rather than doing the mathematics itself.

In sum, we find that almost as many children spoke about computation as spoke about all of the other areas of mathematics combined. This is not surprising given that, as we have seen throughout this volume, computation was, by and large, what the children believed "mathematics" to be. The reasons that the children gave for finding tasks enjoyable suggest different motivational strategies between those who mentioned computation and those who mentioned other areas of mathematics. The children who found computation enjoyable did so because they found it easy and, having mastered the task, they felt competent. The children who found other aspects of mathematics enjoyable seem to have done so out of their interest in the tasks themselves.

Is Mathematics Enjoyable?

To answer the questions of whether and how children find mathematics enjoyable, we have analyzed the responses to Q56: "Do you usually enjoy doing math? How come?" While the previous analysis was based upon children's responses regarding a specific task in mathematics, the context that this question provided for discussion is more generic. Asking the children about "math" allowed them to discuss any aspect of their experience with mathematics, e.g., the curriculum, a particular task, the method of instruction, or "mathematics" as a whole. More than two thirds (70%) of the children's responses were positive. Less than one third (30%) of the children's responses indicated that they did not usually enjoy mathematics.[75]

Mathematics is enjoyable. Those children who found mathematics enjoyable described liking mathematics for three reasons: for the sheer enjoyment of learning mathematics, from the ease and speed with which they can do mathematics, and due to certain activities in mathematics that they enjoy. Underlying many of these responses was the children's pride in their competence in mastering the subject matter.

Approximately one fourth (24%) of the responses as a whole indicated that the children like mathematics because they enjoy learning it. Nearly one half of this group simply mentioned that mathematics was fun or the child's favorite subject. The other responses were more elaborate and presented a variety of reasons for enjoying the learning of mathematics. One child found the novelty of working with numbers to be enjoyable. Another child stated that "[mathematics is] very useful and we're going to need it and it's fun" because "you get to learn... all sorts of things having to do with math." Only one child referred to the teaching of

[75] Note that the children gave more negative responses in the posttest than in the pretest. This will be discussed below in the analysis of change.

mathematics ("sometimes the teacher makes jokes about it") as a reason for why it is "a real fun subject to me just to learn." The most sophisticated statement about the enjoyment of learning mathematics came from a child who linked learning with self-mastery as a source of enjoyment: "You learn things you didn't know before...Um, you do it on your own."

One fifth (20%) of all of the children said that their enjoyment of mathematics was dependent on their ability to do it fast or on their finding it easy. It was clear from their responses that the "mathematics" to which these children referred was arithmetic. As one child stated, "If I didn't know it good then I probably wouldn't enjoy it 'cause I have to be learning it more and more -- and I get stuck in some parts." Two children explained that they enjoy their teacher's giving them tricks "to get answers real quick." The remaining children simply stated that "it's easy" or "I'm getting good grades in math" as their reasons for finding it enjoyable.

Finally, a few children described their enjoyment of specific mathematics tasks as their reason for finding mathematics enjoyable. As one child said, "They have a lotta favorites in math. My favorites. Ratios, and the time test and uh division." Again, the fun of doing computation was what these children typically presented as enjoyable.

<u>Mathematics is not enjoyable.</u> Three tenths (30%) of the children said that they dislike mathematics. Their reasons can be divided into two categories: disliking the way mathematics is taught and disliking the difficulty of mathematics.

Less than one fifth (17%) of the children complained about the way mathematics is taught, calling attention to the repetition involved. As one child stated, "It's um sometimes boring to learn that same thing again." Another child elaborated on this point:

> Um, sometimes I don't enjoy when we already have learned about it and then we're going to other things and then we come to the middle of the year we have to learn about it again. And that's sometimes I don't like that. I like just going on to other things instead of going back. 'Cause sometimes we have to go back.

Two children faulted the teaching of mathematics by criticizing their teachers. One child explained that the teachers "say like in words that children don't know." Another child disliked when she didn't "get it" and found that the teacher wouldn't answer questions because the teacher would say that "she just told you" even though "you still don't get it."

The concern with "getting it" comprised part of the reason why another one tenth (9%) of the children disliked mathematics. While difficulty was also mentioned by two of the children who didn't like the way mathematics is taught, these children focused exclusively on not liking mathematics because they saw it as hard. They explained that "I don't like to get them wrong" and that it was even "hard to think about it a whole lot." The children's statements also indicated that they found the subject confusing.

In sum, the children's positive and negative responses presented different perspectives on mathematics learning. The children who disliked mathematics often did so because they found the way the subject is taught to be boring. Some seemed alienated by the repetition within the curriculum as well as the repetition of drill. Children who enjoyed mathematics found learning about numbers and learning new things to be enjoyable in and of itself. There was a relationship between the enjoyment and the perceived difficulty of mathematics; children who found it difficult also seemed to dislike it, while children who found it easy often liked it.

What Do the Children Enjoy about PSA C*?

In an attempt to gain some insight into children's enjoyment of problem solving, we examined children's responses to the enjoyment questions relating to PSA C*. PSA C* was the most complex PSA presented to the children and also an example of the kind of nonroutine, open-ended problem solving that might appear in curricula developed in response to the call for reform in mathematics education.

We analyzed the responses to two questions, Q14: "Was the Dr. Game thing [PSA C*] interesting to you? How come?" and Q15: "Was the Dr. Game thing [PSA C*] fun? What made it fun?" As stated previously, we used the words "fun" and "interesting" to highlight different aspects of enjoyment.

What is "fun" about PSA C*? In response to Question 15, all of the children said that PSA C* was fun. Children described the fun of PSA C* as stemming from working with the activity in a hands-on way, solving the problem, or talking about and sharing the activity with others.

One half of the children (50%) found PSA C* fun because of the excitement of playing the game or fixing it; particular reference was made to the physical aspects of these activities. These responses were often fairly unelaborate: "I got to fix a game and um answer some questions too." Others described hands-on aspects of the task that they enjoyed: "dicing" or "the way that I gotta roll the dice and spin and all that."

Three tenths of the children (30%) gave responses that indicated that they found solving the problem to be fun. Some of these children gave simple responses, e.g., what was fun was "having to figure out the 'what was wrong.'" Other children found the "thinking hard" to be fun as well as the aspect of the game that was like solving a mystery.

Most of the remaining children (11%) described the "fun" of PSA C* as derived from the more social aspects of the task. For example, a few children mentioned "talking" with the interviewer as fun. Another child felt that it was fun to be chosen for the interview. These children did not refer to any of the mathematical aspects of the task as fun. Their enjoyment was derived from the social context of the testing situation rather than from the problem itself.

What is "interesting" about PSA C*? While responses about "fun" seemed to emphasize doing or playing, responses to the "interesting" question (Q14) emphasized the process of solution -- the more intellectual aspects of the task. All but two of the children found PSA C* interesting. Three fifths of the children's responses referred to thinking or solving the task while the remaining third found the novelty of playing the game interesting.

More than one half of the children (53%) said that the thinking involved in PSA C* was what made it interesting. These children described a variety of aspects of the experience. A few of the children said that the fact that the game was strange to them made it interesting, or, in the words of one child, "weird." Other children mentioned that using "your mind to figure it out" and trying hard made the problem interesting; implicit in these responses was the challenge involved in trying to solve a problem. One child said that his interest came from the challenge of the PSA because it "made me think and stuff."

More than one third (35%) of the children reported that the novelty of the game or of playing it made PSA C* interesting. As one child said, "It was a different game...that I ever played. I haven't really played that before." Another child simply stated that it was interesting because it was "something new" to do. Being given the opportunity to try to do something different from their usual experience seemed to be what made the task interesting for this group of children.

What children disliked about PSAs B* and A*. Because all of the children found PSA C* to be fun, and only two children found it uninteresting, we needed to look beyond PSA C* in order to compare what the children disliked about the PSAs with what they dislike about mathematics. As described earlier, PSA B* and A* are less complex mathematical tasks. The children who complained about PSA B* and A* perceived these tasks to be insufficiently challenging; they felt that they were ordinary number tasks. Slightly less than one fifth (19%) of the children expressed negative comments about PSA B*, while less than one tenth (8%) made negative comments about PSA A*. These children disliked that in PSA B*, "all you do is put them in groups" or that organizing the numbers is boring. One child disliked PSA B* because he hates mathematics. The children who disliked PSA A* spoke in particular about the repetition involved.

In sum, "interest" involved a more intellectual component than the simple pleasure that was expressed in the "fun" responses. PSA C* was fun for children because playing the game itself involved a variety of tasks or actions that the children found pleasurable. PSA C* was interesting because it was different from other games and it allowed the children the opportunity to use their minds by solving a problem. Some children felt that the two less complex PSAs, PSA B* and PSA A*, were less enjoyable than PSA C* because they found them repetitive or less challenging.

Conclusion: Enjoyment of Mathematics and Problem Solving

The children described similar aspects of mathematics and problem solving (i.e., the PSAs) as enjoyable and not enjoyable. The bases of the children's enjoyment typically were novelty and the process of engaging with or learning something that they found fun to do or interesting to figure out. Conversely, the children did not enjoy what they found repetitious and, in the case of mathematics, too difficult.

The children's enjoyment of learning new things and exploring the novel was clearly evident with regard to mathematics. Many of the children who described enjoying "mathematics" did so for the novelty of working with numbers and learning various components of mathematics. These children, a few of whom simply stated that mathematics is "fun" or their "favorite," seemed to be articulating enjoyment of the process of doing mathematics, particularly when the process involved learning new things. While one third of the children said that they did not enjoy "mathematics" per se, all but four children could describe a task in mathematics that they enjoyed. The topics and tasks that many described as enjoyable (e.g., geometry, symmetry) typically fell within areas that would be unique given their arithmetic-based school curriculum and presumably would involve less drill and practice than a traditional curriculum for teaching arithmetic.

Children also attributed their enjoyment to feelings of competence. The children who identified aspects of computational arithmetic as tasks that they have enjoyed often explained their enjoyment in terms of the ease and speed with which they could perform. Some children stated that they enjoyed "mathematics" for the same reasons. These children seemed to view their mathematical competence in terms of their ability to perform arithmetic quickly and automatically. The children who did not like "mathematics" because of its difficulty seemed to have similar beliefs about how mathematical competence is demonstrated. Difficulty, instead of being viewed as a challenge, was considered negative and a sign of incompetence.

When children base their sense of competence in mathematics on ease and speed, they become vulnerable to being alienated from mathematics in two ways. First, and most obviously, they may come to consider themselves incompetent when the subject matter in mathematics becomes more challenging and they find that they cannot perform with immediate success. Second, while performing with ease and speed may be gratifying to children in fifth grade, they may soon find that ease and speed are not motivating enough to maintain their enjoyment and engagement with mathematics. If a number of their classmates already find mathematics boring or dislike it because it is repetitious, these children, too, may eventually see the ease and speed with which they do mathematics as a cause for boredom more than as a sign of competence.

Similarly, the minority of children who found PSA B* or PSA A* not to be fun or interesting also spoke to the issue of repetition. The children's responses suggested that the repetition in these tasks (e.g., making combinations in PSA A*) was not enjoyable because that was "all" one did.

By contrast, the children who found PSA C* to be engaging due to challenge or novelty seemed to consider the activity its own reward. The children's responses indicated that, by and large, the thinking and doing required for the tasks were enjoyable. Perhaps this was due to the purpose that the children saw in the contexts presented with the PSAs. Recall that the PSAs were contextualized activities; each task was placed in a quasi-"real life" context. The purposefulness of the tasks themselves may have provided a reason for seeing the task as worthwhile.

The necessity for mathematics to have a recognizable purpose, while explicit in the literature on mathematics education reform (NCTM, 1989; National Research Council, 1989), was implicit in the children's enjoyment responses. Proponents of mathematics education reform are concerned about making mathematics relevant to children. Most of the children in the present study -- children who were still in elementary school -- seemed to find "mathematics" enjoyable because doing it and knowing how to do it were very relevant to demonstrating competence in their lives at the moment. Perhaps as the children grow older and envision, to a greater extent, their lives outside of school, and as the gratification associated with computation becomes less strong, repetition may lead to boredom; such boredom may contribute to the development of beliefs that mathematics is irrelevant to their lives.

THE EFFECTS OF SQUARE ONE TV: ANALYSIS SCHEME

As mentioned previously, our analysis of change consisted of two separate analysis schemes. For the designated enjoyment questions, we developed a scheme to code the children's reasons for enjoying mathematics and problem solving so that we could assess whether these reasons changed as a result of viewing **SQUARE ONE TV**. We also developed a method of analyzing all of the statements of enjoyment found throughout the interview in response to questions other than those designated for enjoyment. We call this analysis the "general enjoyment" analysis because these expressions of enjoyment occurred spontaneously throughout the interview. We present considerations in developing the schemes and the schemes themselves below. For further examples and instructions on how coding decisions were made within these schemes, please refer to Appendix III.J, where the Enjoyment Codebook can be found.

The Reasons-for-Enjoyment Scheme

Considerations in Development of the Scheme

The reasons-for-enjoyment scheme was designed to capture a variety of aspects of enjoyment as reflected in all of the questions in the PSA and the Mathematics Domains. The children's responses to the designated enjoyment questions contained three different kinds of information, all of which were important to understanding their enjoyment.

The first feature was whether the children felt positively (i.e., had positive affective responses) about the mathematics under discussion; positive affective responses indicated that they liked it, enjoyed it, were excited about it, and so on. When children felt negatively about the subject, they spoke about disliking it, finding it boring, and so on.

The second important feature of the children's responses concerned the reasons for their positive or negative feelings. Some of the children's reasons seemed to be more directly related to mathematics and problem solving than other responses were. For example, some children stated that mathematics was enjoyable due to the thinking that it requires. But others found mathematics enjoyable because they could teach it to their younger siblings; such responses related less to mathematics per se than to the context in which the mathematics was placed. Because we felt that responses related to the child's thinking were qualitatively different from responses that were less concerned with learning or solving mathematics problems, we wanted to distinguish between these different reasons for finding mathematics enjoyable.

The third feature of the children's responses related to the relative level of sophistication of the children's responses. We found that the children's reasons for enjoyment ranged from the very simple (e.g., because it's fun) to more sophisticated statements (e.g., because it helps me to learn things that I will need to get a good job). This, too, had to be captured in our analysis.

Components of the Reasons-for-Enjoyment Scheme

To capture the aspects of children's responses described above, we created a scheme with three distinct components: (a) orientation (the nature of a child's reason for enjoyment), (b) level of sophistication (the degree of abstraction in the child's reason), and (c) valence of affective response (i.e., whether the underlying feeling was positive or negative). The latter two components, valence and level, were combined into magnitude, as explained below. The illustrative examples provided below have been taken from the responses to Question 14 ("Was the Dr. Game thing [PSA C*] interesting to you? How come?") and Question 15 ("Was the Dr. Game thing [PSA C*] fun? What made it fun?").

Orientation. The concept of an orientation allowed us to categorize the different reasons that children gave for their enjoyment. By "orientation" we mean the ways in which the children derived their enjoyment of the task in question. Children's responses could be classified as thinker, doer, social, or evaluative.

Doer responses indicated that children derived their enjoyment from actively working "hands-on." The verb "do" was salient in doer responses. The following two responses indicated that the child derived enjoyment from working with the activity itself. From this working (or "doing"), the first child felt the pleasure of accomplishing something.

> Because you did it on your own and you weren't -- you were doing stuff that nobody else does -- just yourself...Like some of the people wouldn't use a pencil and you wouldn't...And paper.

> Mm hm [it was interesting]. Because I never done it before and that was my first time.

The responses below were also considered to be doer responses. These statements emphasized playing the game or physical aspects of the game as the source of the child's enjoyment.

> [It was fun] that you would spin the thing and then flip the coin.

> [It was fun] just by um multiplying and adding -- just puttin' the chips in front of the places.

> [It was interesting] so you can play the game.

Thinker responses indicated that the children's enjoyment was derived from thinking or solving problems. Here, the reasons for children's enjoyment related to their intellectual involvement with the task. These children may also have described the challenge of the task as their reason for enjoyment. The responses below are examples of the thinker orientation.

> Yes [it was fun]...Putting it back together...it had a mystery...I like mysteries... Because I try to figure them out...I wanna be a detective.

> Mm yeah [it was fun]...Well, just playing the game and, and like um, knowing that at the end you'll like say that you have a, like a mystery to solve and at the end you'll prob -- you'll solve it and that'll be fun.

> Mm hm [it was interesting]...Because I got to figure out like, I was like a detective to figure out what was wrong and um, to see, to see who got the most chips and stuff um, yeah, yeah, I got, when I played and I got to see what was wrong um, it was sort of fun because you got to do a couple of things to figure out what was wrong, not just one thing. Like you could multiply and add and then you gotta see the answer and stuff like that. That's fun.

In these responses, the children mentioned the process of figuring out or solving the problem as the reason that they found the PSA enjoyable. Thinker responses need not have mentioned figuring out the solution to the problem, however. The following children's responses did not mention solutions but were considered to belong in this category nonetheless; rather than finding some physical aspect of the task fun or interesting (as in the doer responses), these children attributed their enjoyment to some aspect of the conceptualization of the game, including the novelty of the game itself.

> [Was it fun?] There's a catch to it. First, you have to figure out something wrong, and there's so many things you have to do...It's just fun.

> [Was it interesting?] Well, it was just interesting to learn how to play a new game...Well, it was in a different design than other games that I've played...And there was -- it was just fun.

Social responses indicated that the children derived their enjoyment from interacting with others or from ways in which the tasks were related to "real life." These statements generally concerned the children's relationship with their social world. In some of these statements, the children stated that they enjoyed the task because it would enable them to assume responsibility, e.g., in a job, in the future. In the following responses, the children enjoyed a given task because of the social context associated with it.

> Yeah it was fun...What made it fun? Um, the people [the cardboard players], the, they, they were, they looked kind of funny. And um, and then the, now, now about it. I felt like I had people there like a companion, 'cause they felt like, they looked kind of funny.

> Well, because [it was] like a job. Like she said that she's gonna hire you and so I felt, well, I got a job now. So I better get to do my job, so I fixed it.

Other social responses might have mentioned the fact that the child was selected to be interviewed or even the interview itself as the enjoyable aspect of the task.

Evaluative responses described the children's enjoyment in terms of meeting standards and expectations of others. Evaluative statements were concerned with performance assessments, getting good grades, and getting right answers. Very few evaluative statements were made in the PSA Domain. The following response was coded as evaluative:

> [It was interesting because] it seemed easy...Because I already know it...So, if I do it again, sometime, I won't get it wrong.

This child enjoyed the ease of the task because he was able to get it right. Enjoyment derived from easy things, from speed or timed drill, or from positive assessments of the child's ability would all be categorized as evaluative statements.

Level of sophistication. As mentioned above, the children's reasons for enjoyment covered a range of sophistication. Some of the responses were very task-specific while others, the more sophisticated responses, placed the task in a broader context, often relating to the development of a child's competence. In this way, statements coded for orientation were also coded for level, an indication of the sophistication of the child's reasoning in terms of his or her ability to articulate the broader context from which he or she derived enjoyment. The highest-level responses indicated that the child derived enjoyment from perceptions of competence due to mastery of the task.

Similar criteria were used to assess the level of the statements in each orientation. For doer responses, level ranged from references to physical aspects of the game (e.g., the spinners) to statements of mastery gained from having made an effort to do the task. The range of thinker responses covered assessments of conceptual aspects of the problem to statements regarding the challenge posed by the task. Social responses ranged from descriptions of enjoyment derived from the interview situation itself to enjoyment derived from being able to use knowledge of the task to assume responsibility, e.g., to teach others. In the evaluative orientation, the children's responses ranged from deriving enjoyment from missing school (to do the PSAs) to deriving enjoyment from developing competence by performing well.

Three levels of sophistication were defined for each orientation. Examples of each level statement for the doer orientation are presented below; examples of statements within the other orientations are presented in the codebook found in Appendix III.J.

Low-level statements generally described enjoyment due to the context, to superficial aspects of the task under discussion, or to simple involvement with the task itself. While they may have, for example, presented elaborate descriptions of the task, the children's low-level reasons for enjoyment indicated little sophistication because they were very task-specific.

> [Was it fun?] Uh huh...When, when you had [to] spin em around and it landed on times or add, you'd get, you'd look um, the, the little board and it had had in the orange line...

> [Was it interesting?] Hm, yeah...And be -- I like to play games...I just...thought it'd be fun to -- I felt more like playing the game instead of fixing it.

Medium-level statements were also task-specific but indicated that enjoyment was derived from a more complex understanding of and involvement with the task in question. At this level, children often mentioned specific heuristics that they used in solutions, assessed alternate solutions, or discussed the appropriateness of their solution.

> [Was it fun?] Just by um multiplying and adding -- just puttin' the chips in front of places.

High-level responses were the most sophisticated in that children found sources for enjoyment by placing the task in a larger context that usually involved the development of the child's competence. In other words, the children enjoyed the task because they understood that the competence associated with doing it would enable them to learn more or to be prepared for the future.

> [Was it fun?] Yeah...That you kind of -- you kind of had to do it on your own. You kinda had to figure out what was wrong and stuff. It was kind of fun.

Valence. Valence assessed the underlying affective response toward the task; it was simply coded as positive or negative. When a child stated that the task in question was enjoyable, it was coded as positive. If the child did not elaborate further, the response was coded only for valence. For example, one child agreed that PSA C* was fun but when asked to give a reason why, she said, "It just seemed fun." This statement was, therefore, coded as positive but had neither an orientation nor a level.

A statement could be positive or negative at any level or within any orientation, although negative responses were infrequent. Very few children, especially in the PSA Domain, flatly stated "No," indicating that a particular task was neither fun nor interesting.

Magnitude. Magnitude is a combination of level and valence. Because the level variable did not distinguish between positive and negative valence, children who stated that they loved mathematics and children who hated it would be placed in the same level if the sophistication of their reasons was similar. For this reason, level was combined with valence to create a new variable that we refer to as magnitude. The analyses of change presented later in this section have used magnitude rather than level.

Interrater Reliability

After the reasons-for-enjoyment scheme was developed, reliability was assessed by having two researchers code a subset of 16 interviews. Reliability was assessed via correlations and percent agreement. These measures indicated that agreement was high. The reader is referred to Appendix III.K for further information on the analysis of reliability.

The General Enjoyment Analysis

Considerations in the Development of the Scheme

To determine whether the designated questions adequately captured the enjoyment present in the interview, we coded a subset of 12 full interviews using the "reasons-for-enjoyment" scheme. While the correlations between the ratings given to the designated enjoyment questions and the full interviews were significant ($p < .01$) and fairly high, we decided to perform an analysis of valence using responses to all of the questions in the interview for three reasons, as described earlier. First, the questions that asked the children explicitly to discuss their feelings about certain situations were not included in the reasons-for-enjoyment scheme. While it was appropriate to exclude these questions from the reasons-for-enjoyment analysis scheme, it did not seem appropriate to exclude these statements entirely from our analysis of enjoyment. The children's statements of their feelings, e.g., happiness or nervousness, were important indicators of their relationship to mathematics. Second, children's expressions of enjoyment (e.g., "It was fun") were found throughout the interviews, not just in response to the designated enjoyment questions. Third, because some of the designated enjoyment questions asked children for evaluations of issues that we had presented to them, we felt that their valence scores might have been somewhat inflated by some children telling us what they thought "we wanted to hear." This seemed to be less of a problem with statements that arose spontaneously i.e., not in response to direct questions. Because such statements (e.g., "It was fun!") were found throughout the interview, such an analysis was in fact possible.

The General Enjoyment Analysis Scheme

General enjoyment statements were coded as either positive or negative. Coding for general enjoyment was virtually the same as coding for valence in the reasons-for-enjoyment scheme. Typically, general enjoyment statements were brief, spontaneous remarks (e.g., "I liked it") made by the child in the course of discussing another aspect of his or her attitude. These brief remarks mentioned the pleasure or interest that the child felt for the mathematical task in question. For example, one child responded that an alien from another planet should learn mathematics because "Well, I'm saying 'yes' because math is my favorite subject." This child's statement indicated that he enjoyed mathematics and, thus, it would be coded as positive. If a child said that he or she hates word problems in response to a question targeted for an attitude dimension other than enjoyment, this would be coded as negative. Similarly, children's statements of positive feelings, such as being happy or excited, were coded as positive while negative feelings, such as shame and frustration, were coded as negative. Further details on general enjoyment coding can be found in the Enjoyment Codebook in Appendix III.J.

Interrater Reliability

Reasons-for-enjoyment scheme. To assess the reliability of this coding scheme, two raters coded a subset of 16 interviews for orientation, level, and valence. Significant positive correlations were observed for orientation ($p < .001$) and level ($p < .01$) and indicated a high degree of agreement between the raters.

The correlation observed for valence was only marginal ($p < .10$). However, a further examination of the data revealed that the marginality of this correlation was not due to a disagreement between the raters; indeed, there was 91% agreement between the scores given by the two raters.[76] Thus, it appeared that the scheme was clear and replicable across raters.

General enjoyment scheme. To assess the reliability of this coding scheme, two raters independently coded a subset of 12 interviews. The correlations between the scores given by the two raters was significant ($p < .001$) and indicated high agreement between them.

Further information on the assessment of reliability for both the reasons-for-enjoyment scheme and the general enjoyment scheme can be found in Appendix III.K.

[76] See Appendix III.K. for a further discussion of these findings.

THE EFFECTS OF VIEWING SQUARE ONE TV: RESULTS AND DISCUSSION

Overview of Results

While viewers' and nonviewers' responses did not differ significantly at the pretest, differences between the two groups emerged after the viewers were exposed to 30 programs of **SQUARE ONE TV**. In the PSA Domain, a marginal difference was observed between the change shown by viewers and nonviewers with regard to the proportion of thinker statements they produced; when the variance contributed by either sex or ethnicity was controlled for, these gains were statistically significant. In addition, the general enjoyment analysis revealed that viewers made significantly more positive statements in the posttest than they had before their exposure to **SQUARE ONE TV**.

Reasons-for-Enjoyment Analysis

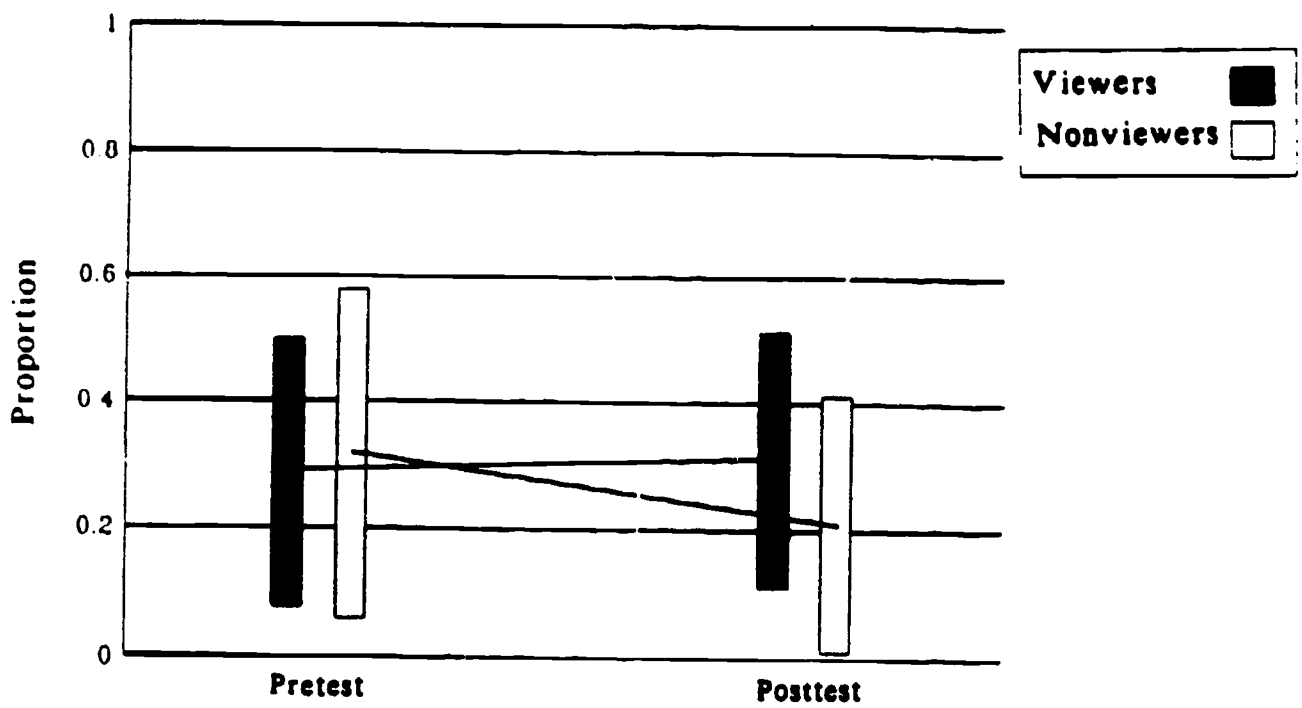
Orientation

Our analysis scheme for the children's reasons for enjoyment consisted of four orientations: thinker, doer, social, and evaluative. In approaching the statistical analysis of change, we considered the relevance of each of these orientations to the goals of **SQUARE ONE TV**. Of the four, only the thinker orientation seemed to be directly related to these goals, in that such statements indicated that the children derived their enjoyment from problem solving itself. For this reason, the thinker orientation was the only orientation analyzed for change.

Results in the thinker orientation. Figure 6.1 shows the average proportion of thinker statements made by viewers and nonviewers in the pretest and posttest with one standard deviation above and below the mean. We expected that viewers would show a greater increase than nonviewers in the proportion of thinker statements they produced.

Figure 6.1

Mean proportion of thinker statements ± 1 SD



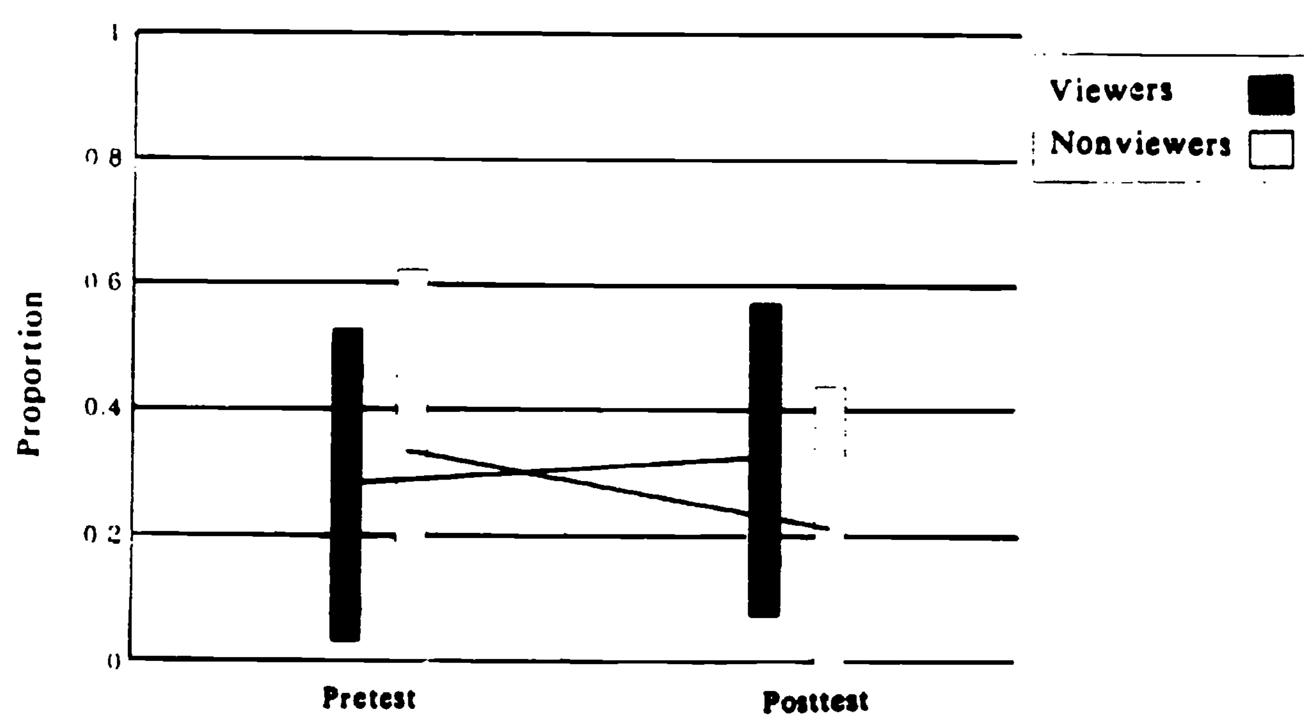
As this figure suggests, looking across the targeted questions as a whole, there were no significant differences between the groups at either the pretest or at the posttest. These effects did not differ significantly by ethnicity or SES. A marginal main effect was found for sex ($p < .10$), with boys producing a greater proportion of thinker statements than girls; in addition, there was a marginal interaction of sex with treatment ($p < .10$) in that nonviewer boys declined significantly from pretest to posttest ($p < .05$) while nonviewer girls (and viewers of both sexes) did not.

Similar results were observed with regard to the questions in the Mathematics Domain. Viewers and nonviewers did not differ significantly in either the pretest or the posttest. No significant effects were observed for ethnicity, and while middle-SES children produced a marginally greater proportion of thinker statements overall ($p < .10$), this effect did not interact significantly with the effects of viewing **SQUARE ONE TV**. A significant effect was also observed for sex, in that boys produced more thinker statements than girls overall, but this effect did not interact significantly with the effects of viewing the series.

However, a different pattern of results was observed with regard to thinker statements in the PSA Domain, as Figure 6.2 illustrates. In this Domain, the viewers' pretest-posttest increase was marginally greater than that of the nonviewers ($p < .10$); when the variance accounted for by either sex or ethnicity was controlled for, this effect became significant ($p < .05$). The two groups did not differ significantly at the pretest. However, from the pretest to posttest, the nonviewers declined significantly ($p < .05$); in the posttest, viewers produced a significantly greater proportion of thinker statements than nonviewers did ($p < .05$). These effects did not differ significantly as a function of either SES or ethnicity, and boys and girls

Figure 6.2

Mean proportion of thinker statements in the PSA Domain ± 1 SD



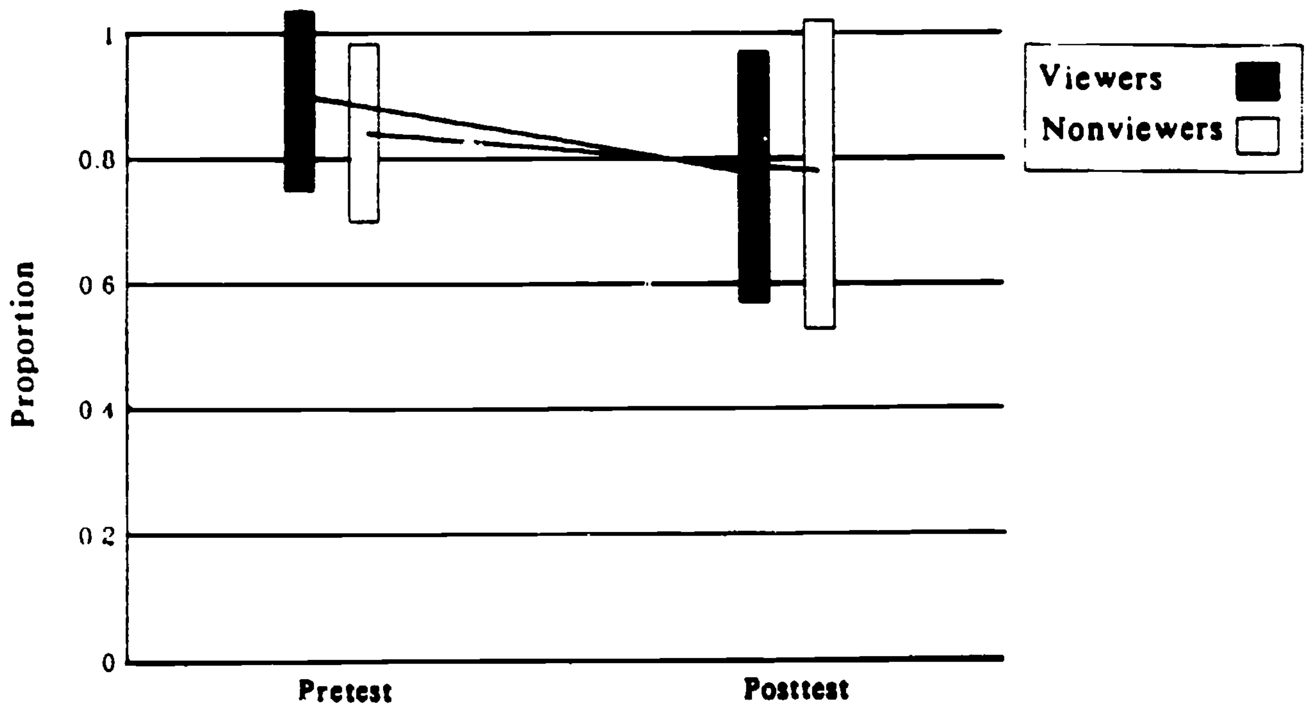
in the viewer group did not differ significantly in either the pretest or posttest.[77]

Valence

Valence indicates whether the children's statements were positive or negative. Figure 6.3 shows the proportion of positive statements given by viewers and nonviewers in response to the designated enjoyment questions in the pretest and posttest with one standard deviation above and below the mean. We expected that the viewers would become more positive after the treatment.

Figure 6.3

Mean proportion of positive statements ± 1 SD



[77] There was, however, a significant ($p < .05$) three-way interaction; this was attributed to a drop ($p < .05$) in the nonviewing boys scores.

As the figure suggests, there were no significant differences between the groups in either the pretest or posttest. These results did not differ significantly as a function of sex, or SES. A significant main effect was observed for ethnicity ($p < .05$) in that minority children produced a greater proportion of positive statements overall, but this effect did not interact with effects of viewing **SQUARE ONE TV**.

The same pattern of results was found in the PSA and Mathematics Domains, with the exception that no significant effect of ethnicity was observed in the Mathematics Domain.

Magnitude

As the reader may recall, magnitude combines the valence and level of sophistication of the children's reasons for their enjoyment of mathematics.[78] Figure 6.4 shows the mean magnitude ratings given to viewers and nonviewers in the pretest and posttest with one standard deviation above and below the mean. We expected that the mean magnitude of viewers' statements would increase as a result of the treatment.

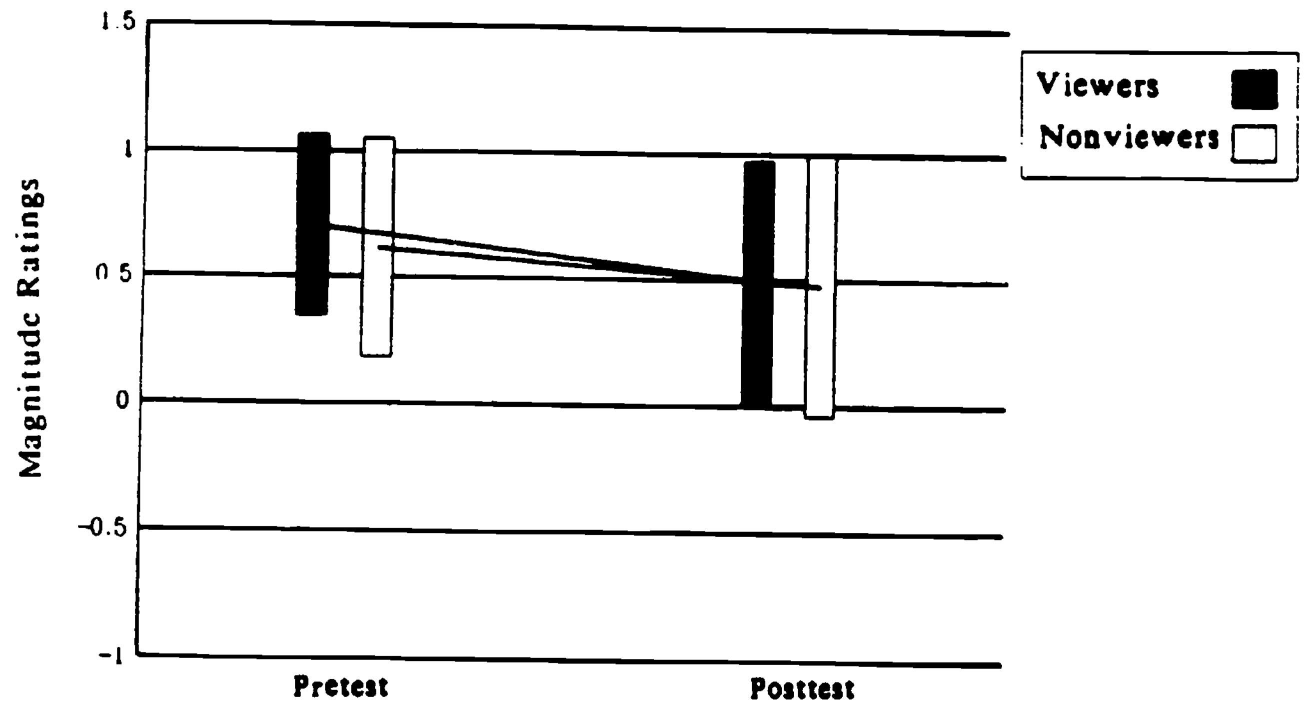
As this figure suggests, there were no significant differences between the groups at either the pretest or the posttest. These effects did not differ significantly as a function of sex or ethnicity. Although a significant main effect was observed for SES, in that the magnitude ratings of low-income children were significantly higher than those of middle-income children overall ($p < .05$), this effect did not interact significantly with the effects of viewing **SQUARE ONE TV**.

[78]Each statement was assigned a rating on a six-point magnitude scale ranging from -3 to +2. The scores were as follows: 2 = positive, high-level; 1 = positive, medium-level; 0 = positive, low-level; -1 = negative, low-level; -2 = negative, medium-level; -3 = negative, high-level. Each child was assigned a magnitude rating equal to the average of the scores given to his or her statements.

Similar effects were observed in the PSA and Mathematics Domains. No significant differences between viewers and nonviewers were observed in either the pretest or the posttest. These results did not differ as a function of sex in either domain. A significant effect of ethnicity ($p < .05$) and a marginal effect of SES ($p < .10$) were found in the PSA Domain, in that minority and low-SES children received higher ratings overall; however, these effects did not interact significantly with the effects of viewing **SQUARE ONE TV**.

Figure 6.4

Mean magnitude ratings ± 1 SD



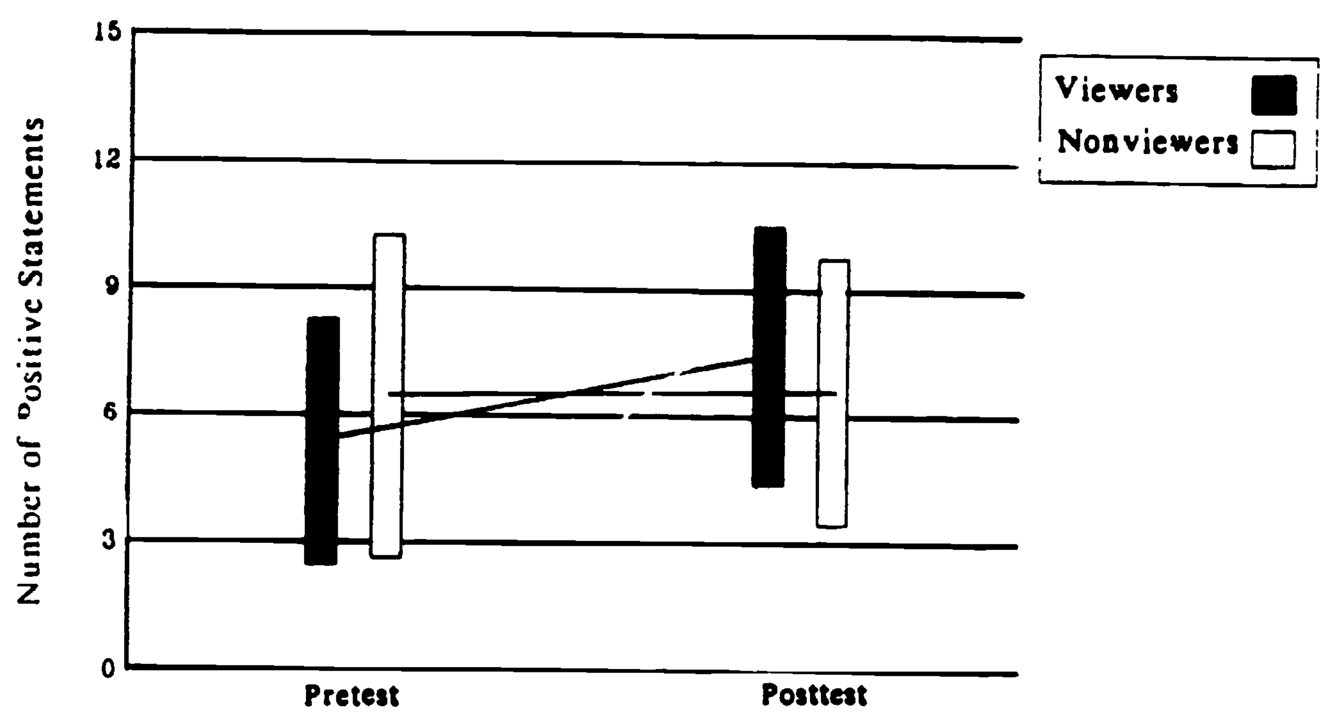
General Enjoyment Analysis

General enjoyment is an assessment of the children's statements of enjoyment made spontaneously throughout the interview (i.e., not including responses to the questions designated for enjoyment). They were, basically, spontaneous statements indicating pleasure, interest, or other affective issues (e.g., regarding happiness or sadness). We expected the viewers to make more spontaneous positive statements as a result of viewing SQUARE ONE TV.[79]

Figure 6.5 shows the average number of positive statements made by viewers and nonviewers in the pretest and posttest with one standard deviation above and below the mean.

Figure 6.5

Mean number of spontaneous positive statements ± 1 SD



[79] As a necessary first step in this general enjoyment analysis, we needed to determine if the number of positive statements was an artifact of the number of questions that each child was asked. To determine this, we correlated the number of general enjoyment statements with the number of questions asked. The correlation was not significant, suggesting that the frequency of positive statements was not significantly related to the number of questions asked.

As the figure suggests, the viewers and nonviewers did not differ significantly in the number of positive statements made at the pretest. However, viewers increased significantly over time ($p < .01$) while nonviewers did not. These results did not differ significantly as a function of sex, ethnicity, or SES.

Discussion

Taken together, the results of the above analyses indicate that **SQUARE ONE TV** had an impact on several aspects of children's enjoyment of mathematics. In the PSA Domain, there were marginal differences between the change shown by viewers and nonviewers with regard to thinker statements; when either sex or ethnicity was controlled for, these gains became significant. In the general enjoyment analysis, viewers made statistically significant gains in the number of positive statements they made spontaneously throughout the interview, while nonviewers did not.

Orientation

As noted earlier, of the four orientations described in the analysis scheme, the thinker orientation seemed particularly related to the way mathematics is presented on **SQUARE ONE TV**. The fact that viewers and nonviewers were found in the PSA Domain is particularly encouraging because thinker statements in this domain indicate that the children derived enjoyment from the process of problem solving itself.

It is interesting to note that nonviewer boys (who began by making the most thinker statements in the PSA Domain at the pretest) declined significantly by the posttest. In the descriptive analysis, we noted that the children were sensitive to repetition: they disliked it. Perhaps these boys, having done the PSAs once, did not understand why they should do them again. Without a context for problem solving, like the one provided by **SQUARE ONE TV**, they did not maintain their enjoyment in figuring out the PSAs.

Valence, Magnitude, and General Enjoyment

While exposure to **SQUARE ONE TV** did not increase either the proportion of positive statements among viewers' responses to the designated questions or their magnitude scores for these questions, persistent exposure to the series resulted in an increase in general enjoyment (i.e., the number of positive statements they made throughout the rest of the interview). The reason for this discrepancy may lie in the fact that within the designated questions, all of the children were extremely positive about the PSAs and mathematics. Even in the pretest, 87% of their responses were positive; as a result, there was little room for growth. This high incidence of positive statements may have had to do with the social desirability of positive responses; children, in the interview setting with unfamiliar adults, may have felt that they should respond favorably.

By contrast, the measure of general enjoyment tallied the children's expressions of pleasure or interest that arose without an interviewer's direct request for such information. Thus, these more spontaneous responses may be a more accurate reflection of what the children actually thought. Taken with the results observed in the thinker orientation, this finding suggests that **SQUARE ONE TV** can have some positive impact on children's enjoyment of mathematics.

CHAPTER 7

CONCLUSION

Introduction

The purpose of this chapter is to synthesize the results presented throughout this volume. The previous chapters presented the results of our inquiry into children's constructs of mathematics and problem solving, as well as their perceptions of its usefulness and importance, and their motivation and enjoyment of mathematics and problem solving. The present chapter reviews those results taken as a whole.

In Chapter 1, we presented several questions that framed our inquiry into children's attitudes toward mathematics. While research suggested that children's attitudes toward mathematics are formed in the late elementary-school years, the attitudes of that particular population of children had not been studied in detail. Our first question, then, was: What were the children's attitudes toward mathematics? In considering this question, we conceived of attitude as consisting of two components. The first component was the children's beliefs about mathematics (i.e., construct of mathematics and perceptions of its usefulness and importance) and their relationship to mathematics (i.e., motivation and enjoyment). The second component was their affective responses (the valence connected to motivation and enjoyment). These components of attitude were explored in three domains of mathematical inquiry: the PSA Domain, the Figuring Out Domain, and the Mathematics Domain. As we developed an understanding of the attitudes of fifth-grade children, we also asked: What effect could sustained viewing of SQUARE ONE TV have on these children's attitudes toward mathematics?

This chapter contains four sections. In the first, we summarize the descriptive analyses relating to mathematics. In the second, we present a similar summary for the descriptive analyses relating to problem solving. The third section explores the similarities and differences between the two descriptive analyses. The final section summarizes the effects of SQUARE ONE TV on children's attitudes and presents suggestions for future research in mathematics education.

Summary: Children's Beliefs about Mathematics

In essence, the children in this study believed that mathematics consists of numbers and arithmetic and that all there is to mathematics is what they have been presented with in school. While they could list, or mention, a range of mathematical content areas apart from arithmetic, the children spoke almost exclusively about arithmetic when they discussed the importance of mathematics, their motivation, or their enjoyment.

The children incorporated some limited aspects of problem solving into this arithmetic-based construct of mathematics by speaking of how mathematics is used to solve problems in the world outside of school and by linking it with a sense of struggle. They identified the problems in textbooks (e.g., "There are eight hundred and fifty cans of soup. [Ben] sold fifty. How many does he have left?") as examples of ways in which mathematics could be used for real-life problem solving. When the children associated mathematics with a process of struggle, they were not commenting on the use of mathematics in problem solving, but on the importance of thinking hard and the experience of uncertainty involved in using arithmetic procedures that they had not yet mastered.

This belief in mathematics as arithmetic was particularly evident when the children discussed the importance of mathematics. The children generally thought that mathematics was important to the extent that they could find applications for arithmetic (e.g., getting change at the store, paying bills) or out of a vague sense that arithmetic would be important for their futures.

Some of the children perceived the importance of mathematics to come from their appreciation of it as fun to do and important to learn. Both of these ideas were set firmly in a school context. Mathematics was important to the children because they found arithmetic problems -- and the drills and games teachers played with them -- to be fun. They also considered learning mathematics (i.e., arithmetic) and doing well in school to be important.

Children who did not find mathematics to be important often found it neither useful nor fun. Having mastered the basic arithmetic skills, some of these children seemed to find applications such as counting money or getting change to be mundane and, thus, not particularly important. Others felt that doing arithmetic was not fun, or was less fun than other activities that they enjoyed and was, therefore, unimportant.

In examining children's motivation toward mathematics, we were essentially looking at their inclination to be engaged with computational arithmetic. Some children found the process of learning computation skills and the thinking involved to be motivating factors. However, it appears that the performance demands related to good grades played a more central role with respect to children's motivation toward arithmetic. For some, the rewards of grades and the certainty of correct answers provided children with a sense of competence. However, other children cited poor performance in mathematics or concerns about failure as reasons to avoid challenging arithmetic. Thus, it appears that the emphasis placed on performance in the mathematics learning environment may have limited the motivation of children who did not see themselves as doing well in mathematics; perhaps, in more subtle ways, it may even have affected the motivation of those who did perceive themselves as successful in mathematics.

The children's enjoyment of mathematics was also based largely upon their experience with arithmetic. Many of the children indicated that they liked mathematics because it is fun to learn and think about, it is easy (and they are able to do it quickly and successfully), and there are particular activities that they find pleasurable. Those children who said that they did not like mathematics focused primarily on the difficulty of the subject and the repetition inherent in both the curriculum and the drill and practice methods used to teach it.

It appears, then, that certain children liked mathematics and others disliked it for precisely the same reasons -- that classroom mathematics is focused on arithmetic and associated directly with ease, speed, and accuracy. Interestingly, the patterns evident with regard to motivation are echoed here. While some children liked classroom mathematics because they could do it fast and get the right answer, others did not because it was too hard and they could not "get it."

Despite this arithmetic- and performance-oriented focus, many children, including some who said they dislike mathematics, named less typical areas of the elementary-school mathematics curriculum, (e.g., geometry, symmetry) and identified aspects of the mathematics learning experience (e.g., thinking hard, taking in new information) as pleasurable. Thus, some children seemed to be articulating enjoyment of the learning process, especially when the process involved learning novel or different things. It seems clear that this aspect of enjoyment ought to be exploited by applying it to more sophisticated problem solving, as it might help steer children's focus away from extrinsic rewards and more upon the inherent interest of the activity.

Summary: Children's Beliefs about Problem Solving

Children saw problem solving (or, to use their term, "figuring out") as a process that entails thinking hard or struggling with the unknown to solve purposeful problems. In discussing this sort of problem solving, they repeatedly made reference to mysteries or detective stories, thinking or schoolwork in mathematics, games or puzzles, and making or fixing things. They enjoyed the figuring out involved in these activities, and used terminology associated with these activities (e.g., "looking for clues") in explaining how they figure things out. In addition, when the children discussed PSA C*, the most mathematically sophisticated Problem-Solving Activity presented to them, they often compared it to mysteries, school, and fixing. Given the ubiquity of the children's mentions of these activities, it is possible that these activities served as sources for the children's ideas as to the nature of problem solving.

It is important to note that while children used the term "problem solving" to refer to mathematics, their use of the term referred not to sophisticated, higher-level problem solving, but rather to the solving of computational arithmetic problems. More sophisticated problem solving (or "figuring out") was seen as a generic process that, despite its emphasis on thinking hard, did not necessarily involve any systematic application of arithmetic or mathematics to a problem.

This construct of problem solving underlay the children's conceptions of its importance, as well as their explanations of their enjoyment and motivation. In all of these dimensions, children spoke of problem solving as a process of thinking hard and figuring out. Given this broad definition of problem solving, it is not surprising that the children felt that skill with problem solving was important to their present and future lives. Children felt that PSA C* was important because one could learn from it, because such thinking would help them in the future, because it would teach them how to fix and play games, and because it would enable them to help others solve problems. Similar reasons (concerning thinking or fixing and playing games) emerged in their discussions of enjoyment, challenge, and their motivation to pursue challenging tasks.

In all of these dimensions, then, the children's reactions appear to have been largely tied to their engagement with a given problem rather than to any extrinsic rewards or demands of the situation; only about 10% of the children's responses mentioned extrinsic factors (e.g., their performance or the social aspects of the testing situation) as reasons for their responses in any of these dimensions.

It is also interesting to note the degree to which enjoyment and motivation, in particular, appeared to be intertwined. Within motivation, children often elected to pursue PSA C* because they found it to be fun. At the same time, children often explained their enjoyment of the problem in terms of their interest in and engagement with it; researchers (e.g., Dweck & Elliott, 1983) typically see such engagement as an essential source of motivation, and engagement was central to many children's definitions of "challenge" in the present study.

Taken as a whole, this pattern of results regarding problem solving and PSA C* suggests two main conclusions. First, it seems apparent that, as one might expect, these various dimensions of the children's attitudes toward mathematics are not independent but operate in a complementary fashion; attitudes within the three dimensions frequently stem from considerations of similar (typically intrinsic) factors, and indeed, one dimension may serve as the source of another (e.g., enjoyment can be a source of motivation, or aspects of motivation can be a source of enjoyment).

Second, given that PSA C*, like all of the PSAs, is an example of the kinds of nonroutine, hands-on problem-solving tasks that some proponents of reform suggest should be the basis of mathematics education (e.g., NCTM, 1989), the reasons children offered for their attitudes appear to be quite encouraging for the reform movement as a whole. Children in the present study did not typically explain their motivation or enjoyment, or their perceptions of the usefulness of PSA C* in terms of extrinsic rewards or performance demands. Rather, they focused upon the intrinsic value of the nonroutine problem-solving task presented in PSA C* and upon the process of thinking or figuring out that it encouraged. While we cannot be c tain whether they would continue to react in this way if problems such as PSA C* were set in the classroom, where one's performance is measured in relation to others', it is possible that the use of such problems in a school context would continue to engage children's interest, help them to see the value of the kinds of thinking involved, and encourage them to become involved in the process of problem solving for its own sake.

Comparisons of the Descriptive Analyses

Similarities Between Mathematics and Problem Solving

The similarities between the children's discussion of mathematics and problem solving have to do with the children themselves rather than with the similarities between these endeavors. These fifth-grade children talked about their experiences with mathematics and the PSAs in ways that expressed their relationship to the world of school and beyond. The children liked to learn and to understand the world around them by trying new things. In mathematics, they spoke favorably of working with numbers and said that they enjoy the novel parts of the curriculum. With the PSAs, the children liked exploring tasks that were new and different from the kinds of problems to which they were accustomed. This emphasis on novel tasks is consistent with the fact that children linked both mathematics and the PSAs to a sense of struggle to master new skills. In addition, the children saw roles for mathematics and problem solving in a real-life context. Arithmetic was used at the store, and problem solving was applied, e.g., to fix bicycles or to save a life in a mystery.

In light of the children's eagerness to learn new things and to apply what they know, it is not surprising that they found repetition and boredom troublesome. In both the Mathematics Domain and the PSA Domain, the children spoke very negatively about repetition. For some children, this made mathematics boring and unpleasant. Similarly, some also found the repetition and perceived simplicity of the less complex PSAs uninteresting.

Differences Between Mathematics and Problem Solving

Perhaps the greatest difference between the children's discussions of mathematics and problem solving was that children more often focused upon intrinsic aspects of the process of problem solving (e.g., thinking hard, doing, engagement) while their discussions of mathematics were more likely to focus on performance. This difference may have had to do with the fact that the mathematics presented in school is frequently taught in a decontextualized manner with an emphasis on producing the one right answer to a problem. While children who are able to master these demands do feel competent about their ability, the children who do not may be at risk of becoming alienated from mathematics. The problem solving that the children in the present study described as motivating and enjoyable, including PSA C*, exists largely outside those demands.

What would happen if the PSAs were placed in the performance context of school? We can only speculate. Evaluating children's progress in comparison to each other might limit their open exploration of difficult problems. The responses of a few of the children seemed to indicate that they might begin to avoid engaging with the activities for fear of getting them wrong and thus looking stupid. In other words, the result might be a similar situation to that seen for school mathematics.

Yet, speculating about the converse situation reveals possible differences between the two activities: What would happen if arithmetic were taught without the demands of performance? While it may be difficult to imagine the removal of such performance demands, the repetition and drill used to help children master their facts might be seen as fun or, without the rewards of grades, as boring. The fact that children articulated more limited applications of arithmetic than problem solving also suggests that the children might not understand why mastering arithmetic was so important without the performance rewards built into the classroom. The wider range of interesting activities and occupations that the children related to problem solving indicates that they might find learning problem solving to be more intrinsically interesting and engaging than arithmetic, regardless of whether and how they are evaluated.

These observations raise complex questions for curriculum reform in mathematics education. How can mathematics be presented to children, and arithmetic be learned, so that children do not limit their understanding of mathematics to arithmetic? Moreover, if the pressures of evaluation and grades do prove to limit the extent to which children feel free to explore and to learn, then how can children be encouraged to engage with open-ended problem solving without causing them anxiety?

While the descriptive analyses from this study do not present any definitive answers, they suggest that if a curriculum were to begin with contexts and activities children enjoy and to which they are attracted (e.g., mysteries, puzzles), a foundation might be laid for children to develop a different understanding of mathematics. The emphasis that proponents of mathematics reform place on problem solving and real-life applications of mathematics is clearly in keeping with what the children in this sample seem to have wanted from their learning. At the same time, children's sensitivity to being evaluated and to finding activities boring or repetitious needs to be constantly kept in mind in the development of such curricula. The responses of children in this study provide some insight into ways in which these issues might be addressed.

The Effects of SQUARE ONE TV

Given that the children's construct for understanding mathematics was so narrowly defined by classroom arithmetic, and that attitudes toward mathematics are typically stable over time, one would expect it to be difficult to change the children's thinking about and attitudes toward mathematics and problem solving. However, the children in this study were at an age when researchers have considered them to be in the process of forming attitudes toward mathematics (see, e.g., Kulm, 1980). Perhaps as a result, the findings of the present study indicated that persistent viewing of SQUARE ONE TV had an impact upon the children's conceptions of and attitudes toward mathematics and problem solving in several ways.

Children's Construct of Mathematics

Persistent exposure to the series resulted in viewers' speaking about more advanced mathematical content and more practical and sophisticated problem solving than nonviewers. It seems that the presentation of a wide range of mathematical content and problem solving in the series helped the children to assimilate this wider world of mathematics into what they discussed as mathematics and problem solving. It is quite remarkable that **SQUARE ONE TV** had this effect given that the series was created as a supplement to mathematics education and that the children viewed it in the absence of broader curriculum reform. Further effort to present children in this age group with a wide variety of mathematical content could be critical in encouraging them to expand their ideas about the subject.

Yet, two issues remain. First, it seems that, in large part, the children still considered arithmetic to be the foundation of mathematics; even at the posttest, the Goal III content areas most frequently mentioned by children were Numbers and Counting and Arithmetic of Rational Numbers. Changing the children's entire conception of mathematics to mathematical problem solving is a task that a supplement such as **SQUARE ONE TV** cannot possibly accomplish without an accompanying change in the daily mathematics curriculum. The second issue concerns children's conceptions of problem solving. The conceptual salience of arithmetic in their thinking about mathematics may guide children to consider any problem with numbers or computation to be mathematical, while other, perhaps more sophisticated mathematical problems, are not perceived as mathematics. These issues will need to be addressed clearly and persistently within mathematics curricula if children are to develop richer and more integrated conceptions of mathematical problem solving. **SQUARE ONE TV**, too, might consider addressing these misconceptions more explicitly.

Motivation and Enjoyment

Persistent viewing of the series also had an impact on the children's motivation toward and enjoyment of mathematics and problem solving. Viewers' motivation became less focused on performance concerns and more centered on engagement with problems. They also elected to pursue complex mathematical problem-solving tasks over other easier and more routine problem-solving tasks. The viewers made a greater number of spontaneous positive enjoyment statements, and their enjoyment became more focused on thinking and figuring out. These results suggest that the lively presentation of mathematical problem solving on SQUARE ONE TV had an effect on the children. Exposure to the series resulted in their coming to see mathematics as more engaging.

The approach taken in the series seems to be particularly appropriate for children of this age. The ubiquity of statements relating to their enjoyment indicates how important and, thus, motivating, enjoyment is to children of this age. This does not mean that children want problems to be easy or only entertaining. The children in this sample were very clear in saying that they enjoyed thinking hard and struggling with difficult problems when those problems were interesting to them.

Yet, within motivation, children often spoke of wanting to get answers right and perform well for others. Clearly, it is important for children to want to perform well in whatever tasks they pursue, but this should not become their sole motivation or their sole means of judging their own competence. Children need to be exposed to positive examples of persistence and failure as well as to examples of problems with more than one answer, such as those shown in some SQUARE ONE TV segments. Helping to shatter the myth that problems should be easy to solve and yield one right answer could be a powerful role for SQUARE ONE TV to play in the reform movement in mathematics education.

Usefulness and Importance

Neither the type nor the future orientation of the applications mentioned in the Attitude Interview changed from pretest to posttest, although one slight effect was found in the Essay. As the descriptive analysis indicated, the children's applications for mathematics were largely confined to applications of arithmetic. The children seemed to find uses of arithmetic involving money to prese... very compelling applications of mathematics. This may be so for two reasons: First, uses of arithmetic with money are often used to teach children about money and the usefulness of arithmetic. Second, it is possible that being able to use money competently is particularly exciting to children of this age. This is the age when some children may first be asked to run errands and make purchases for their parents. The importance to these children of being able to get the right change, combined with their understanding of arithmetic as computation, may have limited their ability to incorporate into their thinking the variety of mathematical applications shown on the series.

Because children may find applications of arithmetic that involve computation with money to be compelling, **SQUARE ONE TV** might pay particular attention to the applications of mathematics that it presents to children. While presenting applications involving computation and money might help to reinforce children's current conceptions of the usefulness of mathematics, applications that extend beyond arithmetic or money might help the children to develop a broader context for the uses of mathematics as well.

Effects of Sex, SES, and Ethnicity

Having reviewed the significant effects that exposure to **SQUARE ONE TV** exerted on various aspects of viewers' attitudes toward mathematics, we now turn to a consideration of the degree to which these effects may have varied as a function of children's sex, ethnicity, or socioeconomic backgrounds.

Many of the analyses in which differences were found between viewers and nonviewers showed no significant effects of sex, SES, or ethnicity. Neither children's discussions of advanced mathematics, nor their discussions of practical and sophisticated problem solving, nor their inclination to pursue the PSAs that they found most challenging, nor their spontaneous statements of positive enjoyment were affected by their sex, ethnicity, or socioeconomic background, even though each of these aspects of attitude was affected by exposure to **SQUARE ONE TV**.

In the analysis of the usefulness and importance of mathematics, we observed a significant effect of sex: a significant difference was found between viewers and nonviewers (in that viewers produced more essays concerning specific applications of mathematics), and between boys and girls (in that girls produced more essays containing specific applications). However, this effect of sex was observed among both the viewers and nonviewers; thus, it does not appear to reflect a differential effect of **SQUARE ONE TV**. Similarly, a significant interaction of sex with the treatment was found for children's orientation in the enjoyment analysis; yet, this interaction was attributable to a significant drop in the nonviewer boys' scores, and so, this effect, too, does not appear to reflect a differential effect of **SQUARE ONE TV**.

In the motivation dimension, the Choices and Challenge analysis showed several marginal effects of sex, ethnicity, and SES among the data on viewers' inclination to pursue PSA C* over the other PSAs. However, these effects did not form any consistent pattern across the questions included in the Choices and Challenge analysis. While a marginal effect of ethnicity was found, in that marginally more nonminority viewers than minority viewers changed toward pursuing PSA C* over the other PSAs, this effect was not present in the complementary analysis of the viewers' choices at the posttest. Similarly, although sex exerted a marginal effect in the analysis of the viewers' choices in the posttest, it did not appear in the analysis of change. Finally, while SES exerted a marginal effect in children's choices of PSA

C* over the other PSAs, it had no significant effect on their choices of PSA C* over the arithmetic worksheet or their choices to pursue the PSA that they found most challenging. Thus, no consistent pattern of differences by sex, SES, or ethnicity was evident in this analysis, despite the fact that six of the eight Choices and Challenge analyses revealed significant effects of exposure to **SQUARE ONE TV**.

Effects of sex and SES were also observed in two of the other analyses included in the motivation dimension, but these effects were quite different from those discussed immediately above. Although, in the pretest, marginally more viewer boys than viewer girls chose to pursue PSA C* over an arithmetic worksheet, significantly more girls than boys in the viewer group changed their choice to PSA C* after being exposed to **SQUARE ONE TV**. Also, while, overall, viewers showed a greater positive change in their orientations than nonviewers did (i.e., they showed a greater tendency to become motivated through engagement with mathematics), this effect was strongest for viewers of low-SES backgrounds.

These last differences seem to be encouraging, as they indicate a greater effect of the series on girls and children of lower socioeconomic backgrounds; however, because such results were observed for only two of the analyses included here, this is by no means a consistent effect. Thus, taking the above results as a whole, it appears that **SQUARE ONE TV** exerted various significant positive effects, and that these effects did not differ in any consistent way as a function of the children's sex, ethnicity, or socioeconomic backgrounds.

Implications for Future Research

The present study carries two sets of implications for future research: one related to the study of the development of attitudes toward mathematics generally, and the other related to the study of the effects of **SQUARE ONE TV** upon those attitudes. We will consider each set of implications in turn.

The development of attitudes toward mathematics. One clear implication of the present study is that children's constructs of mathematics appear to be central to other aspects of their attitudes toward mathematics as well. Children's notion of mathematics as discrete operations appeared not only in their definitions of the subject but also in discussions of its usefulness and importance, their motivation, and their enjoyment of mathematics. Clearly, research on attitudes toward mathematics must not assume that children will define "mathematics" in the same way as researchers do. It is not sufficient to present children with pencil-and-paper scales that ask them questions about "mathematics"; rather, researchers must ensure that they also know what mathematics the children are referring to in their answers.

A second implication stems from the close relationship observed between children's motivation toward pursuing mathematics, their enjoyment of the subject, and their perceptions of its usefulness and importance. A number of children in this sample cited enjoyment of mathematics as a reason for their motivation or their perceptions of its importance. However, Armstrong and Price's (1982) research with adolescents has suggested that children's perceptions of the usefulness of mathematics are better predictors of their continued enrollment in mathematics classes than their enjoyment of mathematics is. The source of the discrepancy between Armstrong and Price's results and those of the present study (in which motivation and enjoyment appear to be closely related) is not clear; perhaps it is due to the different measures used in the two studies, or perhaps this points to a developmental difference between the adolescents studied by Armstrong and Price and the fifth graders who participated in the present study.

Indeed, given that much of the previous research on attitudes toward mathematics has been conducted with children older than those in the present study, there seems to be a great deal of room for investigation as to how attitudes toward mathematics develop over time. A possible first step might be to perform a descriptive analysis similar to the ones used here with subjects of the age studied in most of the previous literature. Once a detailed picture of older subjects' attitudes is available, an in-depth comparison might be made to the results of the present study; the similarities and differences between the two age groups would then provide an indication as to what additional age groups (older or younger than the children in the present study) would have to be studied to complete the picture and establish a richer understanding of children's attitudes toward mathematics. Clearly, longitudinal research would be of tremendous importance here as well.

The effects of **SQUARE ONE TV**. The analyses of change included in the present study indicate that **SQUARE ONE TV** had a significant impact on some aspects of viewers' attitudes but not others. In some instances, this was true even within a single dimension; in motivation, for example, exposure to the series resulted in viewers' becoming more motivated by engagement with problems but did not lead to a significant change in their magnitude scores.

These results point to various types of research that might be conducted regarding the effects of **SQUARE ONE TV** on children's attitudes toward mathematics. One type focuses on those aspects of attitude for which significant effects were found in the present study. Because subjects were tested only twice in this study (once before the beginning of the treatment period and once after the viewers had been exposed to 30 programs of the series), it is not clear whether a full 30 programs was truly required to produce the observed effects. A study in which subjects were tested several times over the course of the treatment period would be of great help in determining the amount of exposure that is necessary to have a positive impact.

Conversely, it is unclear why exposure to the series failed to have a significant impact on other aspects of the children's attitudes. It is possible that the treatment period was not long enough to produce changes in these aspects of attitude or that subtle changes did in fact exist in areas that our measures did not probe, or that, as Kulm (1980) points out, some dimensions of attitude may be easier to change than others are. Further research using longer treatment periods and/or different measures would be of great value here.

Finally, in considering the results of the present study, it must be remembered that although the viewers watched **SQUARE ONE TV** in school, their teachers were instructed not to incorporate material from the series into their lessons or even to comment on the series in any way; the results reported here reflect the product of sustained, unaided viewing by the children. Thus, it would be valuable to investigate the potential impact of exposure to **SQUARE ONE TV** when viewing is not unaided -- that is, when teachers incorporate the series into a broader context of instruction, or when parents or other caregivers elaborate upon the series in settings outside the classroom.

Whatever the results of future research, though, the message of the present study is clear: Sustained exposure to **SQUARE ONE TV** can have a significant positive impact upon children's constructs of mathematics and problem solving, and upon some aspects of their motivation toward mathematics, their enjoyment of the subject, and perhaps their perceptions of its usefulness as well.

REFERENCES

Aiken, L. R. (1970). Attitudes toward mathematics. Review of Educational Research, 40, 551-596.

Aiken, L. R. (1974). Two scales of attitude toward mathematics. Journal for Research in Mathematics Education, 5(2), 67-71.

Allport, G. W. (1935). Attitudes. In C. Murchison (Ed.), A handbook of social psychology. Worcester, MA: Clark University Press.

Armstrong, J. M., & Price, R. A. (1982). Correlates and predictors of women's mathematics participation. Journal for Research in Mathematics Education, 13, 99-109.

Carraher, T. N., Schliemann, A. D., & Carraher, D. W. (1988). Mathematical concepts in everyday life. In G. B. Saxe & M. Gearhart (Eds.), Children's mathematics: New directions for child development, 41, 71-87. San Francisco, CA: Jossey-Bass.

Carter, C. S., & Yackel, E. (1989, March). A constructivist perspective on the relationship between mathematical beliefs and emotional acts. Paper presented at the annual meeting of the American Educational Research Association, San Francisco, CA.

Cobb, P., Yackel, E., & Wood, T. (1989). Young children's emotional acts while engaged in mathematical problem solving. In D. B. McLeod & V. M. Adams (Eds.), Affect and mathematical problem solving: A new perspective (pp. 117-148). New York: Springer-Verlag.

Cohen, J. (1960). A coefficient of agreement for nominal scales. Educational and Psychological Measurement, 20, 37-46.

Comprehensive School Mathematics Program. (1989). CSMP Mathematics. Kansas City, MO: McRel.

Corsini, R. J. (Ed.). (1984). Encyclopedia of Psychology (Vol. 1). New York: Wiley.

Davis, R. B. (1984). Learning mathematics: The cognitive sciences approach to mathematics education. Norwood, NJ: Ablex.

Dweck, C. S. (1975). The role of expectations and attributions in the alleviation of learned helplessness. Journal of Personality and Social Psychology, 31, 674-685.

Dweck, C. S. (1986). Motivational processes affecting learning. American Psychologist, 41(10), 1040-1048.

Dweck, C. S. (1989). Motivation. In R. Glaser & A. Lesgold (Eds.), Foundations for a psychology of education (Vol. 1, pp. 87-137). Hillsdale, NJ: Erlbaum.

Dweck, C. S., & Elliott, E. S. (1983). Achievement motivation. In P. H. Mussen (Gen. Ed.) & E. M. Hetherington (Vol. Ed.), Handbook of child psychology Vol. 4 (pp. 643-691). New York: Wiley.

Dweck, C. S., & Henderson, V. L. (1988). Theories of intelligence: Background and measures. Unpublished paper. University of Illinois, Champaign-Urbana.

Dweck, C. S., & Licht, B. G. (1980). Learned helplessness and intellectual achievement. In M. E. P. Seligman & J. Garber (Eds.), Human helplessness: Theory and application (pp. 197-221). New York: Academic.

Dweck, C. S., & Repucci, N. D. (1973). Learned helplessness and reinforcement responsibility in children. Journal of Personality and Social Psychology, 25, 109-116.

Eccles, J. S. (1980). Self-perceptions, task perceptions and academic choice: Origins and change. (Final Report to NIE).

Fennema, E. (1989). The study of affect and mathematics: A proposed generic model for research. In D. B. McLeod & V. M. Adams (Eds.), Affect and mathematical problem solving: A new perspective (pp. 205-219). New York: Springer-Verlag.

Fennema, E., & Sherman, J. (1976). Fennema-Sherman mathematics attitudes scales: Instruments designed to measure attitudes toward the learning of mathematics by females and males. JSAS Catalogue of Selected Documents in Psychology, 6(1), 31.

Fennema, E., & Sherman, J. (1977). Sex related differences in mathematics achievement, spatial visualization and affective factors. American Educational Research Journal, 14, 51-71.

Ginsburg, H. P., & Asmussen, K. A. (1988). Hot mathematics. In G. B. Saxe & M. Gearhart (Eds.), Children's mathematics: New directions for child development, 41 (pp. 89-111). San Francisco, CA: Jossey-Bass.

Greeno, J. (1988). For the study of mathematics epistemology. In R. I. Charles & E. A. Silver (Eds.), Research agenda for mathematics education: Vol. 3. The teaching and assessing of mathematical problem solving (pp. 23-31). Hillsdale, NJ: Erlbaum, and Reston, VA: National Council of Teachers of Mathematics.

Hart, L. E. (1989). Describing the affective domain: Saying what we mean. In D. B. McLeod & V. M. Adams (Eds.), Affect and mathematical problem solving: A new perspective (pp. 37-45). New York: Springer-Verlag.

Hatano, G. (1988). Social and motivational bases for mathematical understanding. In G. B. Saxe & M. Gearhart (Eds.), Children's mathematics: New directions for child development, 41 (pp. 55-70). San Francisco, CA: Jossey-Bass.

International Association for the Evaluation of Educational Achievement. (1986). SIMS Detailed Report, United States for the Second Study of Mathematics, Second International Mathematics Study.

Kouba, V. L., & McDonald, J. L. (in press). What is mathematics to children? Journal of Mathematical Behavior.

Kulm, G. (1980). Research on mathematics attitude. In R. J. Shumway (Ed.), Research in mathematics education (pp. 356-387). Reston, VA: National Council of Teachers of Mathematics.

Lave, J., Smith, S., & Butler, M. (1988). Problem solving as an everyday practice. In R. I. Charles & E. A. Silver (Eds.), Research agenda for mathematics education: Vol. 3. The teaching and assessing of mathematical problem solving (pp. 61-81). Hillsdale, NJ: Erlbaum, and Reston, VA: National Council of Teachers of Mathematics.

Mandler, G. (1989). Affect and learning: Reflections and prospects. In D. B. McLeod & V. M. Adams (Eds.), Affect and mathematical problem solving: A new perspective (pp. 237-244). New York: Springer-Verlag.

McLeod, D. B. (1989). Beliefs, attitudes, and emotions: New views of affect in mathematics education. In D. B. McLeod & V. M. Adams (Eds.), Affect and mathematical problem solving: A new perspective (pp. 245-258). New York: Springer-Verlag.

Mielke, K. W., & Chen, M. (1983). Formative research for 3-2-1 Contact: Methods and insights. In M. J. A. Howe (Ed.), Learning from television: Psychological and educational research (pp. 31-55). London: Academic.

Miles, M. B., & Huberman, A. M. (1984). Qualitative data analysis: A sourcebook of new methods. Beverly Hills, CA: Sage.

National Council of Teachers of Mathematics. (1980). An agenda for action: Recommendations for school mathematics. Reston, VA: Author.

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

National Research Council. (1989). Everybody counts: A report to the nation on the future of mathematics education. Washington, D.C.: National Academy.

Nicholls, J., Cobb, P., Wood, T., Yackel, E., & Patashnick, M. (1990). Assessing students' theories of success in mathematics: Individual and classroom differences. Journal for Research in Mathematics Education, 21(2), 109-122.

Research Communications, Ltd. (1990). Analysis of survey of student interests. Chestnut Hill, MA: Author.

Resnick, L. (1988). Treating mathematics as an ill-structured discipline. In R. I. Charles & E. A. Silver (Eds.), Research agenda for mathematics education: Vol. 3. The teaching and assessing of mathematical problem solving (pp. 32-60). Hillsdale, NJ: Erlbaum, and Reston, VA: National Council of Teachers of Mathematics.

Reyes, L. H. (1984). Affective variables and mathematics education. Elementary School Journal, 84(5), 558-581.

Reyes, L. H., & Stanic, G. M. A. (1988). Race, sex, socioeconomic status, and mathematics. Journal for Research in Mathematics Education, 19(1), 26-43.

Rokeach, M. (1972). Beliefs, attitudes and values. San Francisco, CA: Jossey-Bass.

Romberg, T. A., & Wilson, J. W. (1969). The development of tests (NLSMA Report No. 7). Pasadena, CA: A. C. Vroman.

Saxe, R. W. (1971). What's a school for? Elementary School Journal, 72, 7-11.

Schoenfeld, A. H. (1983). Beyond the purely cognitive: Belief systems, social cognitions, and metacognitions as driving forces in intellectual performance. Cognitive Science, 7, 329-363.

Schoenfeld, A. H. (1985). Mathematical problem solving. New York: Academic Press.

Schoenfeld, A. H. (1988). Problem solving in context(s). In R. I. Charles & E. A. Silver (Eds.), Research agenda for mathematics education: Vol. 3. The teaching and assessing of mathematical problem solving (pp. 82-92). Hillsdale, NJ: Erlbaum, & Reston, VA: National Council of Teachers of Mathematics.

Shaw, M. E., & Wright, J. M. (1967). Scales for the measurement of attitudes. New York: McGraw-Hill.

Stevenson, H. W., Lee, S., Chen, C., Stigler, J. W., Hsu, C., & Kitamura, S. (1990). Contexts of Achievement. Monographs of the Society for Research in Child Development, 55(1-2, Serial No. 221).

Strauss, A. (1987). Qualitative analysis for social scientists. New York: Cambridge University Press.

Willoughby, S. S., Bereiter, K., Hilton, P., & Rubenstein, J. H. (in press). Real Math. Peru, IL: Open Court.

APPENDIX III.A:

Goals of SQUARE ONE TV

ELABORATION OF GOALS OF SQUARE ONE TV

GOAL I. To promote positive attitudes toward, and enthusiasm for, mathematics by showing:

A. Mathematics is a powerful and widely applicable tool useful to solve problems, to illustrate concepts, and to increase efficiency.

B. Mathematics is beautiful and aesthetically pleasing.

C. Mathematics can be understood, used, and even invented, by non-specialists.

GOAL II. To encourage the use and application of problem-solving processes by modeling:

A. Problem Formulation

1. Recognize and state a problem.
2. Assess the value of solving a problem.
3. Assess the possibility of solving a problem.

B. Problem Treatment

1. Recall information.
2. Estimate or approximate.
3. Measure, gather data or check resources.
4. Calculate or manipulate (mentally or physically).
5. Consider probabilities.
6. Use trial-and-error or guess-and-check.

C. Problem-Solving Heuristics

1. Represent problem: scale model, drawing, map; picture; diagram, gadget; table, chart; graph; use object, act out.
2. Transform problem: reword, clarify; simplify; find subgoals, subproblems, work backwards.
3. Look for: patterns; missing information; distinctions in kind of information (pertinent or extraneous).

4. Reapproach problem: change point of view, reevaluate assumptions; generate new hypotheses.

D. Problem Follow-up

1. Discuss reasonableness of results and precision of results.
2. Look for alternative solutions.
3. Look for alternative ways to solve.
4. Look for, or extend to, related problems.

GOAL III. To present sound mathematical content in an interesting, accessible, and meaningful manner by exploring:

A. Numbers and Counting

1. Whole numbers.
2. Numeration: role and meaning of digits in whole numbers (place value); Roman numerals; palindromes; other bases.
3. Rational numbers: interpretations of fractions as numbers, ratios, parts of a whole or of a set.
4. Decimal notation: role and meaning of digits in decimal numeration.
5. Percents: uses; link to decimals and fractions.
6. Negative numbers: uses; relation to subtraction.

B. Arithmetic of Rational Numbers

1. Basic operations: addition, subtraction, division, multiplication, exponentiation; when and how to use operations.
2. Structure: primes, factors, and multiples.
3. Number theory: modular arithmetic (including parity); Diophantine equations; Fibonacci sequence; Pascal's triangle.
4. Approximation: rounding; bounds; approximate calculation; interpolation and extrapolation; estimation.
5. Ratios: use of ratios, rates, and proportions; relation to division; golden section.

C. Measurement

1. Units: systems (English, metric, non-standard); importance of standard units.

2. Spatial: length, area, volume, perimeter, and surface area.

3. Approximate nature: exact versus approximate, i.e., counting versus measuring; calculation with approximations; margin of error; propagation of error; estimation.

4. Additivity.

D. Numerical Functions and Relations

1. Relations: order, inequalities, subset relations, additivity, infinite sets.

2. Functions: linear, quadratic, exponential; rules, patterns.

3. Equations: solution techniques (e.g., manipulation, guess-and-test); missing addend and factor; relation to construction of numbers.

4. Formulas: interpretation and evaluation; algebra as generalized arithmetic.

E. Combinatorics and Counting Techniques

1. Multiplication principle and decomposition.

2. Pigeonhole principle.

3. Systematic enumeration of cases.

F. Statistics and Probability

1. Basic quantification: counting; representation by rational numbers.

2. Derived measures: average, median, range.

3. Concepts: independence, correlation; "Law of Averages."

4. Prediction: relation to probability.

5. Data processing: collection and analysis.

6. Data presentation: graphs, charts, tables; construction and interpretation.

G. Geometry

1. Dimensionality: one, two, three, and four dimensions.

2. Rigid transformations: transformations in two and three dimensions; rotations, reflections, and translations; symmetry.

3. Tessellations: covering the plane and bounded regions; kaleidoscopes; role of symmetry; other surfaces.

4. Maps and models in scale: application of ratios.

5. **Perspective: rudiments of drawing in perspective; representation of three-dimensional objects in two dimensions.**

6. **Geometrical objects: recognition; relations among; constructions; patterns.**

7. **Topological mappings and properties: invariants.**

APPENDIX III.B:

Interview Protocol

This appendix presents the protocol used in administering the Attitude Interview in the posttest. Recall from Chapter 2 that PSA A* was also administered within the Attitude Interview; text pertaining to PSA A* can be found in Volume II, Appendix II.B.

The pretest protocol is identical to the posttest protocol except that it does not include two additional questions noted in the text.

Note that some questions are clustered together (i.e., single spaced) because they were asked as a unit.

POSTTEST
SESSION 2 - Attitude Interview

This protocol is for use in the posttest, session 2.

As you know, what we're interested in is how you think about things. So, I'll be asking you all sorts of questions about how you think and feel.

I'd like to start by talking to you about what you did yesterday. You were working with ______________________? [Let child fill in the name.]

1. Do you remember the thing with Dr. Game [PSA C*]? What did you have to do?

2. When __________________ first described it to you, did you think you could do it? How come?

3. How did you begin? How did you know to begin with that?

4. Did you realize or discover anything as you were working on it? [i.e., about what was going on with the game?]
5. Tell me about it. How did that make you feel?

6. When we finished and you left the room, how did you feel?

7. Did you think about it [PSA C*] after you left the room? What did you think?

8. Did you talk to your parents or family or anyone about it [PSA C*]? If so, to whom? What did you say?

9. How do you feel about the job you did [on PSA C*]? [Say light-heartedly.]

10. Do you think it's important to be able to figure out things like this -- the Dr. Game thing [PSA C*]? How come?

11. Would you say you learned something from it [PSA C*]? What?

12. Remember how you were thinking when you were doing this [PSA C*]? Do you think that you could use that kind of thinking in other situations? When?
    >>> In school?
    >>> Outside of school?
    <u>NOTE:</u> If homework is the response given, say "how about outside of school, not including homework?"

13. If, some time in the future, you had the chance to try another Dr. Game thing [PSA C*], would you like to?

14. Was the Dr. Game thing [PSA C*] interesting to you? How come?
15. Was it [PSA C*] fun? What made it fun?

16. Let's say that when you're in high school you have a chance to take a class that teaches you how to figure out things like the Dr. Game thing [PSA C*]. Would you like to take it?

What do you think you would learn?

17. Is that important?

18. Do you remember the other thing that you did yesterday -- with the clocks/party tables [PSA B*]? Do you think it's important to be able to figure out things like that? How come?

19. How do you feel about the job you did [on PSA B*]? [Say light-heartedly.]

20. Was the clock/party tables thing [PSA B*] interesting to you? How come?
21. Was it [PSA B*] fun? What made it fun?

22. [Re: PSA B*] Now, do you remember the optional part? The optional part was that you could make one of the three shelves/tables have exactly twice as many clocks/people as one of the other shelves/tables. Did you try it? How come?

AT THIS POINT IN THE INTERVIEW, PSA A OR PSA A' WAS ADMINISTERED. REFER TO VOLUME II, APPENDIX II.B FOR THE TEXT THAT WAS USED.

26. Did you realize or discover anything when you were doing this [PSA A*]?

27. Is being able to figure out things like this [PSA A*] important? How come?

28. Would you say that you learned something from it? What?

29. Remember how you were thinking when you were doing this [PSA A*]? Do you think that you could use that kind of thinking in other situations? When?

30. Was it [PSA A*] interesting to you? Why?/Why not?
31. Was it [PSA A*] fun? What made it fun?

32. Of the three things you have done with us -- the thing with Dr. Game [PSA C*], the clocks/ party tables [PSA B*], and the circus/stripes on shirt [PSA A*] -- which one did you like the best? Why?
33. Which would you most like to work with again? Why?
34. Which one would you say was most challenging for you? How so?

Now, I'd like to ask you some questions about things that you are curious about and like to figure out. [Put aside PSA A* manipulatives] Let's move on.

35. What kinds of things do you like to figure out?
    <u>NOTE</u>: If child mentions more than two things, ask each question below for the first two things mentioned.
36. Why do you like to figure ____________ out?
37. Is/are __________ challenging to you? How so?

38. Do you like challenging things? How come?
39. What kind of challenging things do you like?

40. Has there ever been anything that you wanted to know and figured out by yourself? Tell me about it.
41. How did you feel?

42. Have you ever tried very, very hard to figure something out and not been able to do it? Tell me about it.
43. How did you feel?

44. What do you feel is important for you to figure out [in life]?
NOTE: If child is confused, say "What kinds of things do you feel are important to figure out?"
>>>What about out of school?

[FOR THE FOLLOWING PASSAGE, SAY "HER" with GIRLS and "HIS" with BOYS.]

Now, you've told me some things that you like to figure out, plus you had the things with Dr. Game [PSA C*], the clocks/party tables [PSA B*], and the circus/stripes on shirt [PSA A*]. Then there are other things. Let's take a few examples, like if someone went into his/her room and found that all the money was gone from his/her piggybank and he/she wanted to figure out how to get it back. Or if someone was going to make decorations for a party that starts at a certain time, and wanted to figure out when he/she should start preparing. Or if someone wanted to figure out the fastest way to get to a friend's house. All of these things involve figuring out even though they're very different.

So, let's talk about figuring out for a moment.

45. What are the different steps you would take in order to figure something out?
NOTE: If child has difficulty understanding what is being asked here, try: "Can you list for me the things you usually have to do in order to figure something out?"
>>> Anything else?
46. Is there anything that people usually have to do no matter what kind of thing they're trying to figure out? What?
>>> Anything else?

Now, let's move on to something else. I'd like to talk a bit about math and then about social studies.

47. If you had to explain what math is to someone who had never heard of it, maybe someone from another planet who happens to speak English, what would you say that it is?
48. Should this person who doesn't know math learn about it? How come?

49. Can you tell me where you got your ideas about math?
50. Is what you do in math class all there is to math?

51. Is math useful to you in your life now? Why or why not?
52. Is it useful for you in your life outside of school? Why or why not?
53. Will it be useful for you in the future? Why or why not?
54. How important is math to you? How come?

55. Can you tell me about a time when you did or learned something in math that you really enjoyed?
>>> What was it?
>>> What about it did you enjoy?
56. Do you usually enjoy doing math? How come?

57. Can you tell me about a time that you realized or discovered something in math?

58. IF YES: How did that feel for you?
59. IF NO: Is there anything in math that makes you feel good?

60. Can you tell me some fun and interesting ways to use math?
61. Can you name some fun ways to use math outside of school?
    NOTE: If homework is the answer given, ask "What about fun ways to use math, not including homework?"
62. Can you tell me some fun and interesting ways that adults use math?

63. If you had a chance to work on another project with Dr. Game, or do this [show copy of division worksheet] which would you rather do? Why?
64. Which would be more of a challenge for you?

65. If you didn't study for a math test and got a 100, what would you think?
    NOTE: Probe further if child cites personal experiences.
66. If you did study a lot for a math test and failed it, what would you think?
    NOTE: Probe further if child cites personal experiences.

67. Some people say that the only thing that math is adding, subtracting, multiplying and dividing. What do you think of that?
    >>>IF CHILD DISAGREES: What else is there? What is it good for? How can you use it?

Now, I'd like to talk about social studies for a little while.

DEPENDING ON TIME, ASK AS MANY OF THE FOLLOWING SOCIAL STUDIES QUESTIONS AS POSSIBLE. THE MINIMUN YOU SHOULD ASK IS THREE.

68. If you had to explain what social studies is to someone who had never heard of it, maybe that person from another planet who happens to speak English, what would you say that it is?

69. Should this person learn about social studies? How come?

70. Can you tell me where you get your ideas about social studies?

71. If you didn't study for a social studies test and got 100, what would you think?
72. If you did study a lot for a social studies test and failed it, what would you think?

73. Can you tell about a time when you did or learned something in social studies that you really enjoyed? What was it? What about it did you enjoy?
74. Do you usually enjoy social studies? How come?

75. Can you tell me about a time when you realized or discovered something in social studies?

76. Is what you do in social studies all there is to social studies?

77. Is social studies useful in your life right now? Why or why not?
78. Is social studies useful in your life outside of school? Why?

79. Will social studies be useful in the future? Why?

80. How important is social studies to you? How come?

81. Could you help us with something else? We'd like to know what kinds of things -- like the things we did here with Dr. Game [PSA C], the clocks/party tables [PSA B*], and the shirt stripes/circus performers [PSA A*] -- that kids like best. We'd like to know what kinds of things you'd like to work on if you were given a choice. I'm going to read these statements to you [present sheet with statements]. I'd like to know which of these statements comes closest to describing the kinds of things that you would like most to work on. [Point to each statement and read aloud].

Things that are fairly easy so I'll do well.

Things that I'll learn something from, even if they're so hard that I'll make a lot of mistakes.

Things that aren't too hard, so I don't make many mistakes.

Things that are hard enough to show that I'm smart.

AFTER CHILD INDICATES A RESPONSE, ASK THE FOLLOWING QUESTION:

*82. [Point to statement child selects]: Does that one do a very good job of describing the things you most like to work on? [Probe for how or how not.]
>>> Is there anything you would like to change about this statement to make it a better description for you?

That's all the questions I have for you. Do you have any for me? Thank you very much for helping us.

* Questions marked with an asterisk were only included in the posttest protocol. Note that the statement sheet referred to in these questions is attached.

WHICH OF THESE FOUR STATEMENTS COMES CLOSEST TO DESCRIBING THE KINDS OF THINGS THAT YOU WOULD LIKE MOST TO WORK ON?

I'd like:

Things that are fairly easy so I'll do well.

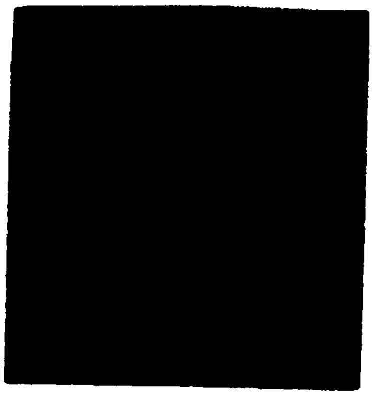
Things that I'll learn from, even if they're so hard that I'll make a lot of mistakes.

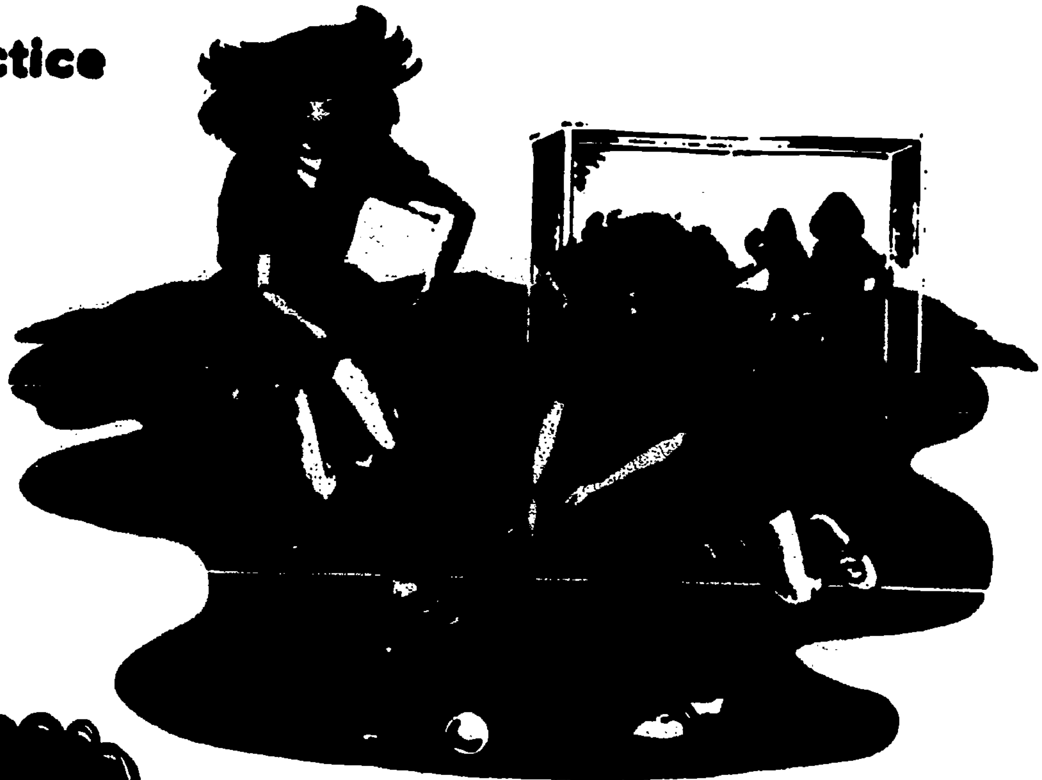
Things that aren't too hard, so I don't make many mistakes.

Things that are hard enough to show that I'm smart.

Dividing: Practice

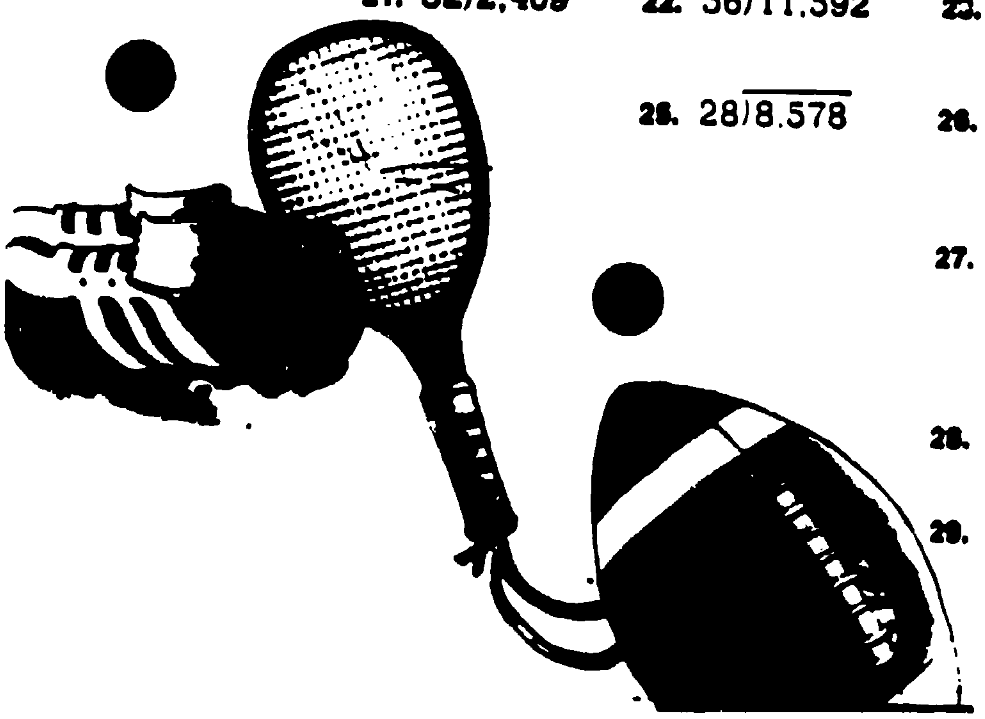
Divide and check.





1. 30)240
2. 40)252
3. 70)363
4. 51)328
5. 87)368
6. 24)132
7. 23)217
8. 55)441
9. 42)160
10. 18)432
11. 36)1,643
12. 81)4,893

13. 50)15,320
14. 26)1,846
15. 72)40,176
16. 64)6,460
17. 44)17,454
18. 93)6,375
19. 58)41,006
20. 67)59,161
21. 32)2,409
22. 56)11,592
23. 49)4,621
24. 62)10,862
25. 28)8,578
26. Find $101.68 divided by 82.
27. Find the quotient when $233.68 is divided by 46.
28. Estimate: $3,545 ÷ 73
29. Estimate: $7,188 ÷ 88



APPENDIX III.C:

Categories for Descriptive Analysis:

Construct of Mathematics

Responses to Q47 by Category

QUESTION 47: If you had to explain what math is to someone who had never heard of it, maybe someone from another planet who happens to speak English, what would you say that it is?

Distribution of Responses
Q47: N = 48

Problem Solving: 25% (12)	Discrete Operations: 75% (36)
Utility: 13% (6)	Numbers: 23% (11)
Figuring Out: 13% (6)	Basic Arithmetic: 42% (20)
	Word Problems: 10% (5)

DISCRETE OPERATIONS

NUMBERS:

Responses that emphasize that mathematics has to do with numbers, properties of numbers or activities with numbers.

Well, the way...getting numbers. Well, taking numbers that have other numbers...Hm, taking numbers and other numbers and adding numbers -- the number that multiply numbers. Dividing them.

Like it's a, it's a subject. Math they do like, they work with the numbers...I don't know more.

A subject that has to do with numbers? And problems.

Numbers that you put together. And sometimes you have to add them, put them together.

I'd say it's about a whole bunch of numbers. Whole bunch of numbers where you have to join to make one. That's what it mostly is. You gotta join all to make one number.

BASIC ARITHMETIC:

Responses that explain that mathematics is, generally, the basic arithmetic operations. These responses do not need to name all four operations.

Um, you use, you have to, you have to, you had to, you have to use numbers to find out the answer or bring down something or add something. Subtract uh...Or it's a easier way than just, just counting, you just add 'em up and you have to memo -- mem -- memorize it.

It's how to add, subtract, divide, multiply. Um...and I'd tell 'em that it's real easy. And they could learn it real fast.

That it's like when you work out problems from addition, subtraction, multiplication, and measurement...and how to add and things like that.

I'd say that math is um, math is about problems that you got to solve with addition, subtraction, multiplication, and division. And, it has to do about numbers. I'd tell him that and that's it.

WORD PROBLEMS:

> Responses in which the child explains what mathematics by referring to word problems as well as basic arithmetic. Also, responses in which a child explains mathematics by giving examples of how the basic arithmetic operations work in terms that are evocative of textbook story problems.

It's like if you had five oranges and you got and you bought another one, you would have six oranges and that's like addition. And then subtraction is like, if you had six oranges and you took one away, then you'd only have five.

Okay, I would explain we have two numbers you explain what two is. Like it's two things of something like two trashcans or something. And then you have to take two away from three trashcans. And you're zeroing out that number from the other number and you have a leftover. Or, I'd explain where add the three to the two. And you come up with five. Because you draw the lines out and you get five. And multiplying, I'd show her two trashcans times two and I'd draw another two. And it'd make four. Or stuff like that. Simple stuff and then go on to harder stuff.

Uh, I'd say math is um is a um study where you have to find out how much there is and if you take -- and if you take it away, how much there's left. That's what I think. And she wouldn't understand it. I'd probably give um give 'em an example. [R: Like what?] Uh, if I found some rocks, I'd probably have eight, and then away take four. I'd probably ask 'em, "How many are left?" and she'd say "Four." I'd go "Yeah! You learned subtraction!"

First I'd tell him if she knew like four plus six. Ask her what that was, if she knew that. And if she didn't, first I would say like, there are four apples, let's say apples...and umm...well, four apples and then, Billy had four apples and then Max came and gave her six apples and I would ask her how many, count them all up, see how many there were, and then that's the way you would find out what it'd come out to. Ten.

<u>PROBLEM SOLVING</u>

UTILITY:

> Responses in a which the child explains that mathematics is a useful enterprise by giving an example of how it can be used. These responses may discuss numbers and arithmetic as well as a use for mathematics.

It's a subject that will help you learn more if you don't know how to add or something. And, I would say that math is helpful for, for you 'cause if you're in a store and you give them more than enough money, that, and they don't give you back the change, and then you won't know and, and so that's, that's why you -- they have, your parents, or you have to count the money, the amount of money, the amount of money that, that it's supposed to be and go, and if they don't give you back your change go, "Where's my change?"

I would say math er, is about adding, multiplying and div -- subtracting and dividing. And that if you...It's, it's when, when, you, you get two numbers or more than two you, you either subtract it, add it, multiply or divide it with another number, then you get an answer. And...and that there's, there's other things besides multiplying, adding, subtracting or dividing. Like, like um math questions. Like, somebody, if somebody had to get to another house in forty minutes and she, they took the bus twenty-five minutes and walked for ten minutes, she had to figure out how many more minutes she had, they had to walk.

I'll say it's a subject that everyone um learns about. Because, math is mostly to all the subjects that I know, math is the one that really helps you 'cause science and all them, science is helpful too. They teach you about animals and everything in the future and everything, about other living things and everything, but I think math is because math is gonna help you when you need to pay bills and everything it's nee -- you need all those steps that I told you, to use. Yeah the ones are helpful too but I think just math 'cause the other ones are just reading about the past and everything, those aren't really gonna help you to pay bills and see if you have much money for the grocery store or how fast that you run or.

It's an interesting thing for you to do and, you know, um when you really grow up and you want -- you can either be a...whenever you grow up, you're gonna have to do -- use math. Whatever you do, unless it's like in writing or something. And you're going to have to do math like in almost everything that you do. Like um like if you were in alien and you had to go to school, right? You wouldn't really know how to do math. So, the teachers will teach you how to do math, and then you may not understand, and you may understand. Okay? And if you don't understand, the teacher will help you. And if you do understand, you pass. [R: Okay, and how would you use that, though? You said it's important because you use it in everything except for writing. What do you mean?] In writing, if you sell a book, you may have to use math because you have to count up how much you want. Okay, um... [R: But how is math important?] 'Cause like when you grow up you're gonna have to use it because you're gonna have to use it -- you're gonna have to know how to pay for anything. So, you may have to add. Add up.

FIGURING OUT:

> Responses in which the child explains what mathematics is by discussing how mathematics is used to figure out how to do things. These responses emphasize learning and thinking as well as mention numbers and arithmetic.

Math, I'd say, well um, my friend told me I was going to have something like that, about social studies and math, about an alien and um, but I didn't really think she was right because um, like yesterday I didn't have the same games she said we were gonna have. And I'd say math is um, is something that you figure out with numbers and you can multiply, you can add, you can subtract and you can divide and you can reduce and you can do all these things just like um, working with numbers mostly. And learning how to, how to do things that you never know before.

Well, it's about uh figuring out things and you don't know by using the multiplication, multiplic -- and division. [R: Okay, anything else?] I'll go tell him to go find the teacher.

Numbers. Um...lines. Hm, how to do things in a different way. You can do it in a different way.

Well, uh, numbers, or, uh, finding out like what, what things are or what you meas -- measure. Or, or weight or, um, I would tell her the different things about math like adding, subtracting, times, multiplication. Uh I'd tell her that there are words in word solving, in problem solving. And in things like that.

Breakdown of Subject Characteristics for Q47

CATEGORY	TOTAL	GIRLS	BOYS	MIN	NON MIN	MED SES	LOW SES
UTILITY	13%	13%	13%	12%	14%	8%	17%
	6	3	3	4	2	2	4
FIGURING OUT	13%	17%	8%	15%	7%	13%	13%
	6	4	2	5	1	3	3
NUMBERS	23%	17%	29%	26%	14%	29%	17%
	11	4	7	9	2	7	4
BASIC ARITHMETIC	42%	42%	42%	46%	36%	33%	50%
	20	10	10	15	5	8	12
WORD PROB.	10%	13%	8%	3%	29%	17%	4%
	5	3	2	1	4	4	1
TOTAL[1]	101%	102%	100%	100%	100%	100%	101%
	48	24	24	34	14	24	24

[1]Because of rounding, not all of the columns sum to 100%.

Responses to Q67 by Category

QUESTION 67: Some people say that the only thing that math is is adding, subtracting, multiplying and dividing. What do you think of that? What else is there?

Distributions of Responses[1]
Q67: N = 47

True: 19% (9)

False:

Other Areas: 57% (27)

More to it: 9% (4)

Use: 15% (7)

TRUE:

Responses in which child basically agrees that mathematics is arithmetic. While the child may express doubt, he or she finally agrees or cannot think why to disagree with the statement.

Yeah, that's probably most it is, because you -- if you had to get things, you'd have to add to see how many things there were. You, so -- that's probably the only thing.

That it's true.

That's right.

I feel like saying no, but I feel like saying yes, too. Well, math -- let's just say yes. I'll just say yes. I dunno. Yes. I'm thinking -- I'm trying to think of something -- of why it just isn't divide, multiply, subtract and multiply. It's...hard to think! It's hard to -- I don't think -- I think -- I think that's basically what it is. It's basically...

I think they're right because that's all you do in math is multiply and divide and subtract and do fractions and all of that.

FALSE:

OTHER CONTENT AREAS:

Responses in which the child disagrees with the statement because there are other content areas that he or she can name that are also mathematics and are not arithmetic. These children tend to list the other content areas that are not arithmetic.

[1]The total number of discrete operations responses is the sum of all categories but Use, i.e., 85%.

No, that's not all it is because there's like word problems, and place value, and all that kinda stuff. And that's fun too. Hm, you don't really need to use 'em.

No. No, that, no there's a bunch m -- there's a whole lot more things. Like all the fractions, all um words that, um, oh, what do you call it, the sentences of, that, that you, you use words to, to do it and there's a whole, and um, um, alber-ab-abra-what's, can't think of it, I can't. [R: Yeah, algebra?] Yeah algebra. And there's, yeah that, there's a whole more things than just adding, multiplying and dividing and subtracting. [R: Okay what good is, what is the other stuff good for do you think?] Uh, well, I don't know right now.

No. It when some -- geometry and, I think, biology. [R: Okay. What is it good for?] Different things like -- if you wanna separate things -- sometimes you can divide. Into groups.

No. Because there's more, more things to do. It's not just adding, subtracting, dividing, multiplying. And there's, there's, there's a lot of more things to do. [R: Okay, like what?] Reducing fractions. And...and...that's all that I could think of.

No. I don't think that's true. Because there's a lot more um stuff in math that you have to learn, other than just adding, subtracting, multiplying, and dividing. There's a lot more stuff you have to learn. [R: What good is the other stuff?] Uh, for adults, that really helps 'em sometimes. Uh, like say um you're an adult and you didn't go to college, and you wanna take a math course, you'd -- and um it's a college course, math. Um, you'd really have to know all of that stuff from high school. 'cause if you go to college, you can't just know adding, subtracting, dividing and multiplying. [R: What else is there?] Um, algebra, I guess. Isn't that sort of kind of math? Algebra and other subjects.

MORE TO IT:

Responses that disagree with the statement because there is more, either in content or in the value of mathematics, to the subject than "just" arithmetic.

Well I think it's partly right and partly wrong. 'Cause you do all those things, except it's not just that. You um, it's the way um they teach you and you learn things and um, and it's um -- and um and you can, you can make it as a game and, and it's o -- it's other things than just doing that, it's learning things for yourself and knowing how to do it when you grow up and, and it's partly right because um you do do all those things and you do more and um, and that's all hardly you ev-ever do except other things. You do more like, like you normally just do all those basic things, you, you have to learn geometry and all those things and um, and you can be more like, you can make it as a game or you can just work it out and spend real hard time not liking it that much.

No. There's more things to math. There's like fraction um equivalent fractions and, and...yeah, that, sometimes it could be, it could be just that, adding multiplying and dividing and subtracting. Sometimes it could be that and, most of the time it'll be that but then sometimes it'll be like fractions or problem solving. [R: What is it good for?] You can go and learn more about math instead of just learning some other things. You could go on and learn more and more things instead of just learning, just one part of it, you can learn the whole thing.

I think that's um, wrong. 'Cause math is not just adding subtracting multiplying dividing, it's it's a lot of things, it's, it's fractions it's um, um, all this other stuff like um, fractions and um, it's fun, and um...Some, some subjects are fun. Some -- Yeah, some parts of math are fun, not all of them. Not the routine stuff but the new, the new concepts. It's good for in the real world and it's good um for your mind, your brain. You use uh, you get a lot of stuff in there so you can remember your stuff.

I don't agree with them. Well, because it is a whole lot more than adding and subtracting. It part of your knowledge. It's well, you gotta know math. You gotta learn it. It's not -- it's not just -- learn it -- it's not just adding and subtracting and multiplying. Or dividing. Well, you have to learn it. They're saying that it's just -- that it's just something they gotta know. It's more than what you gotta know. You gotta know it. You gotta know it real good.

USE:

Responses in which the child disagrees with the statement that mathematics is arithmetic and mentions how mathematics is used as part of a rationale for disagreeing with the statement.

Um, it is that also plus you get to learn a lot of new games in math and a lot of different stuff like fractions and stuff. It's not just adding, multiplying, dividing, and subtracting. It's like fractions and estimating, a lot of numbers put together. Um, estimating. You could like, for estimating you could, say you're going to have your party and you um, you can invite just your family and you don't know how much is going to come so you esti -- you figure out how much is in every family that you've invited and you estimate and try to get a bigger number than that so that in case they bring some friends you have enough.

Well, most of math is, but you have to do like measuring and that, you have to do different stuff. You have to measure stuff and you have to, sometimes you have to do problem solving and that. You have to read the questions and that to find -- and then you, you have to read questions and that to find our the answer and stuff. Well, they have, you have to, they tell you like if somebody went to the store and bought something and you paid with a five dollars and how much change would you have? You have to read the whole question to figure out. [R: Okay and what is that stuff good for?] Well it, you could measure how tall you were and how much you weighed and that. Well it improves your reading and that sometime -- it'll improve your reading a little bit and it'll help you to solve the puzzles and -- not puzzles, but it'll help you solve math problems and that. 'Cause if you don't read the thing you could get it wrong 'cause it could say add or subtract, that's why you have to read it.

I don't. Fractions, like and, some you have to divide. Help you so you'll know how -- how to divide. Area -- the area of something. Somebody moves -- comes to their house and...how to build it -- how much space you can use. Um -- peri -- uh, I can't pronounce it! I can't pronounce the letters. Like if you need to know the perim -- the promi. [R: You got it! Perimeter.] Of a house. You'll know.

Hn hn. Problem solving. It's the whole math class. Like um there are -- let's see -- there are eight hundred and fifty cans of soup. [Ben] sold fifty. How many does he have left. Like that. [R: Is there anything else?] Fractions. Equivalent fractions. Uh, perimeter. Area. [R: Okay, and um, what is that stuff good for?] Well, like if you were trying to measure the outside of a football field, like let's say, right here is the -- football field. The stadium and -- here's the field. And they didn't -- they were just building it and it didn't have any of the lines ...and since it didn't have any of those lines, you would have to measure a hundred yards. Yeah, about ten -- one yard and usually a yard sticks about yard. So just measure one yard and...It might take a long while, but I don't know how they manage.

Breakdown of Subject Characteristics for Q67

CATEGORY	TOTAL	GIRLS	BOYS	MIN	NON MIN	MED SES	LOW SES
TRUE	19% 9	22% 5	17% 4	15% 5	29% 4	21% 5	17% 4
FALSE- MORE TO IT	9% 4	9% 2	8% 2	9% 3	7% 1	17% 4	0% 0
FALSE- ADDL AREA	57% 27	61% 14	54% 13	61% 20	50% 7	46% 11	70% 16
FALSE- USE	15% 7	9% 2	21% 5	15% 5	14% 2	17% 4	13% 3
TOTAL[1]	100% 47	101% 23	100% 24	100% 33	100% 14	101% 24	100% 23

[1]Because of rounding, not all of the columns sum to 100%.

Responses to Q49 by Category

QUESTION 49: Can you tell me where you got your ideas about math?

Distributions of Responses[1]
Q:49: N = 46

Self: 20% (9) Family: 37% (17)

School Only: 37% (17) Use: 4% (2)

Non-Responses: 2% (1)

SCHOOL ONLY

Responses in which school, teachers, mathematics class or textbooks are the only source of ideas about mathematics mentioned by the child.

My math teacher.

In -- in my class.

Kindergarten?...Kindergarten.

Um, my math class. Um, my math book. And that's it.

From school. They always try to tell you you need to know this. They're always tryin' to tell you, "You need to listen, and you need to know this because later in your life, you're gonna have to use it."

In school. Just school. Teacher tells us everyday.

FAMILY

Responses that indicate that mathematics is learned at home, usually from a family member such as parents, grandparents or siblings. Most of these responses also mention school as a source as well.

In math class. [And] um, well my Mom's real good in math and when she helped me -- when she helps me with my homework I ask her some other hard questions that aren't even on my homework.

Mostly from school. [And] Mm, my, my Dad. Mm, he know, he knows a lot of math, he does math real good and he's, he's always, he's always like, in every subject we have, he don't like us see erase a lot and uh, and he wan -- he wants us to do good and um, and he's always, he's

[1] The total number of responses that mention a school source alone (i.e., "School Only") or in addition to another source is 83% (38).

always putting a, a math problem when we talk. During dinner or something here and there and we have to guess and.

Um, my Dad. My Dad is good, real good at math and so I just, I like ma -- I um, he started teaching me these multiplications. I, I, from my teacher she taught me too and then this is like, I like math better than any subject. [And] my sister. My sis -- 'cause my sister, she's in a higher grade than me and my Dad taught her first and she sometimes teaches me some good things that I don't know yet. So when I get to that, that age or something I'll know it already. Um she's, she's twelve and a half. [R: So she's in, like sixth grade?] Seventh.

School. [And] well, my mom, she helped me a lot. Very much, 'cause we came from South America, that's where I was born. She had to teach me English and all that. So she ended up teaching me a lot.

SELF

> Responses in which a child describes the source of his or her ideas about mathematics to be "myself," "my brain," "my mind" or other descriptions attributing knowledge to the child him- or herself. These responses may also include a school source.

From my brain cells? [R: Do they come from anywhere around or are they inside your head to start with, or -- ?] No, they come from somewhere around. Because you have to learn it first before you know it.

Mmm...I just started thinking about them, in my head. To tell you about a, a per -- the person that didn't know how to do math.

I just thought of them. I just thought them.

From my mind, my teacher. [And] my mom.

I guess my brain! (Laughs)

USE

> Responses that explicitly indicate that the practice or doing of mathematics is a source of knowledge about mathematics. School may also be mentioned as a source.

From my math class [and] just when I go to the store. Like if I buy a candy or something. And then in my head, I subtract and then when they always get my change, I always count it.

Hm, from doing it. [R: From doing it? Okay, in school?] Yeah [and] well, sometimes when I buy something, and they say it's this much money, sometimes I try to figure out that it was-- there are two prices and try to figure out how much it costs. See if they're right.

NON-RESPONSES

Well, ...no. Mm mm.

Breakdown of Subject Characteristics for Q49

CATEGORY	TOTAL	GIRLS	BOYS	MIN	NON MIN	MED SES	LOW SES
SELF	20% 9	29% 7	9% 2	24% 8	8% 1	13% 3	26% 6
FAMILY	37% 17	33% 8	41% 9	33% 11	46% 6	44% 10	30% 7
SCHOOL	37% 17	38% 9	36% 8	36% 12	39% 5	35% 8	39% 9
USE	4% 2	0% 0	9% 2	3% 1	8% 1	4% 1	4% 1
DK	2% 1	0% 0	5% 1	3% 1	0% 0	4% 1	0% 0
TOTAL[1]	100% 46	100% 24	100% 22	99% 33	101% 13	100% 23	99% 23

[1]Because of rounding, not all of the columns sum to 100%

Responses to Q50 by Category

QUESTION 50: Is what you do in math class all there is to math?

Distributions of Responses
Q50: N = 45

Future school: 33% (15) Agree: 26% (12)

Use: 15% (7) Uncertain/Don't Know: 24% (11)

Non responses: 2% (1)

AGREE

Responses that present simple, unelaborated agreement with the statement that mathematics class is all there is to mathematics.

I think so.

Mmmm, yeah.

Yes.

Sort of. No? Well, yeah. I guess that all math is because -- constantly teaching and teaching and teaching, that's really all math is.

Well, alls we do is math, but, yeah. Yeah.

USE

Responses in which the child disagrees with the proposition that mathematics class presents all there is to mathematics and then describes an application for the use of mathematics outside school.

Mmmm, no. Well you, you have to do formulas and that stuff, you have to do how wide and how long stuff are. You have to measure stuff.

No. Like, if you have to go somewhere, you need to know how to add or like if you're to have a party, you need to know how much food and everything for a person.

(Shakes head "No") If you're gonna buy something like how much. You can like get -- get [change] back.

[R: Is there anything else to math besides what you do in math class?] Uh, yes. There's reading, you have to read in order to find out problems and, there's a little bit of social studies like um, how much water is in the climate or. Or, or -- that's part of math I think.

No. Well, like when you go to the store and you wanna pay in check, he/she doesn't know how to write you know like, like twenty-five dollars (doesn't know) twenty then twenty-five. Like that.

FUTURE SCHOOL

> Responses in which the child may agree or disagree with the proposition but note that there is more within the curriculum for them to learn particularly in the future.

Mmm, no. Well, sort of. Well there's, we-well what we do is, we reduce, we have, we're on reduced I think now and um, there's also geometry and all those other things that we, what we have to learn before we go out. And um, let's see, but um the basic things we already know. Most of 'em for our age.

Hn hn. 'Cause there's more harder stuff in different grades. That's all I can think of.

No. There is stuff they haven't taught us yet. That we'll learn when we're bigger.

No. Geometry. We don't -- we don't do that. We don't know -- plus, minus, we don't do that -- we just do multiplication, division. We don't do no algebra. [R: Yeah? How do you know about algebra? From your brother?] Nah, my -- my tia -- she does algebra in that college. Geometry and math and all that -- she really into it. She really is.

...No, there could be a lot of things, like, I'm only in the fifth grade, there's got to be a lot of stuff more. In college and high school and junior high.

UNCERTAIN/DON'T KNOW

> Responses in which the child seems to be ambivalent about agreeing or disagreeing with the statement and either says that they don't know or try to figure out whether or not there is or should be more to mathematics than what they are taught in school.

[R: Are there other things that like are what math is that you don't know you do in school?] Hm, yeah. Well... (Pause: 10 sec.) Well, there's lots of things you have to do in life. There's probably a lot more than they teach you in school.

No. I don't know.

No there's probably more. Like in this grade or in like what? [R: In general, I mean wherever. You said that there probably is more to math, like what, do you have any ideas about what ...e there would be?] Nn nn, but there's probably more...Because to me there's probably more ... n what we're learning. I just feel.

...I don't know. I guess, yeah. I don't know if that's all it is. [R: Okay. Do you think that's all there is?] Mm hm. Because when you go to your math class, they just teach you the same thing over and over. And they never teach you nothing new. [R: uh huh. If they taught you something new what would you think?] Um that that isn't all there is to math.

I'm not too sure about that.

NON-RESPONSES

No. Well, we'd talk about a whole bunch of stuff like what went on like what's going on in the world. Sometimes -- sometimes we do that before math class starts.

Breakdown of Subject Characteristics for Q50

CATEGORY	TOTAL	GIRLS	BOYS	MIN	NON MIN	MED SES	LOW SES
FUTURE SCHOOL	33% 15	31% 7	33% 8	24% 8	54% 7	46% 10	21% 5
AGREE	26% 12	36% 8	17% 4	30% 10	15% 2	23% 5	29% 7
USE	15% 7	9% 2	21% 5	21% 7	0% 0	14% 3	17% 4
UNCERTAIN/ DON'T KNOW	24% 11	23% 5	25% 6	24% 8	23% 3	14% 3	33% 8
NR	2% 1	0% 0	4% 1	0% 0	8% 1	5% 1	0% 0
TOTAL[1]	100% 46	100% 22	100% 24	99% 33	100% 13	102% 22	100% 24

[1]Because of rounding, not all of the columns sum to 100%.

Responses to Q45 by Category

QUESTION 45: What are the different steps you would take in order to figure something out? Can you list for me the things you usually have to do in order to figure something out?

Distribution of Responses
Q45: N = 46

Contextualized: 39% (18)

Non-Responses: 2.2% (1)

Generalized Processes: 59% (27)

One-Step Thinking: 15% (7)

Multi-Step Thinking: 44% (20)

CONTEXTUALIZED PROBLEM SITUATIONS

Responses in which the child gives an example of how he or she would figure something out.

Well, if I was making the party decorations, I would think like, well, it might take me like ten minutes to make the party hats, and then another twenty minutes to make the -- to hang up the streamers and then another fifteen minutes to blow up all the balloons and hang 'em up. And then I just add 'em all up and if -- if it comes up to like and hour, say, an hour -- I'd start about an hour and twenty minutes before the party. So if I mess up, I'll still have a little bit of time.

Mmm, well, um, you know the um, the first question you, you, you said for an example, um, uh what was it? [R: The piggy bank?] Yeah. Well um, I went to my um house and I have a, a rabbit, it's a piggy bank. And I have, I have money in it and I was gonna buy something. I figured out that it was gone! And then um, so, I, I thought, I thought about, are you sure you put it in here? And I looked all over my room, and I looked even in my sister's, figure I'd see if she had it. And she didn't, she just had hers. And so then I thought about it, and I go, who could've taken it? And then go, I go, ask my Mom and Dad. And I we -- I went, and then um, and then I went and asked them. And sure enough my Dad had taken it, he needed, he was gonna do something on it. I don't know what it was. I forgot. And um, I'd, I'd think it over first, if I had put it there or not. And then I'd look in, look in my sister's 'cause she usually takes my money. And then I, and then I um, and then I'd think about who, who o -- other people who would've needed it or something. And, and I, and I give, then I go ask people, like in my, around my house or if my aunts are over my house, then, then one of 'em has to have it.

I'd trace my steps and go where I've gone to check and see if it's there or something. Like if I put it inside my pocket, and I would retrace my steps to see if like it fell out.

Um...well, first you try to -- try to like maybe -- if you're doing something like -- how fast you could get somewhere? Like one way or the other. You could maybe time yourself. Or, maybe think about it, think about the distance. Or maybe who didn't like you that would steal your money. Or they left anything like fingerprints. Something like that.

Um...I'd um -- like if I was reading a mystery book, I look around at the peoples who were last in my room, and um, I look at their face real closely and if they be like um, you know, they don't want to say nothin'? Then I'd probably know that he's the one that um stole the money from the piggy bank. [R: What about in general? I mean, are there steps that you'd um usually have to do or steps that you usually have to take no matter what kind of thing you're trying to figure out?] Well, I can't think of any steps right now. No. Or, like I just said, I wouldn't use any steps. I'd just look at the faces.

GENERALIZED PROBLEM-SOLVING PROCESSES

ONE-STEP THINKING:

Responses in which the child presents one general heuristic or a state of thought as his or her process of figuring something out.

Clues.

Think?...Talk to someone about it. That's it.

Look for clues. Fingerprints.

You mean what I'll think, what I'll do first? First you, you would think...You would think about what you're supposed to figure out. That's what I would think first, I would think that what you're supposed to do. What you would all would think about what I'm um figuring out. Like if I was figuring out how to get a faster way to my friends house, I would figure out, here's my house and there's her house, let me see, I'm gonna figure out what the fastest way is. Um, I'll think about it first. Think about what I'm gonna, what I'm figuring out. And then I'll...I don't know really.

Well, you have to know facts about it.

MULTI-STEP THINKING:

Responses in which children present two or more different general heuristics or steps in their process of figuring something out. These children may also give a concrete example of problem solving.

Well first, first I like, I'd think how, how it could've been done or you know lost or something. How, how can, how it was, where it could be or how it was, how it was, how it is like made or -- how it could've been done. Well first I'd figure out how it'd be done and then I'd, I'd try to find out and then I'd just try to look around for clues or and ask questions. And, and, and see what would've happened or think would've what would've happened.

Well, there's all kind of things you can figure out. You think a lot. You have to think a lot. And think a lot, and um, you kinda look at something. You look at things a lot and stuff. Well I guess it has to be more specific, to know how to -- you have to have it -- you have to give me examples so I can tell you or something. 'Cause there's lots of different things that you can figure out.

You would check all the clues or something that would lead to it. And then you would think about 'em and the way they could go to a person or thing or the reason why it happened. Like if you find a like -- if someone took something from your bank and you found a little scrap of clothes, and you go, well, this is so and so's. And then you lead over there. And you find a reason why they want to do that. You ask questions a lot. You ask a lot of questions.

I guess I'd just think of one thing. Think about it for a while. And then I would try to think of it's right or wrong. Like um...just think of something to try to solve it. And try to see if that would solve it or if it won't solve it if I could think of another. [R: So then what would you do (if it was wrong)?] Think of another one.

Well, you gotta figure out what you're trying to figure out first. And then you gotta um... then you kinda look around. And then you kinda gaze at what you're trying to do, and imagine it. And them um...like, like if you ['re going -- you try to figure out the shortest way to a friend's house -- uh, take one way, and then take the other and time yourself. And walk the same speed. And then see how long it takes.

NON-RESPONSES

I can't remember.

Breakdown of Subject Characteristics for Q45

CATEGORY	TOTAL	GIRLS	BOYS	MIN	NON MIN	MED SES	LOW SES
CONTEXT	39% 18	30% 7	48% 11	41% 13	36% 5	42% 10	36% 8
ONE-STEP THINKING	15% 7	22% 5	9% 2	19% 6	7% 1	8% 2	23% 5
MULTI-STEP THINKING	44% 20	44% 10	44% 10	38% 12	57% 8	50% 12	36% 8
NR	2% 1	4% 1	0% 0	3% 1	0% 0	0% 0	5% 1
TOTAL[1]	100% 46	100% 23	101% 23	101% 32	100% 14	100% 24	100% 22

[1]Because of rounding, not all of the columns sum to 100%.

Responses to Q11 & Q16 by Category

QUESTION 11: Would you say you learned something from it? [PSA C] What?

QUESTION 16: Let's say when you're in high school you take a class that teaches you how to figure out things like the Dr. Game thing [PSA C*]. Would you like to take it? What do you think you would learn?

Distributions of Responses
Q11: N = 47; Q16: N = 47
TOTAL N = 94

Problem Solving: 20% (19)
Q11: 8.5% (4) Q16: 32% (15)

Fixing: 13% (12)
Q11: 8.5% (4) Q16: 17.0% (8)

Thinking: 28% (26)
Q11: 32% (15) Q16: 23% (11)

Games: 11% (10)
Q11: 9% (4) Q16: 13% (6)

Computation/Numbers: 7% (7)
Q11: 9% (4) Q16: 6% (3)

Non-Responses: 21% (20)
Q11: 34% (16) Q16: 9% (4)

PROBLEM SOLVING

Responses in which a child describes what s/he learned or could learn from PSA C* by using the words "problem solving," "solving," or "figuring out," or by describing a solution process.

Q11: I learned how to solve the problem and just learned how to...I just knew how -- how to solve it.

Q11: To umm, well first I have, have to have your mind open about it, just think about it. And you have to kind of like, look real sharply at it you know, see if anything's wrong.

Q11: How to solve things. Well...Well I learned um, I learned about taking time and doing stuff and if you take time you can think about what you're going to be saying and what you're going to be doing.

Q16: I'd be glad to. More about solving things. A better way to figure them out.

Q16: Um, intelligence? Like um you really learn by doin' something like -- like goin' -- like goin' back and figuring out problems and solving mysteries and everything.

Q16: We would probably learn, you know, like, things like uh...You know, just...Probably learn, you know, like, a way to solve problems and things? Like um just...like...some of -- if you had a problem or something, or similar to something in that class, you could probably -- it might people solve it or something.

FIXING

Responses in which the child describes that s/he learned or could learn to fix something or associate learning with building or assembling things.

Q11: Like um, um, just fixing it, like fixing it so, like I just said. And then I learned um, uh, that's about it, so I wouldn't say I did a lot of it, I didn't learn a lot, just one thing. That to, so when get big and I have to fix a car and stuff I just, I just do it myself. Fix a flat tire.

Q16: I'd learn bettcr ways how to fix things and like once you think you found it, maybe there might be something else wrong, and that class will probably teach you about it. Stuff like that.

Q16: How to put things together.

Q16: Uh, I'd learn about the -- how to fix things -- lotta interesting things.

THINKING

Responses that indicate that the child could learn (or did not learn) through thinking or found the experience to be personally enhancing.

Q11: How to um, how to make decision and um, um, and um, I learned, I can't um, I learned that it, it was fun and, and, that after a while I didn't have to be that nervous 'cause um there was nothing that, nothing that I should be nervous about that much.

Q11: Well, just like us, like I said um, help me in the future if somebody asked me to do something for them. I already know 'cause, I'll just know what I need at the end like if you need to go home and concentrate. I know what to get and everything and I know what will be helpful for me and this is a time that I get to, what do you call it, um, this is a good time that, I get a chance to figure out something.

Q11: To take my time and think about things hard.

Q16: I would probably learn how to take care of situations better than before. Like, the stuff that he/she had me to do.

GAMES

Responses in which the child describes that s/he learned or could learn something about the game, usually how to play or to fix it.

Q11: That there's not only one kind of um cube dice.

Q11: How to play the game and how to fix it.

Q16: 'cause um, I would learn more games? And...maybe I could own a store of games so that and then I would know how to play it, and I would be able to tell them. And...that's it.

Q16: How to put games together. [R: Yeah, yeah? You think that would be important?] Yes. Because if somebody asked me how to, as -- asked me how to teach them how to play a game, I would know how to teach them. Because I'll have experience before.

Q16: You don't learn that much. It's just that you learn how to play games and it's fun.

COMPUTATION/NUMBERS

Responses in which the child states that s/he learned, or reviewed (or could learn or review), arithmetic or number learning through the PSA C* situation.

Q11: ...How to multiply a little bit more and, and add or if it had subtract, subtract a little bit more.

Q11: That um how to put numbers in the right order. And um that's all!

Q11: Well, I learned -- I learned a new game. And the -- I learned some mathematics. Well, actually, I knew the mathematics but just to get them refreshed in my brain. Like um when the spinnings and then like if the coin was on times, the two numbers you have to multiply.

Q16: Probably. [R: What do you think you would learn?] ...Nothing. Well, I, I would probably know it all by the stuff that you had to do in it and that already -- like if you had to subtract or multiply or times and that. Like I said before, it would be fun and that. And it would give me something to do.

Q16: Um, more multiplication. And to figure out um, to figure out things that are wrong in Dr. Game [PSA C*]. Um, and, I guess that's all.

NON-RESPONSES

Responses in which the child either responds negatively with no other response or said that they didn't know what they did or could learn from PSA C*.

Q11: (Shakes head)

Q11: Hm...Hn hn...(Shakes head) Not very much. Well, it was...uh naw.

Q11: ...No.

Q11: Mmm, mmm, I don't, I don't think so.

Q11: No, not really. It's just a game.

Breakdown of Subject Characteristics for Q11

CATEGORY	TOT	GIRLS	BOYS	MIN	NON MIN	MED SES	LOW SES
P-S	9% 4	8% 2	9% 2	9% 3	7% 1	13% 3	4% 1
FIXING	9% 4	4% 1	13% 3	12% 4	0% 0	4% 1	13% 3
THINKING	32% 15	46% 11	17% 4	27% 9	43% 6	42% 10	22% 5
GAMES	9% 4	4% 1	13% 3	9% 3	7% 1	4% 1	13% 3
COMP/#S	9% 4	8% 2	9% 2	9% 3	7% 1	4% 1	13% 3
NR	34% 16	29% 7	39% 9	33% 11	36% 5	33% 8	35% 8
TOTAL	102% 47	103% 24	100% 23	99% 33	99% 14	100% 24	99% 23

Breakdown of Subject Characteristics for Q16

CATEGORY	TOT	GIRLS	BOYS	MIN	NON MIN	MED SES	LOW SES
P-S	32% 15	38% 9	26% 6	27% 9	43% 6	39% 9	25% 6
FIXING	17% 8	17% 4	17% 4	21% 7	7% 1	4% 1	29% 7
THINKING	23% 11	25% 6	22% 5	18% 6	36% 5	30% 7	17% 4
COMP/#S	6% 3	8% 2	4% 1	9% 3	0% 0	9% 2	4% 1
GAMES	13% 6	13% 3	13% 3	18% 6	0% 0	9% 2	17% 4
NR	9% 4	0% 0	17% 4	6% 2	14% 2	9% 2	8% 2
TOTAL	100% 47	101% 24	99% 23	100% 33	99% 14	100% 23	100% 24

APPENDIX III.D:

Codebook: Construct of Mathematics

INTRODUCTION

The purpose of this codebook is threefold: to define construct of mathematics; to explain the coding procedures for the Categories of Mathematics and Problem Solving Analysis, and to explain the procedures for coding according to Goal III of SQUARE ONE TV. More information relating to the conceptualization of these analysis schemes, which are used to assess change due to exposure to SQUARE ONE TV can be found in Chapter 3.

I. DEFINITION

This section defines construct of mathematics, provides a brief description of the two analyses that will be discussed in this codebook, and presents the questions in the interview that have been designated for construct of mathematics.

A. Definition of Construct of Mathematics

A construct of mathematics is one's conception of what mathematics is: what it consists of, what it is good for, what one does with it.

In assessing the children's constructs of mathematics, we needed to evaluate their ability to discuss problem solving as well as their ability to discuss mathematics (since children did not typically integrate the two).

B. The Construct of Mathematics Analyses

We developed two different ways of assessing change in children's constructs of mathematics.

First, we analyzed the children's statements relating to mathematics and problem solving by examining the relative sophistication of their responses. This is called the Categories of Mathematics and Problem Solving Analysis.

Our second analysis consisted of categorizing the children's statements about mathematics and problem solving by using Goal III of SQUARE ONE TV which lists the mathematical topics that are presented on the series. The Goal III Analysis assesses the range and frequency of the mathematical topics that the children mention.

The remainder of the codebook will present these analysis schemes in greater detail.

C. Index of Questions Designated for Construct

The following is the list of questions designated for construct of mathematics, identified by the three domains of mathematical inquiry:

PSA DOMAIN

11. Would you say you learned something from it? [PSA C*] What?

12. Remember how you were thinking when you were doing this? Do you think that you could use that kind of thinking in other situations? [PSA C*] When? In school? Outside of school? Outside of school not including homework?

16. Let's say when you're in high school you take a class that teaches you how to figure out things like the Dr. Game thing would you like to take it? What do think you would learn?

18. Do you remember the other thing that you did yesterday -- with the clocks/party tables? Do you think it's important to be able to figure out things like this? [PSA B*] How come?

27. Is being able to figure out things like this important? How come?

28. Would you say you learned something from it? What?

29. Remember how you were thinking when you were doing this? Do you think that you could use that kind of thinking in other situations? [PSA A*] When? In school? Outside of school?

FIGURING OUT DOMAIN

35. What kinds of things do you like to figure out?

36. Why do you like to figure out [the activities mentioned in response to Q35]?

38. Do you like challenging things? How come?

39. What kind of challenging things do you like?

40. Has there ever been anything that you wanted to know and figured out by yourself? What? Tell me about it.

42. Have you ever tried very, very hard to figure something out and not been able to do it? Tell me about it.

44. What do you feel is important for you to figure out? What kinds of things do you feel are important to figure out? What about out of school?

45. What are the different steps you would take in order to figure something out? Can you list for me the things you usually have to do in order to figure something out?

46. Is there anything that people usually have to do no matter what kind of thing they're trying to figure out? What? Anything else?

MATHEMATICS DOMAIN

47. If you had to explain what math is to someone who had never heard of it, maybe someone from another planet who happens to speak English, what would you say that it is?

48. Should this person who doesn't know math learn about it? How come?

49. Can you tell where you got your ideas about math?

50. Is what you do in math class all there is to math?

51. Is math useful to you in your life now? Why?

52. Is math useful for you in your life outside of school? Why?

53. Will it be useful for you in the future? Why?

55. Can you tell me about a time when you did something in math that you really enjoyed? What was it? What about it did you enjoy?

60. Can you tell me some fun and interesting ways to use math?

61. Can you name some fun and interesting ways to use math outside of school? What about fun ways to use math not including homework?

62. Can you tell me some fun and interesting ways adults use math?

67. Some people say that the only thing that math is is adding, subtracting, multiplying, and dividing. What do you think of that? What else is there? What is it good for? How can you use it?

II. CODING FOR CATEGORIES OF MATHEMATICS AND PROBLEM SOLVING

This section presents step-by-step procedures for the Categories coding.

A. Overview of Categories Coding Scheme

Coding for Categories of Mathematics and Problem Solving involves an analysis of the statements that children make about mathematics and/or problem solving to determine the relative sophistication of the children's responses. Responses relating to mathematics can be categorized as "non-mathematics," "basic," or "advanced." Problem solving responses are categorized as "generic," "computation," "practical," and "sophisticated." Each of these will be defined very briefly below.

Mathematics Categories

"Non-mathematics" responses are those in which the statement that a child gives does not give an example of mathematics or problem solving.

"Basic" responses are those in which the child mentions the word "math" with no further elaboration or mentions the basic arithmetic operations, fractions, numbers, counting and the relationships between numbers (i.e., order relations).

"Advanced" responses give examples of more advanced content areas of mathematics such as measurement, geometry, graphs or combinatorics.

Problem-Solving Categories

"Generic" problem solving refers to the use of the terms "problem solving" or "figuring out" with no further elaboration. Fragments of problem solving as well as references to puzzles or games without further elaboration are categorized here also.

"Computation" refers to problem solving that uses basic arithmetic to get answers.

"Practical" responses give examples of fixing or figuring out when the child is referring to practical, concrete problem situations.

"Sophisticated" responses present examples of situations that would involve abstract thinking or complicated, logical processes in their solution.

B. Coding Procedures

This subsection presents the step-by-step procedures for coding responses for Categories of Mathematics and Problem Solving.

Review of Codesheets

The codesheet (a portion of which is depicted below) provides space for the coder to record all information that is relevant to the analysis. (An example of a completed codesheet is presented at the end of this section.)

Q	NR/NA	NON	BASIC	ADVANCED		PS-GEN	PS-COMP	PS-PRACT	PS-SOPH
11				✓				✓	
12									✓
16			✓						

- o The question number is noted in the first column ("Q") to the far left.
- o The "NR/NA" column provides a space to record whether the response is non-responsive ("NR") or was not asked ("NA").
- o The "Non" column is used to note if a response is non-mathematical.
- o The "Basic" column is for mathematics responses that are categorized as "basic."
- o The "Advanced" column is used to indicate "advanced" mathematics responses.
- o The "PS-Gen" column is used for "generic" problem-solving responses.
- o The "PS-Comp" column is for "computation" problem-solving responses.
- o The "PS-Soph" column provides a space to record "sophisticated" problem-solving responses.
- o The narrow column toward the left of the "Basic" column is provided to record when a child uses the term "math" if the term has not been used in a question posed by the interviewer.
- o Similarly, the narrow column to the left of the "PS-Gen" column is provided to record mentions of "figuring out" and "problem solving" when they have not been used by the interviewer in a question to the child.[1]

Coding Procedures

In general, coding requires that each response be categorized as to the type of mathematics and/or problem solving, if any, that is mentioned. The steps involved are presented below. The reader is advised to read this entire codebook before attempting to code.

[1] The information from the narrow columns was used for the descriptive analyses and not for the analysis of change.

1) Print out from the database all responses to the designated construct questions for each child.

2) Beginning with the data from one child, read the child's response to the first question, Question 11. The first coding decision will depend on the following:

a) If the question was not asked, write "NA" in the "NR/NA" column.

b) If the child responds by saying that she or he does not know or gives an unintelligible response or merely gives a "yes" or "no" response, then write "NR" in the "NR/NA" column.

c) If the child responds to the question with some other response, then the coder needs to determine whether the response is non-math or mentions mathematics or problem solving. This will be explained below.

3) The first step in categorizing a response involves deciding whether it is non-math or is either mathematics or problem solving. Asking the questions below will help the coder make the correct choice.

a) Is there mathematics evident in or underlying the child's response? If so, then the response will be coded in one of the two mathematics categories.

b) Whether or not there is underlying mathematics involved in the response, is the child describing something -- or a part of something -- that would require a systematic or logical process of reasoning to solve? If so, then the response will be coded in one of the four problem solving categories.

c) If the answer is "no" to both (a) and (b) immediately above, then place a check mark in the "non-math" column.

Note that a response can be coded <u>both</u> for mathematics and problem solving. If it is coded as "non-math," it will be <u>neither</u> mathematics nor problem solving.

4) If the response to (3a) above was affirmative, then the response should be coded for one of the two mathematics categories, "basic" or "advanced" (and the appropriate column should be marked):

a) "Basic" pertains to mentions of the word "math" with no further elaboration (if the interviewer's question did not use the word "math"); references to counting, arithmetic, fractions, numbers or figures themselves (e.g., number recognition), putting numbers in sequences (e.g., from low to high), making combinations; transactions involving money including paying taxes or bills.

b) "Advanced" mathematics would consist of explicit mention or an example of measurement, geometry (including shapes, angles, spacial relations), combinatorics, algebra, estimation, probability and statistics, graphs, maps, models and use of computers.

5) If the response to (3b) above was affirmative, then the response should be coded for one of the four problem-solving categories, "generic," "computation," "practical," or "sophisticated" (and the appropriate column should be marked):

a) "Generic" refers to mentions of "problem solving" or "figuring out" with no further elaboration (if the interviewer's question did not contain the term); fragments of a problem solving process (e.g., "looking for clues" or "investigating"); puzzles, brain teasers or other games that are not placed in a context other than school or recreation.

b) "Computation" involves explicit mentions of problem solving in which basic computation is used to get answers or to figure out problems.

c) "Practical" responses discuss or mention examples of fixing, figuring out or problem solving when the problem to be solved is a practical, concrete ("hands-on") situation.

d) "Sophisticated" responses discuss or mention examples of problems that, were one to attempt solution, would require abstract thinking and the use of logical problem solving processes.

6) If the child mentions "math," "problem solving," or "figuring out" when those terms are not in the interviewer's question, then "N," "PS," or "FO" should be recorded in the narrow columns on the codesheet that are designated for these responses.

7) Repeat this procedure for each of the remaining responses to the construct questions.

C. Categories of Mathematics and Problem Solving Codesheet

SUBJECT: 1 CODER: E

Q	NR/NA	NON		BASIC	ADVANCED		PS-GEN	PS-COMP	PS-PRACT	PS-SOPH
11						PS	✓			
12							✓			
16							✓			
18				✓				✓		
27				✓						
28				✓						
29	NR									
35			M	✓						✓
36	NA									
38		✓								
39	NR									
40	NR									
42	NR									
44	NR									
45	NR									
46	NR									
47				✓						
48				✓				✓		
49	NR									
50						PS		✓		
51				✓				✓		
52	[51]									
53				✓				✓		
55				✓						
60				✓				✓		
61				✓				✓		
62				✓						
67	NA									

D. Special Coding Guidelines

Certain rules have been developed to make coding decisions more simple so as to maintain consistency of coding. These rules are explained below.

Identifying Codable Responses

o Given that a large number of questions designated for construct will also be coded for other dimensions of attitude, many responses to these questions will be "non-responsive" or "non-math."

o Reference to "figuring out" per se does not mean that the child is giving a codable problem solving response. In the example below, the child's use of the "figuring out" relates to the difficulty of the task, not to a description of problem solving:

> "No...Because sometime -- they're hard and you can't figure out what's wrong." [Q38]

o References to "organizing" or "arranging" when numbers or other numeric principles are not mentioned or implicit (e.g., relating to the sorting in PSA B* or A*) should be considered "non-math."

o If a child says that she or he had already responded to the question (e.g., "like I said before"), then this response is considered "non-responsive."

o If a child refers to "working things out" without any particular context, the response should be coded as "non-math."

Identifying Types of Mathematics

o Mentions of ordering and "twice as many" are coded as "basic."

o If a child gives an example of computational problem solving (e.g., "If I have to divide a cake into pieces..."), it is coded as "basic" mathematics.

o Comparing prices is considered to be inequalities and is designated as "advanced."

o "Figuring out" a worksheet is "basic" despite the child's use of the term "figuring out."

Identifying Types of Problem Solving

o Unelaborated mentions of number tricks and "clues" or "codes" should be considered "generic."

o If a child discusses working someplace and describes heuristics ("checking," "getting information," etc.) or mathematics that he or she might use, this is considered "practical."

o If a child describes "working things out" in the context of PSA C*, this is considered "practical."

o Scientific inventions or experiments are "sophisticated."

Other Guidelines

o While a response can be coded both for mathematics and problem solving, only one kind of mathematics and problem solving can be selected within each. The highest level response should be selected for coding. Thus, if a child mentions arithmetic and geometry in a response, the response should be considered "advanced" only. It should not be double-coded as "basic" and "advanced."

o Questions 51-53 and 60-62 each form a sequence. The first question simply asks the child for a use for mathematics. The second asks specifically for a use outside of school and the third for a use in the future. If a child, for example, responded to the first question with a use outside of school, then the interviewer would skip the second question in the sequence. This also held true for future responses "spontaneously" given by a child.

When the question was previously answered by a preceding response, place the number of the question where the response was given in parentheses in the "NR/NA" column. Like so:

	NR/NA	NON	BASIC
51			✓
52	[51]		

E. Examples of Coded Responses

This section presents examples of coded responses for easy reference.

Non-responses

Q27: Is being able to figure out things like this important?
S: I don't think so.

Q28: Would you say that you learned something from this?
S: I don't think so.

Q38: Do you like to do challenging things?
S: No...Um, sometimes...Um because some things I feel lazy and don't feel like doing things.

Q55: Can you tell me about a time when you did or learned something in math that you really enjoyed?
S: No, I can't remember anything.

Non-mathematics Responses

Q44: What do you feel is important to figure out?
S: Things that the teacher says in school...Like on different -- different subjects you have to figure out what the teacher is saying. If you can't then you have to ask the teacher. [R: Outside of school?] How to get away from bullies.

Q40: Has there ever been anything that you wanted to know and you figured it out by yourself?
S: Yeah...Uh um, when uh when uh like people -- if you wanna know people talking about you and then you're talking to your friend, and then you say their name, and then you know that they're talking about you.

Basic Mathematics Responses

Q12: Could you use the kind of thinking [PSA C*]...for something in school?
S: I think so...Like when you...like in math...

Q40: Has there ever been anything that you wanted to know and you figured it out by yourself?
S: ...Problems. Um, in math.

Q48: Should this person -- do you think this person [the alien] should learn -- who doesn't know anything about math -- should he learn about it? ...
S: So, if he buys something at the store, it's less than five dollars and he gives five dollars and they don't give change, he'll have to know.

Q47: If you had to explain what math is to someone who had never heard of it, maybe someone from another planet who happens to speak English, what would you say that it is?
S: You use numbers and you multiply by other things to find out answers.

Advanced Mathematics Responses

Q55: Um, can you tell me about a time when you did or learned something in math that you really enjoyed?
S: ...Symmetry.

Q58: What are the different steps you would take in order to figure something out?
S: ...You estimate like how long you can take to dress up and do all the things you have to do, and estimate how long it's going to take you to get there and then...

Q47: If you had to explain what math is to someone who had never heard of it, maybe someone from another planet who happens to speak English, what would you say that it is?
S: ...Well, you have to do a lot of adding and subtracting and multiplying and dividing. With the numbers and um...once you know how to do all of that, then you get into the harder part. It's um...um...like algebra or something.

Q67: Some people say that the only thing that math is is adding, subtracting, multiplying and dividing. What do you think of that?
S: That's not the only things. Perimeter and measurements and graphic and, and number lines and word problems and there's lots.

Generic Problem Solving Responses

Q35: What kinds of things do you like to figure out?
S: ...Riddles.

Q45: What are the different steps you would take in order to figure something out?
S: Clues.

Computational Problem Solving Responses

Q47: If you had to explain what math is to somebody who had never heard of it...what would you say that it is?
S: Like, like um math questions. Like, somebody, if somebody had to get to another house in forty minutes and he, they took the bus twenty-five minutes and walked for ten minutes, he had to figure out how many more minutes he had, they had to walk.

Q47: If you had to explain what math is to somebody who had never heard of it...what would you say that it is?
S: It's like if you had five oranges and you got and you bought another one, you would have six oranges and that's like addition. And then subtraction is like if you had six oranges and you took one away then you'd only have five.

Q35: What kinds of things do you like to figure out?
S: Hm, word problems.

Q48: ...Should this person who doesn't know math learn about it?
S: Yeah...Because, like, say that other person goes to the store, and he has ten dollars, and he buys something for, eight dollars and fifty cents. They could just give him like a dollar back.

Practical Problem Solving Responses

Q67: Some people say that the only thing that math is is adding, subtracting, multiplying, and dividing. What do you think of that?
S: Like perimeter. Like I already told you like perimeter and all that? You need to know that in order to build things.

Q67: Some people say that the only thing that math is, is adding, subtracting, multiplying, and dividing. What do you think of that?
S: ...Area -- the area of something...Somebody moves -- comes to their house and...how to build it -- how much space you can use.

Q11: Would you say that you learned something from it [PSA C*]?
S: ...I learned, I learned a lot of stuff from it...Like um, um, just fixing it, like fixing it so, like I just said...That to, so when I get big and I have to fix a car and stuff I just, I just do it myself.

Sophisticated Problem Solving Responses

Q16: Let's say that when you're in high school you have a chance to take a class that teaches you how to figure out things like the Dr. Game thing [PSA C*]. Would you like to take it?
S: (Nods)...Because if -- if I were um wanted to be a policeman, I would know how to figure out things.

Q35: What kinds of things do you like to figure out?
S: Mysteries...Not that scary -- that kind of stuff. Like those Encyclopedia Brown's mysteries? Those kind of mysteries.

Q16: Uh, let's say that when you're in high school you have a chance to take a class that teaches you how to figure out things like the Dr. Game thing [PSA C*]. Would you like to take it?
S: I'd learn how to, how to um, how to know that, how to they'd teach me how to um pretend I can't get the words out...How to make decisions, how to, how to um, how to, I can't...How to um find out what's wrong with things by yourself and um and being in like your own mystery and all...Like um, the um, you have a mystery to solve and, and like, and you, you're supposed to solve it and it, and it's um, and then, and then after the end you solve it and you feel real good cause you solved a mystery and you were the one who, who solved it instead of somebody in a book.

Q16: When you're in high school you have a chance to take a class that teaches you how to figure out things like the Dr. Game thing [PSA C*]. Would you like to take it?
S: ...when I grow up if I was a scientist or somebody, and I could make games like that...[which is why] you have to find out what's wrong with them.

III. GOAL III ANALYSIS

The purpose of this section is to present step-by-step procedures for the Goal III Analysis of the construct of mathematics questions in the interview as well as the Essay.

A. Overview of Goal III Analysis

The Goal III Analysis is designed to identify the specific content areas of mathematics that the children mention in response to the construct of mathematics questions. This analysis gives us a more detailed report of the topics that the children mention as composing the realm of mathematics.

B. Coding Procedures

This subsection presents the step-by-step coding procedures for doing the Goal III Analysis.

Review of the Codesheet

The codesheet is Goal III itself. Coding is done by placing a tally mark next to the appropriate mathematical content area. The coder should be familiar with the codesheet, i.e., Goal III, before beginning to code.

Coding Procedures

Coding for Goal III is very straightforward. When working with the interviews, the Goal III coding can be done simultaneously with the Categories Analysis.

1) Begin with the same printout of responses to the construct of mathematics questions that was used for the Categories Analysis.

2) For each explicit reference to mathematics content, a tally should be placed next to the description of that content on the Goal III Codesheet. The Goal III Codesheet is identical to the elaboration of Goal III presented in Appendix III.A. (Note that it is also the same as the Annotated Goal III content list, presented in section III.C of this codebook, minus the bracketed annotations.) Every reference should be coded.

3) Continue to tally the content areas until all responses have been considered.

C. Special Coding Guidelines

This subsection presents an annotated list of the Goal III content areas to assist the coder in making coding decisions.

Annotated Goal III Content List

The annotations to the content list are presented in brackets next to the Goal III content areas.

A. Numbers and Counting
1. Whole numbers. [include number recognition and counting]
2. Numerations: role and meaning of digits in whole numbers (place value); Roman numerals; palindromes; other bases.
3. Rational numbers: interpretations of fractions as numbers, ratios, parts of a whole or set. [anything relating to fractions but not ratios]
4. Decimal notation: role and meaning of digits in decimal numeration. [any reference to decimals]
5. Percents: uses; link to decimals and fractions. [any reference to percents]
6. Negative numbers: uses; relation to subtraction.

B. Arithmetic of Rational Numbers
1. Basic operations: addition, subtraction, division, multiplication, exponentiation; when and how to use operations. [also includes computational problem solving]
2. Structure: primes, factors, and multiples. [includes "twice as many" and references to odd or even numbers]
3. Number theory: modular arithmetic (including parity); Diophantine equations; Fibonacci sequence; Pascal's triangle.
4. Approximation: rounding; bounds; approximate calculation; interpolation and extrapolation; estimation.
5. Ratios: use of ratios, rates, and proportions; relation to division; golden section. [any reference to ratios]

C. Measurement
1. Units: systems (English, metric, non-standard); importance of standard units. [any reference to measurement or to units of measurement]
2. Spatial: length, area, volume, perimeter, and surface area.
3. Approximate nature: exact versus approximate, i.e., counting versus measuring; calculation with approximations; margin of error; propagation of error; estimation. [estimation only in reference to measurement, otherwise it's B.4. above]
4. Additivity.

D. Numerical Functions and Relations
1. Relations: order, inequalities, subset relations, additivity, infinite sets. [number lines and comparing prices are considered to be infinite sets and inequalities, respectively]
2. Functions: linear, quadratic, exponential; rules, patterns.
3. Equations: solution techniques (e.g., manipulation, guess-and-test); missing addend and factor; relation to construction of numbers.
4. Formulas: interpretation and evaluation; algebra as generalized arithmetic. [references to algebra]

E. <u>Combinatorics and Counting Techniques</u> [if child mentions arranging or organizing without any reference to exhausting the possibilities, etc., it is tallied here as 0.]

1. Multiplication principle and decomposition. [if child mentions multiplying in reference to solving PSA B* or A*, as a way of determining the maximum number of possible combinations]
2. Pigeonhole principle. [if child mentions one-to-one correspondence between two sets of items]
3. Systematic enumeration of cases. [if child mentions using some systematic procedure for solving a problem (usually PSA B* or A*) with ordering]
4. References to arranging or organizing without reference to multiplying or exhausting possibilities.[2]

F. <u>Probability and Statistics</u>

1. Basic quantification: counting; representation by rational numbers. [counting per se should be coded as A.1.]
2. Derived measures: average, median, range.
3. Concepts: independence, correlation; "Law of Averages."
4. Prediction: relation to probability.
5. Data processing: collection and analysis. [references to use of computers]
6. Data presentation: graphs, charts, tables; construction and interpretation. [references to graphs, etc. are included here]

G. <u>Geometry</u> [mentions of "geometry" or "trigonometry"]

1. Dimensionality: one, two, three, and four dimensions.
2. Rigid transformations: transformations in two and three dimensions; rotations, reflections, and translations; symmetry.
3. Tessellations: covering the plane and bounded regions; kaleidoscopes; role of symmetry; other surfaces.
4. Maps and models in scale: application of ratios. [any reference to maps or models]
5. Perspective: rudiments of drawing in perspective; representation of three-dimensional objects in two dimensions.
6. Geometrical objects: recognitions; relations among; constructions; patterns. [references to shapes or parts of geometrical objects such as the radius; references to making a number line]
7. Topological mappings and properties: invariants.

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[2]This subcategory was developed to capture responses made by the children regarding PSA B* and A*.

APPENDIX III.E:

Categories for Descriptive Analysis:

Usefulness and Importance

Responses to Q48 & Q54 by Category

QUESTION 48: Should this person ["someone from another planet"] who doesn't know math learn about it? How come?

QUESTION 54: How important is math to you? How come?

Distributions of Responses[1]
Q48: N = 47; Q54: N = 45
TOTAL N = 92

Use:[2] 65% (60) Q48: 74% (35) Q54: 56% (25)	Learn: 28% (23) Q48: 21% (10) Q54: 36% (16)
Money/Store: 29% (27) Q48: 45% (21) Q54: 13% (6)	General: 9% (8) Q48: 11% (5) Q54: 7% (3)
Other: 5% (5) Q48: 11% (5) Q54: 0	School: 12% (10) Q48: 11% (5) Q54: 13% (6)
Future: 19% (17) Q48: 19% (9) Q54: 18% (8)	Fun: 8% (7) Q48: 0 Q54: 16% (7)
General: 12% (11) Q48: 0 Q54: 24% (11)	Non-Responses: 7% (6) Q48: 4% (2) Q54: 9% (4)

USE

MONEY/STORE:

Responses in which the child gives the example of money transactions as the use for mathematics that makes it important to him/her.

Q48: 'Cause, 'cause you have to like, write checks and add things at the store and stuff...Yeah well, like you have to add your, your, your mileage and stuff on your car.

Q48: It will be helpful to him or her, if she was in a store and she didn't know how much money she had, she'd just give him that amount -- and she would -- she left right after she paid him. And she was -- he wasn't able to give her the money, the change back.

Q48: 'Cause if she came to live here um, she's got to know how to use it in his life...Like learn if she goes to buy groceries, uh...or if she wants to figure out how much stuff would be, together.

[1] 16% of all responses (15/92) were negative: four in "Learn: Fun," eight in "Learn: General," and three in "Non-Responses."

[2] Across all Use categories, 45% of the responses (41/92) mention money or selling.

Q48: So like if he, if they have like a store to go shopping he could know what to get and like if there's a, there's like small lemons, ten for a dollar and then the big lemons are twenty for a dollar, he shouldn't get the small lemons because he just wants the little bit, he should get the big ones to save up.

Q54: 'Cause you need to um like I said, count money and stuff...You just need to know about it. [R: But now -- you've learned now how to count money, right? I mean, you know how to do that part. Well, why do you have to keep taking it? S: Hm... [R: Why do you think?] S: Because there's -- there's some thing that you haven't learned yet. [R: Hm hm.] S: And you still need to figure out what those things are.

Q54: 'Cause like I said, I, you need to know math 'cause you won't, you won't have to um, you won't lose money and stuff and you got to know math or, or you won't, you won't give the right amount of money.

OTHER:

Responses in which the children only mention uses other than money transactions.

Q48: Because she probably might use it...Like in health, how many um cups of water should you drink and you know stuff like that.

Q48: Well, because if they um learn about the -- the -- if they wanna go from a like from, let's say, Mars to Pluto, if they wanna know the distance, they'll have to look on one of the space maps and look down where it says how many inches are...is the distance...And so they'll have to measure it. Here, they'll see a one, two, three, four...And if it's it -- they look down there and they say, "Hm, let's guess that about..." Let's say it was about five centimeters -- and they say that's a inch...So, they'll look for the word "inch" and they'll find -- find out that it's not that much.

Q48: Well, you like -- if you have -- a row of students -- you're gonna have to count how many -- like, if you have students -- you're gonna have to count how many, like if you go on a field trip, you have to know how manny to take and then how many you have to come back...So, you don't leave somebody there.

Q48: Um, she might um um one of these days when she goes to her own planet and uh finds -- she has five space ships, and three were taken, um, she wouldn't know how many space ships would be left.

FUTURE:

Responses which explicitly discuss the importance of mathematics to the child's future.

Q48: Because, um, say she wants to be a lawyer, like I do. Um, she could, say, mmm, like there's a number of people in a room and you have to get every one of those witnesses up onto the stand in a certain amount of time you could estimate stuff...Say like she gets married and she has to go to the grocery store for her husband and let's say seven ounces of tomatoes a $1.59 and over here says a pound of tomatoes a $1.49. It'd be better just to get, if you like use your head you could get the pound instead of the seven ounces 'cause it's more and it's cheaper.

Q48: 'Cause when, when they grow up they, you get, you might not know what, or like, ...they might have to subtract or time or times and they don't, they don't know about it if they're not going to be able to do it.

Q48: Well, if...well, um, if he -- if they're gonna let him to go to work or something, just 'cause he's from another planet [Laughs] I think he should know how to do math because he needs to -- he -- if he's gonna live, he needs to have money or something, so he has to have a job so he has to know math. I mean, lots of jobs have to do with math...Like if you're a bookkeeper, not that kind of bookkeeper, but in HEB [the local food store chain] they have bookkeepers and my grandmother's a bookkeeper...Some of the top kind of jobs have to do with math and stuff...Like the real fancy jobs and stuff that you have, like...the real high jobs, where you get paid a whole bunch of money! [Laughs]...Like being um...president or something like that...Real high.

Q54: Because it helps me grow up because um -- I'm not sure now!...Helps me learn more about division and all that...Because it helps me learn how to calculate things in the future, like, maybe if I wanted -- work in a store or something.

Q54: Um, it's very important. A lot because it's gonna be very useful when I get a job. And they're gonna give me lots of paperwork...And I'm gonna use math when I'm doing the paperwork, like they give me. And money, and I have to pay some on the rent, and I have to pay the bills and then I would get the money I get, I'd just subtract all that money from the car and bills, from the, from the money I get and then I'll be able to pay the car. Everything.

GENERAL:

Responses in which a child describes the usefulness in general terms, without specific examples.

Q54: Not really important now!...But I am in top group...Because I really don't use it that much right now.

Q54: Um, about the least [important] it'll be in my life...Um, like the lowest. I har -- I hardly ever use it out of school.

Q54: Yes, 'cause I go to the store sometimes and then no because I don't go to the store that often and at home, I don't really have use for math. Outside, I don't really have use for math, either.

Q54: It's very important because it helps me during the to -- during the day.

Q54: It's like if uh it was one of my belongings -- that it was very important to me...It's real important...I love it...It's like one of my favorite subjects. That's the part only I like school. Math and art...I dunno, I just -- it's like a -- like a feeling I got...That, one of these days I'm really gonna need it.

LEARN

GENERAL:

Responses that indicate that mathematics is important to learn.

Q48: 'Cause if they come back to Earth again [Laugh] then, then they're gonna have to know it a lot or they're gonna be stuck in the hole...'cause like if somebody asks, ask some math problem or something 'cause they don't know, know it totally, [I mean 'cause] say I don't know. I mean it'd be kind of silly to say I don't know. I'm not from here and stuff.

Q48: 'Cause when she um comes to earth or something, she's gonna have to learn it because she's not gonna know what to do. She's gonna have to get a job. She's gonna have to know to do everything...Like she's got -- she's gotta have a (college degree) or something. [R: And why would she need to learn math? For that?] Because, if you want to be a cash register person, you'd have to know math because you have to press all these buttons. And make change.

Q48: 'Cause, there's lots of things here that you have to learn and that use numbers and all that kind of stuff.

Q54: Because of things in the, the people want you to do things that you read a number they need to know that -- if you don't know nothing of it -- it's gonna be like -- It's gonna be hard to learn it when you're older.

Q54: Because math is more to learn and you learn more things...Like there's more things to learn in math than everything else probably...In math you could just learn more things like how to figure out things and an easier way to do some things. And easy ways.

SCHOOL:

Responses in which the child indicates that mathematics is important to learn for reasons relating to school.

Q48: Yes so they'll know about, so they don't have to um, like just in case somebody goes ask him what math is, they'll know about it and they'll, they might be smart at, they might be smart um if they learn math and some people can get smart. And join things about math like, a mathematics club, whoever gets the highest multipli -- um, if you multiply and whoever gets the num -- highest number, he could join that and they could win for instance a thousand dollars or something...So that he'll learn about dividing, multiplying, subtracting and adding so they'll learn more about it.

Q48: Yes, I think she'd use it every day [if she lived on Earth]...Like in word problems.

Q54: It's important because, it's gonna help me in high school and it's gonna give me an education.

Q54: ...All yo -- all you gotta do is just add up all the numbers that they give you and the just take test and all that...But usually I know all the answers so I don't think it's important.

FUN:

Responses that indicate that the child finds mathematics important (or not important) to the degree that s/he enjoys learning it.

Q54: I don't really like math to tell you the truth but...Mmm well 'cause it's hard, all that division and everything, those steps and everything and (Sigh), you know it's a mostly subject that is really hard for me and, and everything. Other subjects too but, that's one enormous subjects 'cause you are really have to put your mind to it like stories and everything thay ask you, and you have to multiply or do division and everything. It's a really hard thinking that what do you have to do, what step you have to do and.

Q54: Hm, not very much. I don't -- I don't really like it...Um, I don't get very good grades in it...

Q54: Real important...Because it's my favorite subject and um I really like doin' it!...'cause um the way the teacher -- the way she makes it is fun as it could be for us to just to learn it...Like, we have games with long division, in rows, and rows versus rows. It's real fun.

Q54: Well, I don't really think it's important but...Because mmm, 'cause it's not fun...You could be play -- um -- like playing my Nintendo instead of doing math in school or something.

Q54: Really important...It's my most favorite subject...It's just interesting...Because, like we were learning today where you can change and um um improper fraction into a proper fraction...And you change one number to a totally different number...And you can -- it's just weird the way you have two numbers and it could be a ten or something. Could be another number.

NON-RESPONSES

Q48: Well, they probably still wouldn't need to know, 'cause they probably wouldn't get to be -- have a job -- they'd probably be um like do experiments on 'em.

Q48: Maybe, I donno.

Q54: Because...Because it...

Q54: It's a little important, not so much. Because there might be other things I have to think about and I can't just think about math. I might have to think about like social studies or something.

Q54: Not really important, not too important.

Breakdown of Subject Characteristics for Q48

CATEGORY	TOTAL	GIRLS	BOYS	MIN	NON MIN	MED SES	LOW SES
USE-$/STORE	45% 21	44% 10	46% 11	49% 16	36% 5	38% 9	52% 12
USE-OTHER	11% 5	13% 3	8% 2	9% 3	14% 2	13% 3	9% 2
USE-FUTURE	19% 9	22% 5	17% 4	18% 6	21% 3	25% 6	13% 3
USE-GENERAL	0% 0	0% 0	0% 0	0% 0	0% 0	0% 0	0% 0
LEARN GENERAL	11% 5	4% 1	17% 4	12% 4	7% 1	8% 2	13% 3
LEARN SCHOOL	11% 5	17% 4	4% 1	9% 3	14% 2	13% 3	9% 2
SCHOOL FUN	0% 0	0% 0	0% 0	0% 0	0% 0	0% 0	0% 0
NR	4% 2	0% 0	8% 2	3% 1	7% 1	4% 1	4% 1
TOTAL[1]	101% 47	100% 23	100% 24	100% 33	99% 14	101% 24	100% 23

[1]Because of rounding, not all of the columns sum to 100%.

Breakdown of Subject Characteristics for Q54

CATEGORY	TOTAL	GIRLS	BOYS	MIN	NON MIN	MED SES	LOW SES
USE-$/STORE	13% 6	18% 4	9% 2	13% 4	15% 2	22% 5	5% 1
USE-OTHER	0% 0	0% 0	0% 0	0% 0	0% 0	0% 0	0% 0
USE-FUTURE	18% 8	18% 4	17% 4	22% 7	8% 1	9% 2	27% 6
USE-GENERAL	24% 11	14% 3	35% 8	19% 6	39% 5	30% 7	18% 4
LEARN GENERAL	7% 3	9% 2	4% 1	9% 3	0% 0	4% 1	9% 2
LEARN-SCHOOL	13% 6	14% 3	13% 3	19% 6	0% 0	4% 1	23% 5
SCHOOL-FUN	16% 7	14% 3	17% 4	6% 2	39% 5	22% 5	9% 2
NR	9% 4	14% 3	4% 1	13% 4	0% 0	9% 2	9% 2
TOTAL[1]	100% 45	101% 22	99% 23	101% 32	101% 13	100% 23	100% 22

[1]Because of rounding, not all of the columns sum to 100%.

Responses to Q10 & Q17 by Category

QUESTION 10: Do you think it's important to be able to figure out things like this [PSA C*]? How come?

QUESTION 17: Let's say in high schcol you have the chance to take a class that teaches you how to figure out things like the Dr. Game [PSA C*] thing. Would you like to take it? What do you think you would learn?] Is that important?

Distributions of Responses[1]
Q10: N = 47; Q17: N = 34
TOTAL N = 81

Future: 19% (15) Q10: 23% (11) Q17: 12% (4)	Learn: 44% (36) Q10: 45% (21) Q17: 44% (15)
Helping: 9% (7) Q10: 9% (4) Q17: 9% (3)	General: 33% (27) Q10: 28% (13) Q17: 41% (14)
Game: 16% (13) Q10: 21% (10) Q17: 9% (3)	Intrinsic Value: 11% (9) Q10: 17% (8) Q17: 3% (1)

Non-Responses: 11% (9)
Q10: 2% (1) Q17: 24% (8)

FUTURE

Responses in which the child describes the importance of figuring out PSA C* in terms of his/her future life.

Q10: Because when you're older you might have things like this, like in college and stuff.

Q10: Well, the reason why I think that it is because um I don't know what I'm gonna be -- um be when I grow up and when I find out like if I was gonna be a policeman um I'll have to probably have go to uhm do stuff like that...Well, like if there's a um I had a robbery at my house once and ah they almost stole some of my sister's stuff and but some stuff was broke and I -- and I'll have to try and figure out how to um fix it and what was wrong with it.

Q10: 'Cause, a, like when I grown big I could probably be a detective -- could find mys --wrong with things -- and they could hire me to see if anything's wrong.

Q10: Because later in life we're gonna have to start figuring out stuff like that if you're going to become a teacher, in teaching you gotta know stuff like math.

Q17: Well, because then if you -- that way you can learn more and then you can -- you could have a better um change -- have a better education...That way -- that way when um later when

[1] 7% of all responses (6/81) were negative: one in "Future," three in "Learn: General" and two in "Non-Responses."

you grow up and they might hire you to fix games...That way you can know.

Q17: Because um later on in your life you may want to be a detective...And you -- and you gonna have solve problems and stuff. Cases.

GAME

> Responses that indicated that the child felt that the importance of PSA C* had to do with learning about or playing a game; often involves the importance of knowing how to play or make the game right.

Q10: Because of -- of -- when you go to the store and you might buy a game and you're gonna have to -- or you can look at it -- but you might think you have to figure out if it's missing pieces or something...And then that way you could take it back to the store.

Q10: You can play the game right and there would be nothing wrong with it.

Q10: 'Cause if anything was really wrong you could check like you did with the Dr. Game [PSA C*]...Um like if anything, like if you bought a game, you could check and see if anything is wrong with it.

Q17: Hm...to make games?...Yeah, because if somebody ever get me a game that -- that make -- tell me to try to find -- find out what was wrong with it, I'd show them.

Q17: Well, yeah so like if you get a different game than you could look in that same place if it has that same place, in a different game.

HELPING

> Responses indicating that the child found the importance of PSA C* to relate to an ability to help others.

Q10: It can, it can be helpful because some of em, some kids that have new games, they don't know how to figure it out, so they have to read the directions and if they, they don't know how to read, they'll have to, and their Mom or Dad ain't there to read it and they have an older sister or brother they could and -- if one of them ain't there, it could, it can be, they can just make it and they, they should make the small kids a toys or games um, already done 'cause if there parents ain't there they have to go somewhere...To help the little kids that have games, something like that and they don't know how to do it. It's, it can be already done for them.

Q10: Because you need to find out something else more important than -- you just -- it might be helpful to other people...It would be important 'cause if like someone needed you to find out something that was important, if you couldn't figure it out, it wouldn't be very much help...But if you could, it could help them...Because if people need help, then it's -- they really need, then I think it's important.

Q10: Because you could help somebody who has a broken game.

Q17: So you can help other people that are in danger.

Q17: Yeah, it's important to uh for other people's life to know what -- what's happening and alla that stuff...Like uh -- like if they don't know a problem or something, they come and ask you, and it's really important to them, and you solve it just like -- part of your life.

LEARN

GENERAL:

Responses in which the child indicates that the importance of PSA C* has to do with the value of learning.

Q10: Because you could learn more.

Q10: Because um, to remember your multiplication, and your addition and to try to figure out like um clues, um, I don't know...Like you could, when you're working through it you could figure out stuff like um, you could figure out that something's wrong. Like if you have to try to see what was wrong and then you could see while you're doing it that it, there's someting might be wrong with it.

Q10: Because it's just like tryin' to figure out how a computer could work. And if you didn't know how it worked, you wouldn't be able to use it, or a car -- and you didn't know how it worked, you wouldn't be able to drive around in it, and you'd probably crash... Because they still -- they have lots of stuff in it that -- if you don't know what -- what it is, that you could get hurt...Well, if [PSA C*] really was, a real, real video game, like, you know, you could get electrocuted.

Q17: Because you could learn more...Like, something like when you grow up and you don't know something that you did, did the dar -- Dr. Game [PSA C*], and you'd think harder right there. You could think harder right then you'd learn more.

Q17: Because, well, everybody has problems and there's all different sorts of problems, and, you know, you're gonna have to be able to solve them.

TO FIX: [12% of Q17 responses]
Responses that particularly discuss the importance of learning how to fix things as a benefit derived from learning PSA C*-type things.

Q17: Kind of...[They'll be with] other things -- like bicycles and stuff.

Q17: 'Cause like if you have a bathtub or something, you know that isn't working right you could check what was wrong with it.

Q17: Because you need to know how to fix stuff, like I say, you don't want to spend like forty dollars on just one broke thing.

Q17: So you can learn how to fix things.

INTRINSIC VALUE:

Responses that indicate that what was important to the child about PSA C* had to do with gaining competence and a sense of self-mastery.

Q10: Because like when you -- when you're trying to do something and then you can't do it, you feel like hurt that you couldn't do it...You feel like dow...And you feel -- you don't feel right...When you can't fix it.

Q10: Because um that you know that you did it on your own. Nobody else helped you.

Q10: Because you feel good inside if you can figure out -- like a like a riddle or something...Like if they ask you something real hard that they couldn't figure out and you figure it out, you feel like, "Oh, I did something they can't do now." [R: Uh huh. And who is 'they?'] Anybody.

Q10: Well, because if you couldn't figure out that, then what can you figure out -- I mean it's -- it's life, you gotta -- you gotta -- it's like a challenge to your -- towards yourself. You gotta figure out things for yourself...What if it was a matter of life and death and you didn't even try -- that's the way -- that's the way my friends put it -- one of my friends it. She puts it like life and death, she -- she at least tries. That's what I always feel. I at least try to do something.

Q17: Um, how come, because um, 'cause um, that'll, that'll show you that you know how to do things by, by yourself and um, and that um you're good for something and you, and um, that you know how to do something well and um, you're o -- and um, and you're always good at something and all.

NON-RESPONSES

Q10: It was a cinch. It was a cinch...I don't know [why I said it's important]. They just seem fun.

Q17: (Nods)...Because when...

Q17: No, I don't, yeah, nn, I don't know.

Breakdown of Subject Characteristics Q10

CATEGORY	TOTAL	GIRLS	BOYS	MIN	NON MIN	MED SES	LOW SES
FUTURE	23% 11	17% 4	30% 7	15% 5	43% 6	33% 8	13% 3
GAMES	21% 10	33% 8	9% 2	27% 9	7% 1	17% 4	26% 6
HELPING	9% 4	17% 4	0% 0	6% 2	14% 2	8% 2	9% 2
LEARN	28% 13	13% 3	44% 10	36% 12	7% 1	21% 5	35% 8
INTRINSIC	17% 8	21% 5	13% 3	12% 4	29% 4	21% 5	13% 3
NR	2% 1	0% 0	4% 1	3% 1	0% 0	0% 0	4% 1
TOTAL[1]	100% 47	101% 24	100% 23	99% 33	100% 14	100% 24	100% 23

[1]Because of rounding, not all of the columns sum to 100%.

<u>Breakdown of Subject Characteristics for Q17</u>

CATEGORY	TOTAL	GIRLS	BOYS	MIN	NON MIN	MED SES	LOW SES
FUTURE	12% 4	6% 1	17% 3	13% 3	9% 1	6% 1	19% 3
GAME	9% 3	6% 1	11% 2	0% 0	27% 3	17% 3	0% 0
HELPING	9% 3	6% 1	11% 2	13% 3	0% 0	0% 0	19% 3
LEARN	44% 15	50% 8	39% 7	44% 10	46% 5	44% 8	44% 7
INTRINSIC	3% 1	6% 1	0% 0	4% 1	0% 0	6% 1	0% 0
NR	24% 8	25% 4	22% 4	26% 6	18% 2	28% 5	19% 3
TOTAL[1]	101% 34	99% 16	100% 18	100% 23	100% 11	101% 18	101% 16

[1]Because of rounding, not all of the columns sum to 100%.

APPENDIX III.F:

Codebook: Usefulness and Importance

INTRODUCTION

The purpose of this codebook is to explain the coding procedures for the Applications Analysis, which consists of coding responses to questions relating to usefulness and importance. More information about the conceptualization for this analysis, which is used to assess change due to exposure to **SQUARE ONE TV**, can be found in Chapter 4.

I. DEFINITION

This section defines usefulness and importance, explains the concept of "applications" and describes how applications appear in the interview.

A. Definition

Usefulness and importance concerns children's perceptions of the usefulness of mathematical knowledge. There are three aspects to perceived usefulness: how children perceive mathematics to be useful in their present lives, how mathematics is perceived as useful for the future, and how mathematics is perceived as generally valuable, or important, to know.

This analysis scheme examines perceived usefulness by assessing the applications that children mention as examples of the present and future usefulness of their mathematical knowledge. An application is a specific example of how mathematics can be used or applied to situations in life, particularly outside of school.

B. How Applications Appear in the Interview

Two types of questions were developed to elicit responses concerning children's perceptions of the usefulness of mathematics. These questions were designed to provoke the following kinds of information from the children:

o Applications. These are questions in which the children were asked to give an example or examples of how mathematical knowledge can be used in the present or in the future.

o Value. These are questions in which the children were asked to express their understanding of the importance of mathematical knowledge to their lives more generally.

As Chapter 4 indicates, children primarily responded to both types of questions by giving applications for the use of mathematical knowledge, despite the intent of the question. Thus, applications appear in response to both types of questions developed for the use/importance dimension.

II. CODING FOR APPLICATIONS

This section presents the procedures for coding for applications. It also contains a section on special coding guidelines and a section giving examples of types of applications.

A. Index of Use/Importance Questions

The questions developed for use/importance are listed below. The questions that were designed to elicit responses about the value (or importance) of mathematics have been marked with the letter "V".

PSA DOMAIN

V 10. Do you think it's important to be able to figure out things like this [PSA C*]? How come?

12. Remember how you were thinking when you were doing this? Do you think that you could use that kind of thinking in other situations [PSA C*]? When? In school? Outside of school? Outside of school not including homework?

V 17. Is that important [PSA C* learning in high school]?

V 18. Do you remember the other thing that you did yesterday -- with the clocks/party tables? Do you think it's important to be able to figure out things like this [PSA B*]? How come?

V 27. Is being able to figure out things like this important [PSA A*]? How come?

29. Remember how you were thinking when you were doing this [PSA A*]? Do you think that you could use that kind of thinking in other situations? When? In school? Outside of school?

MATHEMATICS DOMAIN

V 48. Should this person who doesn't know math learn about it? How come?

51. Is math useful to you in your life now? Why?

52. Is math useful for you in your life outside of school? Why?

53. Will it be useful for you in the future? Why?

V 54. How important is math to you? How come?

60. Can you tell me some fun and interesting ways to use math?

61. Can you name some fun and interesting ways to use math outside of school? What about fun ways to use math not including homework?

62. Can you tell me some fun and interesting ways adults use math?

These questions and each child's responses have been coded into a database. The database permits manipulation of the interview data so that all responses to a particular question or every use/importance response for every child can be easily collected for analysis.

B. Overview of Coding Scheme for Applications

Coding involves assessing each response to the above questions for the presence of an application for the PSAs and for mathematics. Each application is then coded for the type of application and the time of the application. These will be explained briefly below.

Type of Application

There are three types of applications used to assess the quality of the specific uses that the children mentioned. An application can be classified as "repeat," "baseline" or "unique." "Repeat" applications are the least abstracted from the context of the question while "unique" application are the most abstracted, and, thus, the most sophisticated, of the applications.

Time of Application

An application can either be in present time, indicating a use to which that the child can put his or her knowledge in his or her current life, or be in future time, indicating a use that the child could make of mathematical knowledge in the future.

More information regarding type and time of applications can be found in Chapter 4 and in the following sections of this codebook.

C. Coding Procedures

This subsection presents the codesheets and step-by-step procedures for coding applications.

The Codesheet

To begin coding, you will need a copy of the Applications Codesheet. One Codesheet is used for each interview analyzed.

As the reader can see from the insert below, the Codesheet provides columns in which to record necessary coding information. (An example of a completed codesheet is presented at the end of this section.)

		TYPE			TIME		
Q	APPLICATIONS	R	B	U	PRES	COND	FUT
10	If somebody asks you to fix game	✓			✓		
12	fixing a car		✓				✓
17	NA						

o In the left margin, the domain (i.e., either PSA or Mathematics) should be noted.

o The "Q" column provides a space to note the question number.

o The space to the right of the "Q" column provides a place to record an abbreviated version of the child's response.

o The "R," "B," and "U" columns are for indicating with a checkmark whether a response is "Repeat," "Baseline," or "Unique."

o The "Pres" column is for indicating that an application is set in present time; the "Cond" and "Fut" columns indicate conditional and future tense, respectively.

Coding Procedures

Coding for applications requires that each response made by a child to one of the designated questions be analyzed for the presence of applications and that each application is then classified according to type and time. Note that following these general coding procedures are specific coding rules for particular situations and examples of responses. The coder is advised to read all of this material before beginning to code responses.

1) Print out from the database all responses to the designated questions (i.e., 10, 12, 17, 18, 27, 29, 48, 51, 52, 53, 54, 60, 61, 62) for each child.

2) With each child's consecutive set of responses, begin by reading the response to Question 10. Write the question number in the column under "Q". Then, do one of the following, as appropriate:

a) If the question was not asked, write "NA" (for "Not Asked") in the space provided for the response.

b) If the response is a simple "yes" or "no" without further follow up, write "NR" (for Non-Response) in the space provided for the response.

c) If a child gives a response, then the coder needs to determine whether the response contains an application.

3) To determine if a response contains an application, first ask if the child is telling how or when he or she can use some aspect of problem solving or mathematics. The situation must imply another moment in time when the problem solving or mathematics can be used.

The following responses do not contain applications because they express values or what seem to be aphorisms rather than specific uses, at another time, to which problem solving or mathematics can be put:

"Because if you don't know an answer to...to the question, then how you supposed to know what's -- what it's supposed to mean?" [Q10]

"It's important because, it's gonna help me in high school and it's gonna give me an education." [Q54]

"Because if you don't find out the problem it's just going to have stay there..." [Q10]

4) Then determine <u>what</u> is the use to which the problem solving or mathematics is put. Is there more than one application given? For each distinct application, jot the response down in the child's words in the space provided. Each different example should be recorded on a separate line on the Codesheet (i.e., each question may have more than one codeable application).

The child often will identify an application with the words "if", "like", "when" or "whenever." These words signal that the child is identifying a use for problem solving or mathematics which can take place at another moment in time. Some examples follow:

"Like a mystery in books and stuff."

"When you go to the store..."

"Whenever you work -- and if you're in an office."

"Like if you get a game and -- and you lose some stuff..."

5) Once an application is identified, the type of application must be assessed. The following will assist the coder in assessing type:

a) If the child gives an application that simply takes the context of the question and makes it into an application, then that application is considered to be a "Repeat" application and the "R" column is marked.

For example, one version of PSA B* involves placing people at different tables. If the child were to say that one use for this type of problem solving would be to place people at tables, this response would be considered "Repeat" because it is identical to the context of the problem solving in the question.

b) If the child gives an application that describes a task used by the child in solving the PSAs or that involves computation with money, that application is considered "Basic." The "B" column should then be marked.

For example, if given the same question regarding PSA B*, the child responds that she could use this problem solving to sort or arrange things, this response would be considered to be "Basic" because it provides an application that is both very general and minimally abstracted from the context of the problem solving in the question.

c) If the child gives an application that is specific and generalizes away from the specific context of the question to another real-life situation, then the application is considered to be "Unique" and the "U" column is designated.

For example, if in response to the same question relating to PSA B*, the child responds that she could use this problem solving to organize library books according to their call letters and return them to the proper shelves, this response would be considered to be "Unique" because it is both specific and abstracted from the context of the question.

6) After the type of application is identified, the time of the application must be identified. While present and future/conditional time are the two categories of time that are being analyzed, children often use a variety of verb tenses to indicate applications that might occur either in the present or the future. The following will assist the coder in making these distinctions:

a) If the application can, given the context, take place in the child's current life, then it is considered to be "Present" and that column should be marked.

b) If a child gives a response that uses a conditional verb tense and the application concerns something that could only occur in the child's future, the application should be marked under the "Cond" column.

c) If the application can only take place in the future and a verb tense other than conditional is used, then the application should be marked under the "Fut" column.

7) Repeat this procedure for each of the responses to the designated use/importance questions.

D. Applications Codesheet

SUBJECT: 71 CODER: Eliz

Q	APPLICATIONS	TYPE: R	TYPE: B	TYPE: U	TIME: PRES	TIME: COND	TIME: FUT
10	If somebody asks you to fix the game! you know how to fix	✓			✓		
12	fixing a car		✓				✓
17	NA						
18	you work in a store	✓					✓
27	If the announcer announces next person. (read circus)	✓			✓		
29	NR						
48	NA						
51	to buy something		✓		✓		
52	[51]						
53	I have to help my kids		✓				✓
54	NA						
60	NA						
61	NA						
62	NR						

NA = NOT ASKED/PROBED
NR = NO ANSWER OR OTHER

E. Special Coding Guidelines

This subsection presents more detailed guidelines for making some of the fine distinctions that the coding requires. Certain rules have been developed to make coding by different coders more consistent.

Identifying Applications

o A general application followed by a specific example is counted as two applications. Note that specificity is important in identifying the second application. If a child merely repeats the first application in different words, e.g., "if you have to put them in order or like have to arrange them", this is not considered to be a second application. Nor is it another application if details of the first application are mentioned rather than another application being given.

The distinction is whether a statement is a specific example of a previously mentioned general application or whether a statement is merely describing a part of that first general application. A useful example that can help to guide in making the distinction is the response one child made to Q61. She said that she could use math in a fun and interesting way by playing math games. That is her first application. Then she said, "Like Mathtronics" which is a game but is a specific example of a game. This specific example counts as a second application.

Further examples:

> "Whenever you work -- and if you're in an office. And um...if you work in an office, you have to do paperwork (1)...And like add up how much money you have with the company (2)...And what your pay is and stuff (3)..." [Q27]

In this example, "add up how much money" and "what your pay is" could be considered as specific examples of "do paperwork."

o However, particularly in responses dealing with money transactions, a child should not be given additional points for responses that specify steps of the transaction or that further describe the transaction. The reason for this is that there are far too many routine examples of going to the store and buying things that would be given weight if the details of these transactions were counted.

Examples:

> "When you go to the store you have to pay the man...And then you're gonna have to know if he gives the right change."

> "Because when he goes to like to the store to get food or something, he's gonna have to know how much money he has...And how much it's gonna cost. What's expensive, what's not."

Not all examples pertain to money transactions:

> "it could really help you like when people solve cases and stuff...That's how they do it. They look at every little thing...keeping count."

"Well, like if someone blames somebody for killing somebody else, and it -- it's really open to anybody. The guy goes out and looks for clues."

In the two above examples, the later parts of the statements (re: keeping count and looking for clues) are details which explain the application that has been identified by the child.

o Yet, when the child actually describes a more complicated transaction than simply paying for items and getting the right change, it should be counted as a separate application.

For example:

"Like when my mom asks me to go to the store, and she asks me to get something (1), I look for the cheapest thing by putting the prices together and the ounces. It would be how much it is per ounce or per pound or whatever, and then seeing if one's more expensive or less expensive. (2)"

This is a very interesting response that is very different from the routine "getting the right change." First we have the context of "go to the store" which counts as one application. This is all that many children say. However, this child this child went beyond this to describe the activity of comparison shopping. That counts as a second application. Note that going to the store to buy something is the context for this and counts as an application separate from making comparisons. Thus, there are two applications for this quote.

o The same response given to two different questions will be counted each time.

Example:

Q12: Could you use that thinking in other situations?
S: "Like um with um work in a toy store..."
Q17: Would what you learned in that class be important?
S: "Yes...'cause if you worked in a toy store, you can fix the games."

o However, if a child says that an answer to a second usefulness question is the same as a previous one without repeating the use, then only one application is credited.

Example:

Q53: Will math be useful to you in the future?
S: (Nods)..."For the same reasons."

o The child may not mention an application that pertains explicitly to the problem-solving aspect of the PSA situation. The child may find utility in the interview situation itself -- finding it useful to know how to answer questions quickly. This is considered to be an application. (When Type of Application is coded, we will distinguish this application from ones that are more relevant to our study.)

Identifying Types of Applications

o Since the context is most salient in the questions relating to the PSAs, "Repeat" uses will primarily occur in the PSA Domain. However, if a child gives an application for mathematics as doing worksheets of problems, this would count as "Repeat" in the Mathematics Domain.

o Sometimes the child will repeat the actual context of the interview situation, e.g., answering questions. This is classified as "Repeat."

o "Basic" applications do not have to be identified as such because they are what is left after the other two categories have been identified.

o In the Mathematics Domain, all responses that have to do with buying things and going to the store are considered "Basic."

o Any mention of applying the skills from the PSAs gets credit for a "Unique" application unless the mathematics that is referred to is the addition and multiplication in the PSAs. If this is ambiguous, it should be scored as "Unique."

o "Unique" applications for the PSAs should refer to some aspect of problem solving rather than fixing.

o A "Unique" application should present a specific use rather than being general. If a child mentions using mathematics at the office, this would be "basic" unless a specific application is given.

o Any response to Q62: fun ways for adults to use math, should be considered "Unique" unless it refers to going to the store or basic operations (adding, subtracting, etc.) which are considered "Basic."

Identifying Time of Applications

o "Future" and "conditional" responses have been consolidated for analysis.

o If a child talks about an activity that s/he identifies as part of his/her immediate world, even if s/he talks about doing it in the near future, this counts as "present."

Examples:

"like right now and I'm gonna go for my class. And then they're doin' work and I'm gonna have to try to figure out how to do it."

"If you have a test, then you'll know how to add or something."

"Um yeah...Because so I could help them...So that I could help him."

o While the actual verb tense used by the child is often a signal to identify time, the child's reference to something in his/her immediate world would be considered "present" regardless of the tense that the child uses.

Example:

"Because if um there's somebody else like asked a question or something, and if you had like practice, done it, and stuff so you'll know how to answer right away."

This response is describing a present situation of competence building for the child although s/he describes it in future and conditional tenses.

Or, further examples:

"Like if get a game and -- and you lose some stuff and -- Then you could like make your own rules."

"Because then if you have a party, that way you can know where to sit people or how many people you're gonna invite."

o In describing the activities of the aliens (responses to Q48), children often use the third person with a variety of imperative or conditional sounding phrases. These should be considered "present".

For example:

"...then they go to the store and gonna have to know how much it's gonna cost...And that -- or how much gas they need or something."

o Questions 17, 53 and 62 will always be in future or conditional since they ask the child for uses in the future. The child may respond to any question with a future-oriented response, however.

o Note that the children in our sample rarely use the first person to express future applications. The children seem to express future time without using the future tense by using the second person and conditional verb tenses or using second or third person and imperative verb tenses.

For example:

"'Cause if you worked in a toy store, you can fix the games."

"that way when um later when you grow up and they might hire you to fix games."

"Uh, like if you grow up [illegible] want to work at a store, you're gonna have to know how much change to give the person."

"Because later in your life you're gonna need to learn how to make decisions yourself..."

"Well, like if you're gonna sell something to somebody, you need to know how much you're gonna -- you're gonna sell for it."

The statements listed above seem to be stronger than conditional. In fact, it almost seems as though the child is expressing an internalized "teacher" or "parent" by stating what is needed to use math.

o If the child is describing a future activity and uses an "if" construction, this is future if the voice expressed is in first person.

Examples:

"If I was the person designing the shirt..."

"If I get a job like this..."

"Like if -- like if I get a job like this or something? So they might hire me and I have to figure something out like that."

F. Examples of Types of Applications

This subsection presents examples of the types of applications broken down by the various PSAs and mathematics.

Repeat Applications

PSA C*:

"Like a game that's broken...Or it's all mixed up." [counts as one application]

"...you might buy a game and...you might think you have to figure out if it's missing pieces or something."

"I would know what to say when somebody asked me a question."

"So I could help him." [i.e., Dr. Game]

PSA B* or A*:

"Because if you worked in a store you could put the clocks in order."

"if all the shows have the clown, the magician, the acrobat and the juggler are all like every time they have that the people might get bored with that. And so they need to switch em around so they won't get bored."

"Just to sit down and think about the problem and the way you could. And then try one out. If you don't think it's gonna work, try the other one out."

Mathematics:

"Where ever you go. At home I ask my dad to tell me math problems so I can answer 'em."

Basic Applications

PSA C*:

"Work in a toy store"

"Like if get a game and -- and you lose some stuff and -- Then you could like make your own rules."

"Because later in your life you're gonna need to learn how to make decisions yourself..." [Basic because doesn't give application for problem solving]

"Because there might be like -- something like where you work, and there might be a problem -- maybe you'll be able to help them solve it."

"Math...Well there was multiplication and adding problems in that game."

"if somebody really did ask you how to do it, then uh you would, they would sell easier if it, if it told you exactly how to play and stuff like that."

PSA B* or A*:

"if you have something and you need to put it in order"

"'Cause if someday you wanna own a factory -- make clothes or something -- and -- and you want different colors like...like uh the lady/man did." [while context is unique the application is specifically the task described in the PSA]

"Because you might have a clothes store!" [said re: application for making t-shirts]

"like get some papers in order to get something" [Basic due to vagueness]

Mathematics:

"then they go to the store and gonna have to know how much it's gonna cost."

"If you have a test, then you'll know how to add or something."
"I play with my sisters...you have to add it."

"Um, you play store...I -- um to sell things."

"If you work in an office, you have to do paperwork." [vagueness]

"How much money you have with the company."

"And what your pay is and stuff..."

"They could have better businesses and stuff like that. And they could -- they wouldn't have as much trouble with money."

Unique Applications

PSA C*:

"Like if teacher gives you a puzzle, she tells you to fix it."

"Like if your dog takes something but you don't know who took it, and you're looking for it."

"'Cause um I think it was Tuesday when these two -- these two girls took off with my friend's um my friend's baby sister, and they took her! And I got her back."

"Like in problem solving."

"Like a mystery in books and stuff."

PSA B* or A*:

"Because you learn that, you learn all that in math."

"Like if you wanna have your own -- your -- when you grow up and you have a kitchen, you could put the flour and all that in there."

"Like if you have like four pairs of jeans and then four four four shirts/blouses and you want to find out how many ways you could do them together."

Mathematics:

"How much gas they need or something"

"To play poker!"

"'Cause you need to know if somebody asks you how many miles it is to a place..."

"You would be working with a daycare, you have to figure how much to get from the parents and stuff."

"To solve the -- one of those ["Murder She Wrote"] -- 'Cause you have to put everything together."

"If you go to a gas station and you have to get so many gallons worth of gas and stuff, you have to know how much that'll fit in your car unless you ha -- fill it up until it starts spilling out of the car."

III. CODING FOR APPLICATIONS IN THE ESSAY

This section presents the procedures for coding applications in the Essay.

A. Overview of Coding Schemes

Essentially, the Applications coding for the Essay describes the degree to which each child writes about mathematics as an undefined noun or describes mathematics in terms of specific applications. There are two components to this coding: Types of Applications and Types of Mathematics.

Types of Applications

When coding for Types of Applications, each essay is coded as either job-related, non-job-related, or general.

> Job-related essays pertain to a specific job. For example, such essays contain statements such as "One kind of people who have this job are architects" or "Truck drivers need measurement to know how much gas they have."
>
> Non-job-related essays describe applications that are not related to a specific job. For example, these essays would contain statements such as "It's good to have this kind of job because when you go to the store, you'll know how to figure out your change" or "I would be able to help my children with their math."
>
> General essays do not describe any specific applications. For example, such essays would contain only statements such as "Math is important" or "I hate math."

Once every essay has been coded in one of these three categories, the job-related and non-job-related categories can be collapsed into a single category of specific applications. Thus, this coding should result in two categories: (a) specific applications and (b) general applications.

Types of Applications

When coding for Types of Applications, each essay is coded as containing references to either specific or general mathematics.

> Specific essays contain references to specific mathmatical topics such as adding, measuring, or using maps.
>
> General essays do not refer to specific mathematical topics, but only to "math" in general.

Note that essays should be coded under this scheme without regard to their coding under the Types of Applications scheme. This idea might be best understood as the difference between "Architects use math" and "Architects have to measure how high and wide walls are." Both statements should be taken as evidence that their essays are job-related (under the Types of Applications coding). However, the first statement would indicate an essay that would be coded as general for Types of Mathematics, while the latter would be coded as specific for Types of Mathematics.

B. Coding Procedures

Each of the above coding schemes should be used separately. That is, separate passes through the essays should be made for Types of Applications and Types of Mathematics. Naturally, though, when coding under one scheme, if you discover that you overlooked a statement when using the previous scheme, then you should correct the error.

Two passes are made through the essays for coding under each scheme. On the first pass, statements pertaining to the relevant dimension are highlighted. Questionable statements are marked with a question mark, to be resolved later. Highlighting for each scheme is done with a different color highlighter.

The second pass is made when the highlighted statements are copied onto a separate sheet and tallied. During this pass, as many questionable statements as possible are resolved; for the sake of conservatism, anything that still remains questionable (e.g., if a kid talks about being a football player without ever making it clear whether "football player" is a job that uses mathematics) is not coded.

Because two passes are made through the essays for each scheme, the net effect of going through the essays so many times is that it becomes difficult to miss any relevant statements, although some may be intentionally excluded if they are not clear enough.

APPENDIX III.G:

Categories for Descriptive Analysis:

Motivation

Responses to Q34 & Q64 by Category

QUESTION 34: Which one [of the three PSAs] would you say was the most challenging to you?

QUESTION 64: Which would be more of a challenge for you [PSA C* or this arithmetic worksheet]? Why?

Distribution of Responses[1,2]
Q34: N=95; Q64: N=86
Total N=181

Category	Total	Q64
Effort:	19% (34)	
Q34: 21% (20)		Q64: 16% (14)
Task:	19% (35)	
Q34: 30% (28)		Q64: 8% (7)
Mastery:	13% (23)	
Q34: 13% (12)		Q64: 13% (11)
Difficulty:	13% (23)	
Q34: 16% (15)		Q64: 9% (8)
Performance/Competition:	9% (16)	
Q34: 7% (7)		Q64: 11% (9)
Miscellaneous:	7% (12)	
Q34: 3% (3)		Q64: 11% (9)
Non-Responses:	21% (38)	
Q34: 10% (10)		Q64: 33% (28)

EFFORT

Responses in which the child describes the most challenging as task requiring more effort, more thinking or more concentration than the other task(s). These include explicit statements about effort, and responses such as: "think more," "think a lot" or "keep working at it."

Q34 (PSA C*): Dr. Game...Because it made me think real hard. I made me put my mind to it.

Q34 (PSA A*): This one...'Cause you had to like, you have to really think about this stuff you had to put on and then you have to make sure that you didn't repeat yourself or nothing.

[1] The categories concerned with a notion of challenge as pushing one's limits (Effort, Task, Mastery, and Difficulty) comprised 64% of the children's responses.

[2] Please recall that these responses are comprised of pretest and posttest data.

Q34 (PSAs C* & A*): I'd say both because they're equally challenging, 'cause I have to think real hard and on the Dr. Game I had to think real hard to find out what was the matter and on this I had to think real hard to find a lot of patterns, as many as I could find.

Q64 (PSA C*): Dr. Game...because it's a lot challenging than this 'cause all you do is just write down problems right there and just like 40 goes into 25 -- can't. So see so it's real, it's, this is real easy and the other one's sort of challenging cause you have to work it out, you have to try and find what's happening and stuff.

Q64 (Worksheet): This...Because you have to divide and multiply and all that and you have to work it out. And you have to think, think and think. And to see if you have something wrong with it you have to erase all over again and you have to, you have to do it again and then, and again and until you get it finally right. And then the Dr. Game you can mark it on paper and you think real hard except now it's always you think with this and it's more like a fun thing. And this, and this most of the time I don't make it for and I just want to do the thing early. And the Dr. Game you hardly even erase and all, and it's not as hard as this.

<u>TASK</u>

> Responses in which the child describes the most challenging task in terms of the task itself and what it requires him/her to do. Some of these responses are implicitly about effort. Responses include: "because you have to do more," "because you have to subtract and multiply," or "because you have to think about what is wrong with the game."

Q34 (PSA C*): Mr. Game...Because you had to find the problem, and then you had to fix the problem...That was challenging.

Q34 (PSA A*): This one...Because I had to try and remember all of the spots they were in.

Q34 (PSA C*): The Dr. Game...Well, trying to figure it out -- everything -- I think is challenging...Well, making everything so the game works. And only doesn't make one person win. That's challenging.

Q64 (Worksheet): This one...Well 'cause you would have to subtract and multiply and divide and all that.

Q64 (Worksheet): Dr. Game...No, this would...Yeah because you have to think of numbers that would go into like 115...

<u>MASTERY</u>

> Responses in which the child describes the most challenging task as the task he/she is not able to does not know how to do. Statements do not indicate negative feelings about inability to arrive at a solution. Responses include: "because I know how to do the other one," or "because I couldn't figure that one out."

Q34 (PSA C*): The Mr. Game...Because I couldn't figure that one out? If you can't figure -- it, challenging is like when it's harder.

Q34 (PSA C*): The first one...'Cause it was hard figuring out what was wrong with it, and I couldn't get it. [R: Is it a good kind of challenge or a not so good kind of challenge?] I think it's a good kind of challenge.

Q34 (PSA C*): Dr. Game...Because you had to figure out what was wrong with it. You didn't have no directions to read or anything, so you didn't really know how to play it. All you needed -- you had to do was just spin the spinners. And flip the coin and give the man a coin.

Q64 (PSA C*): The division if we didn't know division but we know it...Dr. Game...Because this is like -- you probably never seen that game, and that was the first game you seen and you probably don't even know how to play it.

Q64 (PSA C*): Dr. Game...Because I don't know about it and I don't know about it too much and this I know a lot about.

DIFFICULTY

Responses in which the child describes the most challenging task as being hard or describes the other task as being too easy. Responses include: "because it was hard," "too hard to solve," or "because the other one is easy."

Q34 (PSA C*): The one with the times and multiplication...Looks kind of hard.

Q34 (PSA C*): Probably Dr. Game...Because that was pretty hard to solve.

Q34 (PSA C*): ...the Dr. Game was the hardest one. Because there was a lot, when there's lots to do...it's more harder to remember and hard to figure out the, like the answer that you're...trying to figure out an answer or something, it'll be harder because there's lots of things that you have to answer to see what's wrong in the Dr. Game thing.

Q34 (PSA A*): This one...'Cause you have to rememorize which colors you put in order and that, and that's pretty hard to.

Q64 (Worksheet): This...Because the Dr. Game looks easy and this looks harder.

PERFORMANCE/COMPETITION

Responses in which the child evaluates him/herself negatively or describes being evaluated and/or statements about competing with another person. Responses include: "because I try to make 100 on it," "try to get everything right," "because I'm not too good at that one," or "to play with a friend and see who would get the most chips."

Q34 (PSA C*): The game...Because you really had to think about it and what I was thinking is there really...was something wrong with it and you really -- it was like -- I thought it was gonna be obvious and I was gonna look dumb because I didn't know or something...I was just tryin' to think as hard as I could but -- you have to look at it and just keep thinking of what could be wrong with it. And really concentrating on it.

Q34 (PSA A*): ...this was...'Cause there's so many different ways and it just get too confusing and, and like you, you just get messed up.

Q64 (Worksheet): This...because rather something I always end up missing -- these problems -- number 17, 18 and 19. I always mess up on those problems. I never got those ones right. And, not to mention, I haven't got others of them right, either, like the ones down here, because I -- always got confused on 'em and we haven't learned about dividing with decimals and that would be another challenge. I mean -- for me.

Q64 (Worksheet): This...because...they tell me, I get to get a grade for it, and I always try to make 80's and above. It's a challenge for me cause I wanna get good grades, cause I'm an honor student. And that's all.

Q64 (Worksheet): This...To see who gets um, the most answers right.

MISCELLANEOUS

> Responses in which the child describes the most challenging task as fun, important, particularly for the future, as a way to challenge or test oneself, or in some other way that is inconsistent with the categories outlined in this appendix.

Q34 (PSA C*): The Dr. Game...because that give you like a challenge to find out what was wrong with it, then, they just like help you time more and all that. And learning the highest and all that.

Q64 (PSA C*): Dr. Game...because it's more fun...Um, I don't know. I just think it's fun.

Q64 (PSA C*): I guess the Dr. Game...'cause it's fun and challenging. This is boring and challenging. So, I guess Dr. Game would be better...this you have to do work. I don't like work... Well, like you have to do math work in here, and Dr. Game would be something like hide and seek.

Q64 (Worksheet): This...Well, because Dr. Game is just a game, and this is like real problems... Like something that you might have to learn when you're bigger.

Q64 (Worksheet): I guess this...'Cause you have to know your multiplying to know your division. And you have to know how to add and subtract.

NON-RESPONSES

Q34 (PSA C*): The, the, the, one with the dice.

Q34: Um...yeah. I dunno.

Q64 (PSA C*): The Dr. Game...Yeah.

Q64 (Worksheet): This one.

Breakdown of Subject Characteristics for Q34[3]

CATEGORY	TOTAL	GIRLS	BOYS	MIN	NON MIN	MED SES	LOW SES
EFFORT	21% 20	25% 12	17% 8	21% 14	22% 6	17% 8	25% 12
TASK	29% 28	35% 17	23% 11	34% 23	19% 5	30% 14	29% 14
MASTERY	13% 12	8% 4	17% 8	9% 6	22% 6	15% 7	10% 5
DIFFICULTY	16% 15	10% 5	21% 10	15% 10	19% 5	19% 9	13% 6
PERFORM/ COMPETITION	7% 7	6% 3	9% 4	6% 4	11% 3	11% 5	4% 2
MISC	3% 3	4% 2	2% 1	3% 2	4% 1	2% 1	4% 2
NON-RESP	11% 10	10% 5	11% 5	13% 9	4% 1	6% 3	15% 7
TOTAL[4]	100% 95	98% 48	100% 47	101% 68	101% 27	100% 47	100% 48

[3] Recall that these tallies are comprised of responses to pretest and posttest combined.

[4] Because of rounding, not all of the columns sum to 100%

Breakdown of Subject Characteristics for O64[5]

CATEGORY	TOTAL	GIRLS	BOYS	MIN	NON MIN	MED SES	LOW SES
EFFORT	16% 14	21% 9	12% 5	18% 11	12% 3	16% 7	17% 7
TASK	8% 7	7% 3	9% 4	5% 3	15% 4	13% 6	2% 1
MASTERY	13% 11	7% 3	19% 8	10% 6	19% 5.	18% 8	7% 3
DIFFICULTY	9% 8	5% 2	14% 6	10% 6	8% 2	9% 4	10% 4
PERFORM/ COMPETITION	10% 9	9% 4	12% 5	13% 8	4% 1	2% 1	20% 8
MISC	10% 9	12% 5	9% 4	10% 6	12% 3	11% 5	10% 4
NON-RESP	33% 28	40% 17	26% 11	33% 20	31% 8	31% 14	34% 14
TOTAL[6]	99% 86	101% 43	100% 43	99% 60	101% 26	100% 45	100% 41

[5] Recall that these tallies are comprised of responses to pretest and posttest.

[6] Because of rounding, not all of the columns sum to 100%.

APPENDIX III.H:

Codebook: Motivation

INTRODUCTION

The purpose of this codebook is to define motivation briefly; to explain where motivation appears in the interview; and to provide procedures for coding motivation responses. More information relating to the conceptualization of this analysis scheme, which is used to assess change due to exposure to **SQUARE ONE TV**, can be found in Chapter 5.

I. DEFINITION

This section presents a definition of motivation as well as the designated motivation questions in the interview.

A. Definition of Motivation

Motivation concerns why a child pursues the problem solving activities (PSAs), mathematics and other tasks discussed in the interview. It refers to factors other than ability that affect the direction, intensity, and duration of goal-directed activity.

B. Index of Designated Motivation Questions

The following is the list of questions developed to target motivation, identified by the three domains of mathematical inquiry:

PSA DOMAIN

7. Did you think about it [PSA C*] after you left the room? What did you think?

8. Did you talk to your parents or family or anyone about it? To whom? What did you say?

13. If, sometime in the future, you had a chance to try another Dr. Game thing [PSA C*] would you like to?

16. Let's say when you're in high school you have a chance to take a class that teaches you how to figure out things like the Dr. Game thing [PSA C*] would you like to take it? (What do think you would learn?)

    [NOTE: When the "what do you think you would learn" question is probed "why", it becomes a motivation question.]

22. [Re: PSA B*] Now, do you remember the optional part? ...Did you try it? How come?

32. Of the three things you've done with us -- the thing with Dr. Game [PSA C*], the clocks/party tables [PSA B*], and the circus performers/stripes on a shirt [PSA A*] -- which did you like the best? Why?

33. Which [PSA] would you most like to work with again? Why?

34. Which one [of the PSAs] would you say was most challenging to you? Why?

FIGURING OUT DOMAIN

35. What kinds of things do you like to figure out?

36. Why do you like to figure [the activities mentioned in response to Q35] out?

37. Is/are [activities mentioned in response to Q35] challenging to you?

38. Do you like challenging things? How come?

39. What kinds of challenging things do you like?

[Note that only responses to questions 36 and 38 are actually coded. However responses to questions 35, 37 and 39 may provide information that will help in your coding of 36 and 38.]

MATHEMATICS DOMAIN

63. If you had a chance to work on another project with Dr. Game [PSA C*], or do this [arithmetic worksheet], which would you rather do? Why?

64. Which would be more of a challenge for you? Why?

OVERALL MOTIVATION GOAL

81. Which of these four statements comes closest to describing the kinds of things that you would like most to work on?

a. Things that are fairly easy so I'll do well.
b. Things that I'll learn something from even if they're so hard that I'll make a lot of mistakes.
c. Things that aren't too hard, so I don't make many mistakes.
d. Things that are hard enough to show that I'm smart.

II. CODING MOTIVATION RESPONSES

This section sets forth procedures for coding motivation statements and describes the different steps involved.

A. Overview of Coding Scheme for Motivation

Coding responses to the designated motivation questions involves an analysis of the reasons children provide for their motivation (or lack of motivation) toward the problem-solving activities (PSAs) and other activities related to mathematics.

Coding motivation responses involves three types of analysis. First, you will need to categorize statements into one of two "orientations" that describe the different goals or rationales that children provide for their motivation. Second, you will need to determine an appropriate "level" for each statement: "level" characterizes the child's depth of involvement with a particular activity. Finally, you will need to assign a "valence" rating to each statement which indicates the positive (approach) or negative (avoidant) direction of a child's motivation.

Orientation

The two orientations are: "Engagement" and "Performance." The Engagement orientation is concerned with the process of learning or figuring things out, trying hard and challenging oneself. The Performance orientation is concerned with outcome, the demonstration of ability and a concern with performance or external standards (such as grades and/or being "the best," "smartest," or "fastest").

Level

There are three levels of motivation[1]. Within each level there are two categories ("A" and "B"). These categories were developed to capture qualitative differences within each level.

Level 1 motivation is task-based and generally has to do with issues of enjoyment (Engagement) or ease (Performance). There is no mention of effort.

Level 2 motivation generally has to do with a more complex involvement in the activity. In Engagement, this can be seen through an involvement with the problem solving process and a willingness to expend effort by thinking and figuring out. In Performance, this can be seen through an emphasis on obtaining the correct solution and a concern with evaluation.

Level 3 motivation generally has to do with effort, challenge and goal directed behavior. In Engagement this is indicated through a willingness to expend effort for the sake of developing competence in a particular area. In Performance this is indicated through an emphasis on demonstrating competence as gauged by external standards and evaluations.

Valence

Valence can either be positive or negative. Positive valence indicates that a child is motivated to approach or pursue a particular task. Negative valence indicates that a child is motivated to avoid a particular task or situation.

[1] Note: The text of this volume refers to level as a three point scale consisting of "low," "medium," and "high." The development of this scale was based on the distribution of responses for all the levels. Responses coded for levels 1A and 1B were classified as "low," level 2A responses were classified as "medium," and level 2B, 3A, and 3B were classified as "high."

Outline of Motivation Scheme

The following provides an overview of the Motivation orientations and levels:

	Engagement	Performance
Level 1:	Enjoyment of task.	Task difficulty and task requirements.
	A. General statements about task or experience as fun or enjoyable.	A. Ease and speed statements.
	B. Specific statements about task as enjoyable or interesting.	B. Description of what is necessary in in order to do the task.
Level 2:	Effort and problem-solving process.	Effort and demonstrating ability.
	A. Figuring out, thinking or trying.	A. Grades, right/wrong answers, and knowing how to do something.
	B. Challenging oneself by thinking more or wanting to learn new things.	B. Challenging oneself in order to prove ability, particularly by attempting "hard" tasks.
Level 3:	Learning for the sake of learning.	Learning in order to demonstrate ability.
	A. Uncertainty about outcome, tolerance for frustration.	A. Gaining and demonstrating competence.
	B. Sustained involvement with the task involving concerted effort.	B. Effort that is directed toward being the best, smartest or fastest.

B. Coding Procedures

This next section describes guidelines for coding responses to motivation questions. However, before you begin to code, you should read through the entire Codebook paying particular attention to the last part of this Codebook: "Coding Schemes with Examples." This section provides a detailed description of the levels within each orientation, (for both positive and negative valence) and supplies examples of children's statements for each level.

Review of Coding Sheets

The question numbers are noted on the left hand side of each code sheet (the top portion of which is depicted below). Beside each question number columns are provided to take down coding information. They are as follows:

Q	NA NR	G or P	1A	1B	2A	2B	3A	3B	+/-	Response:
-	NR								—	No
8	NR								—	Don't tell grandma.

o The "NA/NR" column provides a space to note when the question is not asked, or when the response can not be coded for orientation and level.

o The "G or P" column provides a space to note the orientation for a particular response ("G" for Engagement and "P" for Performance).

o The "1a," "1b," "2a," "2b," "3a," "3b" columns are used to note the level for a particular response. A check should be placed in one of the columns.

o The "+/-" column is used to note the valence of a particular response.

o The "Response" column is provided to note the actual response or an abbreviated version of the actual response.

Step-by-Step Coding Procedures

Coding motivation responses requires you to read each response and to code it for orientation, level, and valence. The specific steps involved in this coding process are detailed below. Note that a review of the two orientation coding schemes and special coding tips in section "E" is necessary before beginning to code.

1) Print out responses to questions 7, 8, 13, 16, 22, 32, 33, 34, 35, 36, 37, 38, 63, 64, and 81 for each child.

2) Take each child's packet and read his/her responses consecutively to obtain a general sense of the child's overall way of describing motivation. This will be particularly helpful in interpreting a child's motivation orientation.

Once you have an idea of the child's overall orientation (i.e., G or P), you may begin to code each individual response. Note that a child's orientation may not be consistent throughout the interview; however, your understanding of an overall predominance will help to clarify ambiguous or unelaborate statements.

3) After reading through all of the responses for a particular child, go back to the first response. Read the response, and ask yourself if the statement is about motivation:

o Is this response about a child's willingness to be involved with or pursue an activity?

o Is this response about a child's persistence with a particular problem or activity?

o Is this response about a child's wish to avoid a particular problem, activity or situation?

If the response to any of these questions is "yes," then you will need to think about how this response fits into the motivation scheme outlined in this codebook (and you should continue the coding procedure with step 4 below). If the response to all of these questions is "no," then you will not be able to code this statement for orientation and level, and you should do one of the following:

a) If the response is a simple "yes" or "no," (or if the response is not explicitly about motivation), write down the response in the "Response" space. You should write "NR" in the column entitled "NA/NR." Then code the response (whether or not it is explicitly about motivation) for valence only, in the column entitled "+/-" by marking positive ("+") for a "yes" response and a negative ("-") for a "no" response. (See section entitled Special Coding Tips.) Then move on to the next response.

b) If the question is not asked (that is, if the question does not appear in the packet), write "NA" in the column entitled "NA/NR" and move on to the next response.

4) If you have confirmed that the response is about motivation, you will need to determine an orientation for this statement. Reread the statement, and look for clues to help you interpret the actual orientation of the statement. Ask yourself:

o Is this child primarily concerned with his/her performance, i.e. solving the problem, looking smart, obtaining favorable or avoiding unfavorable judgments? (Performance Orientation);

o Is this child personally involved with the task, i.e., saying that he/she finds it enjoyable, likes to think about things, wants to learn? (Engagement Orientation)

If the orientation seems ambiguous, you may want to come back to this statement after coding the other responses in this child's packet. The following are some helpful clues that characterize the two orientations:

a) Statements that indicate an interest in working on "fun," "interesting," or "new" things, an inclination to figure things out, a willingness to work hard or try hard (in order to figure something out), a valuing of learning for the sake of learning, tolerance for frustration and uncertainty, perseverance even when confronted with obstacles, enjoyment of the activity, and/or of challenges that lead to the acquisition of knowledge are examples of <u>Engagement</u> responses:

"Yes, because I really enjoy it. Because I don't know why."

"The shirt [PSA A*], because I wanted to see how it, how it, how it would look with different colors on it and different ways."

"Yes, just about what they asked me and stuff. I just kept on thinking about the games and stuff. Anything else that could be wrong with one. Like the first one [PSA C*]. Or if I could have done the little price tag things [PSA B*] differently."

"Yeah, because I like challenging things. Well you really don't know about it and you ain't too sure if you do know about it or not so you just gotta sit down and try and figure it out."

b) Statements that indicate an interest in doing easy tasks or tasks that do not take a long time, a focus on finding the correct solution to a problem, an emphasis on right or wrong answers or knowing how to do things, an inclination to work hard or challenge oneself because such effort demonstrates ability, a comparison of self to others, an avoidance of unfavorable evaluations, and/or a sense of self worth that is based on outcome are examples of Performance responses:

"This one [PSA A*]. It was easy."

"Yes, I thought that was the answer to the game [PSA B*]. I thought you had to do it instead of just putting them all on the table. [R: Did he/she say it was optional?] Yeah, but I just...I don't know. [R: Did you think you had to do it?] No, not really, but I just did?"

"Yeah...I like figure -- figuring things out, and stuff...It makes me think...It shows that um that I'm smart, I guess."

5) Once you have determined the orientation of a particular response, you will need to determine the appropriate level for this response. In order to know where to look, consider the following:

a) If the response is a general statement about the task, having to do with enjoyment (Engagement), ease or task requirements (Performance), and the statement is not about the process of problem solving or figuring something out, then it is a Level 1 response.

"Hm hm...Well, it's fun." [Engagement 1A]

"Dr. Game [PSA C*]...That's math. And the math Dr. -- the math that's in Dr. Game is easier than that." [Performance 1A]

"Mmm, the clocks [PSA B*]...Well, there's a lot more pieces in the game and you can mess around with them and have fun with them..." [Engagement 1B]

Within Level 1, there are two categories, A and B. These categories capture slight differences within the level. A statements are general statements about the task.

B statements are more specific statements about the task. Notice that in the last statement above, this child provides a specific aspect of PSA C* that he/she enjoys; therefore, the statement is coded as Level 1B.

b) If the response is a statement about trying to figure something out and/or an explicit statement about effort being expended either for the sake of acquiring knowledge (Engagement), or for obtaining favorable evaluations for the effort put forth (Performance), then it is most likely a Level 2 response.

> "Yeah...Maybe um have um -- first thing [PSA C*], it's fun...And...you get to solve problems...Which I like to do...I mean like to um...like you solve problems like that." [Engagement 2A]

> "This [worksheet]...'Cause I already did it...Well I made a hundred on it so I know I can do it again." [Performance 2A]

> "'Cause I thought it would be even more fun if I tried that... Because I will learn more." [Engagement 2B]

> "Well, I guess. Yeah. 'Cause it's kind of fun...Well, I -- as I said, I like multiplying a lot...'Cause uh when I first -- um multiplying looked easy but it got hard sort of, so I like doing it 'cause when sometime -- I think it was -- that was last year but we had a different math teacher. She went away, well -- we had to do multiplications and she would time us, and I would sometimes be the first one, except there's other smart guy in the fifth grade -- he could beat me. I'm one of them that do fast -- working on it." [Performance 2B]

Within Level 2, there are two categories, A and B, that capture particularly important differences. A statements are about figuring out, thinking about or solving the task, getting right or wrong answers, and/or knowing how to do something. B statements are explicitly about effort: working hard, learning or becoming "smart," and challenging oneself. Notice that the last statement above discusses doing "hard things" and demonstrating competence. This statement is an example of Level 2B. The statement preceding this one (33Q32) is also an example of Level 2B because it is specifically about "learn[ing] more."

c) If the response is about trying hard, pursuing challenging activities and working towards a goal, then it is a Level 3 response.

> "...Yeah...Because I like challenging things...Well a you really don't know about it and you ain't too sure if you do know about it or not so you just gotta sit down and try and figure it out." [Engagement 3A]

> "Yes. Well, cause I think it gets me a little more skilled. Well, I think like if I didn't know what something is and I learned it one time, maybe the next time I come -- Maybe I might know the same thing." [Performance 3A]

> "Yeah...I like figure -- figuring things out, and stuff...It makes me think... It shows that um that I'm smart, I guess." [Performance 3B]

Within Level 3, there are two categories, A and B. These categories capture slight differences with respect to the elaboration and explicit mention of goals. A statements are about pursuing and wrestling with challenges and/or about being competent. B statements are explicitly about working toward a goal. Notice that the last statement above indicates a goal for this child's involvement with an activity.

6) Next, you will need to determine the valence of the statement. Statements at any level can be positive or negative; however, children's responses are more often positive than negative.

a) Positive statements indicate a willingness to pursue or approach a problem.

"Yes...I just like playing the game [PSA C*] 'cause it's challenging. You get to try to find what's wrong with it..."

b) Negative statements indicate avoidance of a particular problem or situation.

"Probably not...'Cause I do..'. really know, cause I don't find out, I don't wan -- that I'm not gonna be able to do that one either. [R: Would you be interested in doing another one?] That neither -- even if I did, I wouldn't...'Cause I just don't feel like doing that one."

7) Now that you have coded this response, do the following:

a) Write down the child's statement (or an abbreviated version of it) in the appropriate "Response" row.

b) Place a "G" for Engagement or a "P" for Performance in the "G or P" column.

c) Place a check in the appropriate level column.

d) Place a "+" or "-" sign in the "+/-" column in order to indicate valence. [Please see SPECIAL CODING TIPS concerning issues of valence.]

8) Repeat these procedures for all responses.

C. Motivation Codesheet

SUBJECT: 9 CODER: Sumara

Q	NA/NR	G or P	1A	1B	2A	2B	3A	3B	+/-	Response:
7	NR								—	No
8	NR								—	Didn't tell grandma.
13		P	✓						+	Yes. looked easy.
16		G	✓						—	No. Like to take others, i.e. band
22		P		✓					+	Yes. cause it said to do 2x.
32		G		✓					+	A. Looks more fun Good game. Changing arnd
33	NR									A.
34		P	✓						—	C. looks hard.
36	NA									
38	NR								+	Yes.
63		P	✓						+	C. Easy to fix.
64	NR								—	Division.
81		P			✓				+	~~Hard~~ Easy Show smart.

NA = NOT ASKED
NR = NO ANSWER OR OTHER

D. Special Coding Guidelines

Coding Statements for Predominant Orientation

Sometimes children will give responses in which elements of both orientations are represented but the response predominates in one orientation. This section gives guidelines for coding statements for predominant orientation. To begin with, the coder should read all of the child's statements to develop a sense of the child's overall orientation and ways of expressing him- or nerself. The following guidelines will assist the coder in making decisions concerning predominance:

For these statements, you need to think about how the child relates to the experience of working with a problem or figuring something out. If the statement demonstrates a willingness to approach the problem (i.e., positive valence):

o does it indicate that the child is deeply involved in the process, wrestling with a problem, trying to understand something (i.e., Engagement)? Or,

o does the statement indicate that the child is primarily concerned with the outcome of this struggle? Can you envision this child asking: "will I look smart?" "Will I get it right?" "Will I succeed?" (i.e., Performance)

If the statement indicates avoidance of an activity or situation (i.e., negative valence), think about what the child is avoiding:

o Is the child avoiding the exertion of effort that might lead to frustration and confusion (i.e., Engagement)? Or,

o Is the child avoiding a bad grade, appearing dumb, failure as measured by some external standard (i.e., Performance)?

The following responses are predominantly Engagement statements (the part of the statement that indicates an Engagement predominance has been underlined). However, you will notice that aspects of these statements sound like Performance:

"Not all the time. 'Cause sometimes I don't figure 'em out. And I don't like it when I can't figure it out. I just get mad. 'Cause I want to figure out, I can't. 'Cause I just wanted to learn it, you know." [-G2B]

The above response to Q38: "Do you like challenging things?" indicates hesitation in pursuing challenging tasks because of the potential for getting them wrong or not "being able to figure them out" (a P2A response). However, this statement also indicates an overwhelming sense of frustration with the process of figuring something out because the child "just wanted to learn it" (a typical G2B response).

"The clocks [PSA B*] because it's easy! Clocks. Because it's easy. I don't know. I guess I'm just lazy! I don't know! I'm always trying to get out of doing work. And I always take the easy way out. I would probably pick the clocks." [-G2A]

Generally statements about doing "easy things" are coded as P1A. However, the above statement (in response to Q33: "Which [PSA] would you most like to work with again?") indicates an avoidance of "doing work" because of the effort involved, and is therefore more elaborate than simply liking to do "easy things." Thus, the above statement reflects negative engagement and should be coded as -G2A.

The following are predominantly Performance statements (the part of the statement that indicates a Performance predominance has been underlined). However, you will notice some aspects that sound like Engagement:

> "I felt the regular way I usually feel. But I also still was thinking about that game [PSA C*]. Well I was thinking that maybe there really wasn't anything wrong with it, but I thought that there was something wrong with it...That there, I was thinking that there wasn't something wrong, but I told [researcher] that I thought something was wrong." [+P2A]

Though the above response to Q7: "Did you think about it [PSA C*] after you left the room?" indicates continued involvement with the problem (a typical G2A response), the emphasis in this statement is on arriving at the correct solution (a typical P2A response), and meeting the researcher's expectations.

> "Yes. I just like playing the game cause it's challenging. You get to try to find what's wrong. [R: Do you like to do challenging things?] Yes...It's fun 'cause when I'm play my Nintendo. I, the games are challenging. I try to beat things" [+P2A]

Though the above statement to Q13: "If sometime in the future you had a chance to try another Dr. Game thing [PSA C*] would you like to?" indicates a willingness to be involved with the activity because it is "fun" (a typical G1A response), the emphasis in this statement is on competition and trying "to beat things" (a typical P2A response).

Coding Ambiguous Statements

Although there were very few ambiguous statements within this data set, this section provides guidelines for coding statements that are ambiguous in terms of orientation. Such statements are those in which both orientations, Engagement and Performance, can be identified and neither seems to predominate. In coding these responses, it is important to have determined an overall orientation for a particular child. This is accomplished by reading through the child's entire packet of responses and reviewing the orientation codes that you have already assigned.

For this type of ambiguous statement, in which there seems to be an equal emphasis on Engagement and Performance, you need to think about how this child is defining his/her terms and to look for clues in other responses about the same activity or in which the same terms are used. Note that there are very few responses like this.

The following is an example of an ambiguous statement in which a child defines what he/she means by "challenging:"

> Dr. Game [PSA C*]. 'Cause there looked like lots of things wrong with it, but some were already right, but I didn't know that. [+G2A]

In making a determination of how to code this statement, you should consider that: (a) five out of the eight statements coded for this child are Engagement; (b) though the child uses typical performance terms such as "right" or "wrong," the child is not talking about being evaluated; and, (c) that when discussing Dr. Game in other responses he/she talks about enjoying "finding out what's wrong" and about the activity as "fun."

Thus, in coding ambiguous statements in which there is no discernable orientation, you should:

- o consider the words the child is using and how he/she is defining them;
- o look for clues in other related responses; and,
- o consider how other unrelated statements are coded.

Questions 7 and 8

Questions 7 and 8 ask children whether they thought or talked about their experiences in the Day 1 interview, particularly in reference to the PSAs. Many responses to these questions did not yield statements that were specifically about motivation. However, all responses to Questions 7 and 8 should be assigned a valence rating because these questions were designed to target sustained involvement with the PSAs. A "no" response should be coded negatively, and a "yes" response should be coded positively.

Codable responses to Q7 and Q8 are about continued or sustained involvement with the PSA succeeding the interview. Non-codable responses are descriptions of what the child did during the interview, what the game was about, or how the child assessed his/her past performance.

o The following are examples of responses that should be coded for orientation and level:

> "...Hm hm. I was tryin' to think of what else I could um -- to figure out what was wrong with it [PSA C*]...Like um what kind of things I could do to figure out what was wrong with it and about the amoun. of chips...And I was trying to -- well, just think how -- what else I could do to figure it out."
>
> "Mm hm...Well I start thinking about if there was another way I could solve it."
>
> "My whole family...I made the game exactly like it and showed my whole family...Trying to figure out the problem."

o The following are examples of statements that should not be coded for orientation and level (but may be coded for valence):

> "Hm, not that much...Um, I thought about if um...I thought about what I was gonna do today."
>
> "Next thing I might do -- another of Dr. Game's games...I might be hired again to see wrong...Fun at beginning...Fun again."
>
> "No, I just told my mom that -- that y'all were back. [R: What did she say?] She said that's good."

Question 22

This question asks children whether or not they attempted to do the optional condition in PSA B*. There are two points to consider in coding Q22.

a) Because Q22 targets the reasons for a child's involvement with an activity in the past, many of these responses are simply descriptions of what the child did (and do not indicate a child's relationship to his/her involvement with the task). In such cases, these statements should be coded as NR.

o The following statements should be coded for orientation and level:

"Yes...'Cause I saw a lot cards, so I just went for it. 'Cause there was like a lot cards and all and I'd be bound to at least make one...Double. [R: Did it seem like you had a good chance?] Yes I got two doubled."

"'Cause I thought it would be even more fun if I tried that...Because I will learn more."

"Yeah...Uh just felt that I should do that...It's just, it's, it's just like something else makes me react and I, I'm not doing any it's just that my brain's telling my my hands and all that to react to something and I'm not even, I'm not even aware what I'm doing."

o The following should not be coded for orientation and level:

"Hm hm...At first I miscounted. And then I went to the middle table and I found it -- the oldest one. And I put in -- in the older table. And then I had gotten the optional part. [R: Do you remember why you decided to do it?] Hm, I don't know.

"No...'Cause like I forgot. 'Cause I had made a different row on the side. Just the people that were in twice -- I mean people that had the same age. So I made a different one instead of putting them in the same -- in the same line."

b) There are a number of cases in which a child explains that he/she did not try the optional task and then provides an elaborate reason that demonstrates at least an initial attempt at figuring it out. The valence rating for such statements should therefore be positive. Following is an example of this kind of statement:

"No...[because they] wouldn't be equal. One table would have little bit of people and they couldn't talk if it was life and there was lots of people. In real life then they wouldn't talk, they wouldn't have nothing to talk 'cause they don't have that much people there...And there was, if it was real life and there was real people there. And the young had the most and the middle and the oldest had a little bit. And there would be a, they, they can't talk about things that much. And the young will have a lot of things to talk about..."

"No...'Cause if I would have tried that, some of the older people would have been mixed up with the younger people...Like if I would have doubled the top row, some -- like the fifty-four years old would have been with the sixty-eight years old...[R: What do you mean doubled the top--or?] Twice as many -- put twice as many on.

Question 34, 38 and 64: Level

These questions ask children to talk about challenging activities. In Q34, children are asked to choose the PSA that they think is the most challenging and explain why. In Q64, children are asked to choose between PSA C* and a worksheet of double digit division problems. And, in Question 38, children are asked whether or not they like challenging things and why. Because the word "challenge" is embedded within these questions (and because pursuing challenging activities is typically a Level 2B response), there has to be explicit mention of effort required in the challenging activity, or the statement must indicate a high degree of involvement with the activity for the statement to be coded at level 2B.

o For responses to questions 34 and 64, level is determined by a child's explanation of why a particular task is the most challenging and what challenging means to this particular child. Thus, in order for Q34 and Q64 responses to be coded, a child must specify why he/she thinks the activity is challenging, and indicate his/her relationship to the activity. And, in order for a response to Q34 or Q64 to qualify as Level 2B, there must be explicit mention of the effort required or indication of a high degree of involvement with the activity. The following are examples of responses that should be coded at Level 2B:

> "...Competing like...like which one was more concentration and everything and thinking...I'd probably say the Dr. Game [PSA C*]...'Cause with the t-shirt [PSA A*] all you have to do was fix colors and order, that wasn't very hard. It, I could bring a kinder [a kindergarten student] and they probably could do this...the table [PSA B*] wasn't easy cause all you have to put was numbers in order. The Dr. Game was mostly hard because you had to really put your mind to work to see what was wrong with it 'cause you just can't go in saying...just the leg broke or something from the handle...You have to really put your mind to work and use many equipment like calculators, pencils, rulers, tools and, and many other things so you would have to really put your mind to work at that one to see what was wrong."

> "Dr. Game...'Cause it was hard and you had to think a lot and write down and write down, had to think a lot and try to figure out what was wrong with it and play the game if you want to...Dr. Game...I thought I was gonna find the problem easier, easy. But it was hard...[R: Was that different from the way that you though about PSA A*?] Yes...It was easier and you only, you just have to find different combinations. And you could just scramble em. And write em down like that..."

> "Dr. Game...[R: But you'd rather do the arithmetic worksheet?] Like I said I already know it. It's easy. [R: And is that important? if you already know if? or if it's easy?] Well, it's important to do things that are hard, also. You have to learn, for one thing, but, I pick [to do] this [arithmetic worksheet]."

o Similarly, for responses to Q38, statements must indicate a high level of involvement with the challenging activity in order to be coded at level 2B. The following are examples of such statements:

"Yes, 'cause I'm one person that likes to do all those kind of stuff even though I'm fun, even like, not fun but even though I'm old or young or...I don't know I'm, I just grew up like that liking all those things, that's my future that I like to do those things."

"Yeah...Well...because it takes uh extra effort..."

Questions 32, 33, and 63: Valence
These questions present choices as to which PSA (A*, B*, or C*) the child liked the best and would like to work with again (Q32 and Q33), or as to which activity, PSA C* or the arithmetic worksheet, he/she liked the best (Q63). Thus, when a child simply chooses an activity and does not explain why, it will not be possible for you to assign a valence rating for this statement. Therefore, responses are only assigned a valence rating when a reason for the choice is provided. If, for example, the child chooses PSA C* in response to Q33, but does not provide a reason for his/her choice, this response should receive an "NR" and should not be assigned a valence rating.

Questions 34 and 64: Valence
The valence ratings for responses to questions 34 and 64 are dependent upon responses to the previous questions (33 and 63), in particular to the choice of activity presented in those questions.

A response to Q34 receives a positive valence rating if the child's choice of activity (PSA C*, PSA B*, or PSA A*) is the same as their choice of activity for Q33 (PSA C*, PSA B*, or PSA A*). A response to Q34 receives a negative valence rating if the child's choice of activity is different from their choice of activity for Q33. Thus, if child chooses PSA B* in Q33, and PSA B* in Q34, valence is positive. If child chooses PSA B* in Q33, and PSA C* in Q34, valence is negative.

Similarly, a response to Q64 receives a positive valence rating if the child's choice of activity (either PSA C or arithmetic worksheet) is the same as their choice of activity for Q63 (PSA C* or arithmetic worksheet). And, a response to Q64 receives a negative valence rating if the child's choice of activity is different from his/her choice in Q63.

E. Coding Scheme with Examples

This section provides an elaborate description of the motivation coding scheme and examples of children's responses in the appropriate coding categories.

ENGAGEMENT

LEVEL G1: ENGAGEMENT Involvement in and enjoyment of the task, activity or experience. Responses may refer to the task in general terms, or responses may refer to specific aspects of the task that the child enjoys (or does not enjoy). There is no mention of effort in these statements.

A. Positive responses indicate involvement with the task, experience or activity because it is fun, exciting, a game, or because the child "likes it." Negative responses indicate avoidance of the task because it is unpleasant, boring, or "not fun." Responses are general and tend not to be very elaborate.

Positive:

"This [arithmetic worksheet]. Because um this is fun. I like math. The division part."

"Yes, because I really enjoy it. Because I don't know why."

"This one [PSA A*]. Because I like to work with colors. I like colors."

"Play Dr. Game [PSA C*]. Because Dr. Game is a game that I like doing games and fun things. But then I like math too, so. I'm saying that Dr. Game I like to do."

"Yes, I just kept on thinkin' what - what I was doin'. I wish I just could stay here longer. My body was giving me like a signal, like a funny signal. I don't know. it just gave me a funny signal and then I decided to some back cause we haven't seen you for a long time so -- so it won't -- when I meet a person again or something -- and the camera's right in front of me and everything, I just feel kind of funny. I feel kinda nervous. Or I feel exciting. 'Cause I like doing... Yeah. I was waiting for you to come. I didn't want it -- I really wanted to come but I -- but I had to do it on Wednesday. Dr. Game."

Negative:

"Yeah, I guess. It's sorta fun looking for stuff... takes up my school time. Well, then I don't have to do social studies. 'Cause they're doing social studies in class right now."

"Finding out stuff in the Dr. Game. Well, because it takes a long time cause it's hard, so um it takes up I guess most of my school time."

"I love challenging things. Because I hate sitting at home doing nothing, so I go ask my brother to go give me a challenge or riddle or something. We -- I usually get it right."

LEVEL G1: ENGAGEMENT

B. **Positive responses indicate involvement with the task, activity or experience because the child finds the task interesting, novel or because specific aspects of the task are enjoyable. Negative responses indicate avoidance of the task, activity or experience because it is not interesting or because specific aspects of the task are not enjoyable. [Children often talk about the entire activity as unenjoyable, and not about specific aspects of the problem as unenjoyable, therefore, we have not found any -G1B statements in coding the data.]**

Positive:

"Yes, 'cause I think it [PSA C*] would be fun. [R: What made it fun?] Rolling the dice and flipping the coin."

"Yes, 'cause I like to fix things..."

"Well, not all challenging things but something like the Dr. Game, yeah. 'Cause I like hide and seek. I like to play that and um well that was something like hide and seek. 'Cause I had to find uh some -- us what was wrong with it."

"Yes, because it's interesting..."

"Because the way I was doing it [PSA B*] would've just gone along with it anyway. [R: Was it interesting to you?] Yes, 'cause you're always spending your time and you're thinking like where's the lowest number, and you find the lowest number. And you find the next lowest."

<u>LEVEL G2: ENGAGEMENT</u> Involvement in and enjoyment of problem solving process. Willingness to expend energy, try new things, and challenge oneself. More global understanding of problem solving process. More involvement of self in figuring out process.

A. Responses are general and refer to the more global aspects of problem solving process. Positive responses indicate a willingness to "figure out," "think," look for alternative ways to figure out a problem, and/or experiment. Negative responses indicate avoidance of, anxiety or fear relating to involvement with the task at some level of complexity, i.e., in "figuring out," "thinking," or experimenting. Another example of a negative response might indicate avoidance of an activity that might be boring because another activity presents the opportunity for more substantive involvement.

Positive:

"Yes, because it's fun. It's fun um fixing the game. Because you're helping Dr. Game [PSA C*] fix his game."

"Dr. Game. 'Cause we-re -- I like to work -- to work and figure out things. Like these guys. And fix 'em and everything. And that's the kind -- it was almost like Dr. Game what you had to do. Then I would pick this one."

"Mm yeah...Well it'd be something to do...Mm hm...Uh because, because it might be just something different. Because last time it was different. And this time it was different. So it would probably be a different challenge..."

"Hm hm...Because they're fun...Because you get to solve something...And you get to think about it. That's why."

"Yes, just about what they asked me and stuff...I just kept on thinking about the games and stuff...Anything else that could be wrong with one. Like the first one [PSA C*]. Or if I could have done the little price tag things [PSA B*] differently."

Negative:

"Hm not really... Hm, it was fun and all but not really...Well, um...um...just being -- it was fun but not real um...I don't really like to solve problems and all that."

"[Things are fairly easy so I'll do well]. I don't like using my brain a lot..."

"Dr. Game [PSA C*]. 'Cause -- well, they're both pretty hard, but this [arithmetic worksheet] is boring."

B. Responses are explicit about the effort required in working with a particular task and indicate that the child is approaching a more complex involvement with the task. Positive statements indicate a willingness to expend effort, and an interest in working with challenging activities, learning new things, or using one's mind. Negative statements indicate an avoidance of effort and a complex involvement with the task, and/or an avoidance of thinking hard.

Positive:

"The Dr. Game [PSA C*]. You had to think more. It was harder. You had to...see, this [PSA A*]? It -- like, you didn't have to -- you just had to change 'em around. On the game [PSA C*] you had to find something and figure out why and all that. And like on the clocks [PSA B*], you just put 'em on a shelf. And on the game, you had to -- you had to add up a lot of numbers and all that. You had to find out."

"Yeah things are kind of fun to to just work out...Well they're like, they're not just real easy like you just ru -- run through it. You have to think about it and you have to, you have to like put your mind into it and it's, it's not just easy, you could, it's kind of fun to figure out things. In my opinion I like to figure out things...Well like if it's, if it's ki -- yeah -- I like hard things to do because it's not just, I'll like, oh, like I know it and then it's just run through it. I like to sit there and I like to figure out things. I don't, it's fun for me to just figure out things like that."

"...Because there's not only one math problem you can figure out, there's a whole bunch of others so like you're climbing a ladder and each time you get higher and higher as you do the math problems."

LEVEL G2: ENGAGEMENT

"Dr. Game. 'Cause I mostly all -- I mostly did these at class -- mostly. So, Dr. Game is like a new experience to me."

"Because it's math [arithmetic worksheet]. [R: 'Cause it's math? Is the Dr. Game math?] Mm sometimes. When it has like that spinner one, it had numbers, that's math cause you, you knew what the numbers were...[R: Why would you like to do this?] Because I like to do division.... Because I get to learn things like, like um if somebody, if you have like a piece of candy and your Mom says you have to split it with your friends, you have to know how many friends and you divide it. And you have to cut it."

"Dr. Game...It had a catch to it. You had something to do. You're not really figuring out something -- well you are figuring something out but you also get to become part of it. You get to play the game, and you get into the game by playing it. That's really what it's like."

Negative:

"This one [PSA A*]. Because it was -- you -- you like get to put it in their own ways and write down -- put it -- put in a different way. As many ways as you can. And the other one was a little more hard. They were hard. This one's not hard. [R: Could you do the other things? The Dr. Game thing or the tables in your own way or no?] Hm hm...but I like this one better...Because this one was easier and the other one you had like -- you had um you have to really think about it. And this one, you didn't really think about it."

LEVEL G3: ENGAGEMENT Responses reflect a high exertion of effort either explicitly (i.e., the task is very difficult and requires working hard), or implicitly (i.e., the risk involved in pursuing a novel and seemingly difficult task). Statements relating specifically to the process of learning or acquiring knowledge. High tolerance for uncertainty about process and successful outcome.

A. Positive responses indicate a willingness to exert effort despite uncertainty about outcome and/or a high tolerance for frustration or mistakes. Positive statements also indicate a valuing of learning for the sake of learning. Negative statements indicate avoidance of frustration and uncertainty.

Positive:

"Yeah, 'cause I never done 'em before and probably it's a new experience to me. Like the doctor -- like the time that I first met you I didn't know what Dr. Game. It was like challenging to me because -- since we're gonna get to middle school next year, since I'm in 5th grade...Or they're like -- we're not like kindergartners, that you get a chance to play and do stuff like that. Yeah, we get to put -- do art, right? I draw every day and stuff like that. They barely work [you] over there in that part. Over there you got like the teachers to teach you and everything, to help you...[but it's not like that] here. It's almost like you're on your own and everything."

LEVEL G3: ENGAGEMENT

"...Yeah...Because I like challenging things...Well a you really don't know about it and you ain't too sure if you do know about it or not so you just gotta sit down and try and figure it out."

"Things I'll learn something from even if make a lot of mistakes. Well because I like learning new things. Doesn't matter how many I get wrong as long as I learn how to do it."

"Yes...Well, because um what I did was uh real fun even though it was kind of a -- a thinking project, I still like to think a lot and -- and when I think a lot I think I learn a whole bunch more and kinda forget a little but I could easily gain that little that I forgot and then I could ah remember stuff about what I learned."

Negative:

"No...Um...they're just so frustrating to work with."

B. Statements may relate to personal and future goals. Positive responses indicate enjoyment of challenges, process of acquiring knowledge, and learning for learning's sake. Statements may also indicate sustained involvement with the task. Note that we have not found any negative G3B statements in coding of the data.

"Mm hm...Because it was kind of like a challenge thing. And I like challenges. It's like a challenge because, I mean it makes you think harder and stuff. And in being able to think harder, it makes it more easier later on in your life, whenever you're trying to do something that's hard."

"They asked me how my day was and I told them, "Oh. its great!" And I explained the games to them and stuff. And I even made them those little games. The first one...Got some old plank and I put some numbers and I -- and my cousin John, he's real nice, he helped me make the little arrows. And he nailed them in for me. And then I already had some bingo chips that I could use and I made these - my brother made these little paper guys, because he's good at drawing, and then I used some rubber bands like that I -- that I glued together with - not like glue buy you could heat em up and they'll stick together then they'll dry to make the -- number board. And I put paper over it and we all played it. The orange guy always won. [R: What did your family think?] that's a neat game. They said the orange guy always wins. So we were -- everybody always wanted to be the little orange guy!"

PERFORMANCE

LEVEL P1: PERFORMANCE No or little mention of effort. Ease and/or speed. Emphasis on task and what it requires. Explanation of involvement with task is general.

A. Positive statements indicate a willingness to be involved with task because it is "easy" or does not take long. Negative statements indicate avoidance of hard or difficult tasks and are not elaborate.

LEVEL P1: PERFORMANCE

Positive:

"This one [PSA A*]...It was easy."

"Dr. Game [PSA C*]. [R: Why?] That's [arithmetic worksheet] math. And the math Dr. -- the math that's in Dr. Game is easier than that."

"Dr. Game. [R: Why?] 'Cause that one makes me figure out an easier thing than this [arithmetic worksheet]."

"This one. [R: Why is that?] It's the easiest."

Negative:

"(Shakes head)...I think it would be too hard...I don't know...Probably the problems."

B. Positive statements indicate a willingness to be involved with the task because of external demands of task or what the task requires (may or may not be accompanied by ease or speed statements). Statements about competition that do not indicate effort or challenge. Reasons for doing the task that sound removed from the child. No sense of internalized competence. Negative statements indicate avoidance of external demands, i.e., constraints of task or situation.

"Yes, I thought that was the answer to the game [PSA B*]. I thought you had to do it instead of just putting them all on the table. [R: Did he/she say it was optional?] Yeah, but I just...I don't know. [R: Did you think you had to do it?] No, not really, but I just did?"

"Bets. Because if you lose, you gotta pay the money. If you're the loser, you gotta pay em the money. [R: Why do you like bets?] I dunno. I guess 'cause you can win stuff on bets. [R: Do you like other kinds of challenging things?] No. [R: You said that Dr. Game was challenging because it was hard. And you said bets are challenging too. Are they hard?] No. Bets are challenging. They're not hard."

"Mm hm, yes...it's helpful to learn...It might help you when you grow older?... Like if someone tells you to kind of think about it, do stuff like that...The way we were doing like, maybe they probably later on tell you about that, about the games, and stuff."

Negative:

"No...'Cause um, like I said it, eeep in um hard ones or just like the Dr. Game thing I had? [R: Well whatever you think, what do you think you would learn in a class like that?] Um how to use 'em, how to um work 'em out, work out the problems and stuff...[R: But you wouldn't like to take a class like that?] No...Because um um I used to -- I'm used to doing other things besides um the this the Dr. Game thing and other stuff. Like the other stuff...[R: What do you mean?] Like our teacher, he/she never lets us have fun until we finish with all the work, okay. So I'm used to like doing everything first before I can go outside and play or stuff like that."

LEVEL P2: PERFORMANCE Specific mention of solution. Mention of effort required in easy/hard terms. Approaching a more internalized sense of competence.

A. Positive responses indicate a willingness to be involved with the task because it is possible to obtain the correct solution, "right answer," "good grades," or because the child "knows how" to do it. Positive responses may also be qualified "hard" statements that indicate a willingness to be involved in activities that are "hard, but not that hard." Some positive statements indicate a willingness to be involved with an activity because such an endeavor would be a test of competence. Negative statements indicate avoidance of an activity or situation because of fear of lack of competence, an incorrect solution, "wrong answer," "mistake," or "bad grade."

"The last one. [R: 'Things are hard enough to show I'm smart?'] Yeah. I guess because like it was six divided into like a real long number, then if I get it right, um then...I'll show that I'm smart. [R: Does this statement do a good job of describing most of the things that you like to work on?] Uh, I really like this one and this one. [R: Okay, the first one and the last one?] Yeah. [R: But if you had to pick one that best describes the things that you like to work on the most, which one would you pick?] I'd pick the first one. [R: Okay. So 'things that are fairly easy so I'll do well?'] Yeah."

"...This [arithmetic worksheet]. [R: How come?] 'Cause I already did it. [R: What does that mean?] Well, I made a hundred on it, so I know I can do it again."

"Something similar to this [PSA A*]...I know how -- now I know how to put things in order."

"Yes...well I'd like to try it over again and see if I could do it this time."

"Yes...Um to see if I could um figure it out this time."

"Probably this one...'Cause it's challenging...Well next to the...schoolwork, well, it's hard but some parts of it are easy...And this -- and this has -- well, it's not like school work and it's fun...Well -- you don't have to worry about getting things wrong. And being graded and flunking."

Negative:

"Dr. Game [PSA C*] because you don't really have to put your concentration and well you do have to put your concentration but not really as this 'cause over here you have, you have to be writing your times tables and everything 'cause I know some people don't know what forty could go into. I know forty could go into two and to twenty-five but to fifty-two I don't think they're gonna know it real quick, five and then hurry up and write it down, I don't think they're gonna know it good like that..."

LEVEL P2: PERFORMANCE

"Didn't try [the optional part of PSA B*]. 'Cause I like doing easy stuff and so I just put the thirties and forties and stuff like that together. I didn't try the optional part. [R: What do you like about easy stuff?] Easy stuff like, uh, well, when I know I'm good at it."

"I dunno...I'm not sure. I don't think so...Because sometimes they might be too hard and you can't figure out what's wrong..."

B. Positive responses indicate a willingness to be involved with an activity that requires a great deal of effort, or that is "hard" because such effort reflects or demonstrates ability. Some positive statements may indicate a willingness to be involved in a competition that is challenging and requires effort. Negative responses indicate avoidance of difficult task because this exertion of effort might reflect a lack of ability or result in poor performance.

"Well, I guess. Yeah. 'Cause it's kind of fun...Well, I -- as I said, I like multiplying a lot...'Cause uh when I first -- um multiplying looked easy but it got hard sort of, so I like doing it 'cause when sometime -- I think it was -- that was last year but we had a different math teacher. She went away, well -- we had to do multiplications and she would time us, and I would sometimes be the first one, except there's other smart guy in the fifth grade -- he could beat me. I'm one of them that do fast -- working on it."

"Mmmm mmm mmaybe...'Cause they're sort of easy...[R: Do you like something real hard?] Mm hm...Um because I'm used to doing real hard things. Like my brother, he teaches me all this stuff, real hard stuff and then um, he, he shows me and like, he makes me divide this long, long number. And then um you know if I miss it he says okay and stuff. So I -- so and then I, now I got a...but no, oh no. [R: So but you like it when it's hard?] Yeah."

"Yeah. [R: How come?] I don't know, I just like 'em. [R: What about them?] Well that like, like it's an older person that I'm playing with and they sort of like got an advantage over me but once I get smart enough I got the advantage over them."

"The last one [Things that are hard enough to show that I'm smart]."

Negative:

"[I would like to do] the Dr. Game. Because this [arithmetic worksheet] is one of the things that I discovered that was kind of hard. Double digit divisors. I had to go over it and over it. It's hard for me."

"The game...Because you really had to think about it and what I was thinki[illegible] there really -- there really was something wrong with it and you really -- it was like -- I thought it was gonna be obvious and I was gonna look dumb because I didn't know or something...I just -- I was -- I was just tryin' to think as hard as I could but -- you have to look at it and just keep thinking of what could be wrong with it...And really concentrating on it."

LEVEL P3: PERFORMANCE Emphasis on ability or level of competence. High effort. Involvement with process is means of demonstrating competence in the present or future. A valuing of learning in order to demonstrate competence. Statements that indicate goal directed behavior.

A. Positive responses indicate a willingness to be involved or pursue an activity because of the competence that will be gained and exhibited. Responses may indicate a willingness to be involved in an activity because the child knows how to do it.

"Yes. Well, 'cause I think it gets me a little more skilled. Well I think like if I didn't know what something is and I learned it one time, maybe the next time I come -- maybe I might know the same thing."

"Because the first time I did this yesterday it was easy and if I do it again, it'll probably get harder and harder and then it'll be easy...Because um, we always, like my teacher says that we always get the hard stuff, and not the easy stuff..."

"It's like, 'Oh I'm gonna be able to get it' Because it's gonna be easy to be um it might be hard to y'all but it's gonna be easy to me...Because I already know all the hard stuff...[R: How do you learn the hard stuff?] It just comes to your head...No. You just learn it. Like yesterday we learned subtracting fractions. My teacher told us that last year his/her class, they took three days to find out how to subtract fractions, and we learned in just that day. [R: Was subtracting fractions hard?] No, it was easy. [R: What's a hard thing that you learned?] Uh, I don't know! [R: Are they all easy?] Hm hm."

"I guess...Like if you wanna be a teacher and you'll know how to explain to the students and show 'em how to plus and multiply things. Numbers -- multiply numbers."

Negative:

"I did this page before -- I didn't never want to do this page again...Because one time when I did this [arithmetic worksheet], I didn't really know how to do it, you know, and I don't wanna do it again...Well, because it was real hard! Too hard."

B. Enjoyment of challenge and acquiring challenge because demonstrates competence. High effort. Note that we have not found any negative P3B statements in coding the data.

"Yeah...I like figure -- figuring things out, and stuff...It makes me think... It shows that um that I'm smart, I guess."

"..um the last one. [R: 'Things that are hard enough to show that I'm smart?'] Yeah...well, well probably because if you're doing a hard mystery and then if you solve it and then you feel good and...or like in math and we do a hard pro -- problem and then ev -- nobody can figure it out and then everybody um, well, thi -- thinks you're smart or something...Yeah 'cause then you can feel good about yourself and then you know you can, then you um have confidence that you can do something hard."

APPENDIX III.I:

Categories for Descriptive Analysis:

Enjoyment

Responses to Q55 by Category

QUESTION 55: Can you tell me about a time where you did something in math that you really enjoyed? What was it? What about it did you enjoy?

Distribution of Responses
N=47

Computation:	43%	(20)
Other Areas of Mathematics:	40%	(19)
Miscellaneous:	6%	(3)
Non-Responses:	11%	(5)

COMPUTATION

This category includes statements that mention numbers, any or all of the four basic operations, double-digit divisors, computational word problems, or mathematics worksheets.

How to um multiply and divide. Well, it looked pretty funny when you have to divide with that um the line going on top of the numbers, and everything...The way I learned it is just to take the number that's out here and if it was bigger than the number that was closest to this line, you need to see how many times that number would go into the number outside of it. And you'd put that number up here.

When I do double digit-divisors. When you multiply two numbers...Into a whole bunch, like three or four numbers...It's you have to think about it a lot.

Yeah, I enjoy the papers they gave us for math -- they have to figure out the problem and color in on that. On um multiplying and learning my multiplication I like that...It's a paper that they give -- that has a whole bunch of problems that you have to solve. You have a like a not like --like a little [legend] but not on a map just like a [key]...and it tells you what numbers to color. The answer was forty-two, you color a certain color.

Yes. The division, you had a, divide by the thousands. You had to divide that, that was pretty interesting to me...Cause at first, I didn't know how to do it, I knew how to do it only with one.. So with two it's pretty hard. It'd be fun just to figure out how to do that. Like if you, your little brother,little sister come up to you and they just barely knew how to do it you would probably tell them to, not tell them to, not tell them but show em how to do it.

Word problems. The way -- it was just like the Dr. Game. It was just like the game thing that you...Well, some guy broke in but he stoled stuff. And you had to figure out what he stole, so you -- how many things that he stole. And so you have to count up all these things and then you have to times it by two.

OTHER AREAS OF MATHEMATICS

This category includes statements that mention fractions, decimals, least common factors, telling time, measurement, geometry, algebra, trigonometry, probability, symmetry, area, perimeter, graphs, or general problem solving (i.e.,that problem solving that does not pertain to word problems).

Um...Mostly I'd [always -- were it] hard to me, well not hard hard hard, but hard for me to concentrate and everything. One of 'em was multiply, but the really one that I have really liked was, we were in it yesterday, we only had two days cause it was real simple. It's area equals length times width. That was real simple to me.

Perimeter...Because you get to use the ruler and count each side...And and and you get to figure out how many sides that perimeter has...Because like, and you also you get to know what's a polygon and a hexagon, an octagon.

Symmetry...I could draw the other side...And I could cut it out and it's equal.

Mmm, today um, when we did, um, see what did we today, we did something like um,...like, um, making um, equivalent fractions like, see you have um, you have, you have one half and then you got six squares right here, the squares here. And you got four, five, and six. You got the squares? And then you got um,...then you got um, the easy way, [the teacher] said that we had to multiply and stuff on a piece of paper but I didn't want to so I just went, two three four five six seven and all you gotta do is just do two times two is two four six eight ten twelve fourteen...I enjoyed it, it's easy and stuff.

Well, yesterday my Dad helped me with square surface. And stuff. Like there's usually three numbers, and my Dad said to multiply the first number times the, one of the numbers, then that first number times the other number, then these two times each other and add it all up times two and that would be the answer. The surface.

MISCELLANEOUS

This category includes statements that mention activities or experiences that are not directly related to mathematics, e.g.,"teaching math to a friend" or "learning something new."

Um, well, yesterday...I liked it because uh, I would um, during this time when I come, I'm missing math, and um, and we go like I have to still do the math work. And I like it because um, I'm, I don't know how to do something and then it, and then I, I go, oh I know how to do -- you know, my teacher comes and then I, I go, oh I know how to do -- you know my teacher comes and explains it and, and she's, she's real helpful and she, and she like gives me three examples and all. And then I can, I can, after that I'll, I'll work it through and it won't be real hard for me. And then in, and then like my friend. When I was here she was at the nurse and then I got to teach, teach her how to do it because she didn't know how to do it because she didn't know how either...Well, I like, like I said I like being a teacher because I like teaching things and, and giving assignments like to my sister when we play school and all. And um like being helpful a lot.

I enjoyed learning it because I know I, I can know something new.

Breakdown of Subject Characteristics for Q55

CATEGORY	TOTAL	GIRLS	BOYS	MIN	NON MIN	MED SES	LOW SES
COMPUTA-TION	43% 20	33% 8	52% 12	44% 14	40% 6	40% 10	45% 10
OTHER AREAS	40% 19	50% 12	30% 7	41% 13	40% 6	36% 9	45% 10
MISC	7% 3	8% 2	4% 1	6% 2	7% 1	12% 3	0% 0
NON-RESP	11% 5	8% 2	13% 3	9% 3	13% 2	12% 3	9% 2
TOTAL[1]	101% 47	99% 24	99% 23	100% 32	100% 15	100% 25	100% 22

[1]Because of rounding, not all of the columns sum to 100%.

Responses to Q56 by Category

QUESTION 56: Do you usually enjoy doing math? How come?

Distribution of Responses
N=46

Positive:	70%	(32)	Negative:	30%	(14)
Enjoy Learning:	24%	(11)	Repetition:	17%	(8)
Fast/Easy:	20%	(9)	Difficulty:	9%	(4)
Doing Tasks:	7%	(3)	Other:	2%	(1)
Other:	4%	(2)	Non-Responses:*	2%	(1)
Non-Responses:*	15%	(7)			

POSITIVE RESPONSES

ENJOY LEARNING

These statements indicate that the child enjoys mathematics because he/she enjoys learning it.

Yes [enjoy math] Because you're really just, the whole day you're usually working with, with words and stuff, but a. a certain, at like math, math time you, you change to numbers and fractions and stuff.

Because it's fun. You learn things that you didn't know before...Um [you] do it on your own.

Yeah. Cause i know it good and if I didn't know it good then I probably wouldn't enjoy it cause I have to be learning it more and more -- and I get stuck in some parts.

Yes. It's my best subject. My favorite. Because it's, it's it's, very useful and we're going to need it and it's fun.[Why fun?] Like you can just write down the problems and addition and you get to learn.. all sorts of things having to do with math.

Um see, me and my friends, we liked it because um, sometimes it's fun to learn all this multiplication and adding. And sometimes the teacher makes jokes about it, and we start laughing. It's, it's a real fun subject -- it's a real fun subject to me just to learn.

* Note that within the non-response categories, seven children responded positively and one child responded negatively without giving explanations for their feelings.

FAST/EASY

These statements indicate that the child's enjoyment is dependent on his/her ability to do mathematics well (by doing it fast or finding it easy).

It's my favorite subject. It's easy. That's it.

I get, I'm getting good grades on math. And the other subjects and when I get a hundred on math, I j -- I'm real proud of me I give that paper to my Ma. To look at it. That's all.

The teacher teaches us new things -- she teaches us tricks and how to do math and how to get answers real quick.

'Cause it's easier than all the rest of the subjects.

It's my favorite subject. 'Cause I learned how to divide and subtract and all that. God, we learned that in kinder, so I mean, we learned that in kinder but when you get to hard grade you know how to do it but in a different way, faster way. I guess that's the way.

DOING TASKS

Statements in this category describe mathematical tasks that children find enjoyable.

Because I could, I could learn the easy ways and things like that and I like adding subtracting and multiplication. [Why?] Because it's fun doing those things.

Yeah. They have a lotta favorites in math. My favorites. Ratios, and the time test and uh division.

Yes, 'cause I like dividing and multiplying. I like to um -- do different things like that. I don't know. Make a game for -- me and my brothers. I can help my brothers practice math.

NEGATIVE RESPONSES

REPETITION

These statements are complaints about the way mathematics is taught and often point to the repetition involved in learning mathematics.

Sometimes if it's not too hard...[What don't you enjoy?] Well, that I might have already learned it, and it's um sometimes boring to learn that same thing again.

Not all the time...Um, sometimes I don't enjoy when we already have learned about it and then we're going to other things and then we come to the middle of the year we have to learn about it again. And that's sometimes I don't like that. I like just going on to other things instead of going back. 'Cause sometimes we have to go back.

Because sometimes it's boring and all that kind of stuff. Like when you take a, a test and you already passed it you don't really need to take it over...like with paragraphs, the teacher gave me one that they didn't even know or anything and then one day that, that same page it came up, I did it, and then they made me do it again. I didn't like that.

'Cause to me it's like a big bore. Um it would be funner playing the Nintendos than doing math and multiplying and stuff. Um, just boring. I felt like falling asleep. [What's boring?] Well, my hand gets tired and stuff...And that's it.

No I used to but not anymore. Well I guess it's getting a little harder. And um, and it's hard for me to learn because also my teacher is uh they say like in words that children don't know. Don't know the meaning of or something.

DIFFICULTY

This category encompasses statements in which the child mentions the difficulty of a task as a reason for not enjoying mathematics.

Not all the time. When I don't know how to do it. When I get em wrong or something. I don't like to get them wrong. [When do you enjoy it?] When I get my answers right.

It's not really my favorite thing to do. 'Cause it's hard. It's real hard. Math is just a real hard subject to me. Hard to think about it a whole lot.

Well, sometimes when like I have a math problem or something, I can't really figure it out. I get impatient and...and I get real angry...That I can't figure it out and everything, so, I get all upset.

Breakdown of Subject Characteristics for Q56

CATEGORY	TOTAL	GIRLS	BOYS	MIN	NON MIN	MED SES	LOW SES
POSITIVE							
ENJOY LEARNING	24% 11	20% 5	29% 6	19% 6	36% 5	24% 5	24% 6
FAST/EASY	20% 9	20% 4	19% 4	25% 8	7% 1	19% 4	20% 5
DOING TASKS	7% 3	8% 2	5% 1	9% 3	0% 0	0% 0	12% 3
POSITIVE OTHER	4% 2	4% 1	5% 1	6% 2	0% 0	0% 0	8% 2
NON-RESP	15% 7	12% 3	19% 4	13% 4	21% 3	14% 3	16% 4
NEGATIVE							
REPETITION	17% 8	20% 5	14% 3	19% 6	14% 2	29% 6	8% 2
DIFFICULTY	9% 4	8% 2	10% 2	3% 1	21% 3	14% 3	4% 1
NEGATIVE	2% 1	4% 1	0% 0	3% 1	0% 0	0% 0	4% 1
NON-RESP	2% 1	4% 1	0% 0	3% 1	0% 0	0% 0	4% 1
TOTAL[1]	100% 46	100% 24	101% 21	100% 32	99% 14	100% 21	100% 25

[1]Because of rounding, not all of the columns sum to 100%.

Responses to Q15 by Category

QUESTION 15: Was [PSA C*] fun? How come?

Distribution of Responses

N=44

Involvement with Task:	50%	(22)
Thinking/Problem Solving:	30%	(13)
Social Aspects of Task:	11%	(5)
Non-Responses:	9%	(4)

INVOLVEMENT WITH TASK

These are responses that indicate that the child enjoys the "hands-on" aspect of the task (e.g., playing the game, fixing the game, etc.)

It was fun because like you could -- you wouldn't know what it would land on and you'd have to either times it or plus it...And then look on the board to see who'd get the point.

Because um you did it on your own and you weren't -- you were doing stuff that nobody else does.

When, when you had to spin em around and it landed on times or add, you'd get, you'd look um, the, the little board and it had had in the orange line, if it had, a nine, you put an um or a an a chip to, to the orange man. And if it had it on the green, you put a, put a chip to the, to the green man.

That, of the, the, the game, way, the way you're -- you're supposed to play it...About the game, the way you're supposed to play the game.

When I looked at everything it was fun because when I picked it up and there was two little people standing right there and then you could roll the dice to try to figure out something. And you flip a coin. And then you put some things.

THINKING/SOLVING PROBLEM

This category includes statements that indicate that the child enjoys the thinking or problem-solving aspect of the task.

Well, just playing the game and, and like um, knowing that at the end you'll like say that you have a, like a mystery to solve and at the end you'll prob -- you'll solve it and that'll be fun.

Well, because [the player] then um...you, you get to think um that um how to do it or -- or um -- it was fun because you get to...Okay. Alright, it was fun because um, that uh, you know, you got to think. And it was easy to think and that makes fun.

There's a catch to it. First, you have to figure out something wrong, and there's so many things you have to do.

Because you to solve some -- you had to -- tell what's wrong with the game and everything...It's just that I like um solving things. I like solving problems and stuff...I like adventures and stuff...Like adventure books and stuff so um that's what I like about it.

Well, to look at everything and discover things that I hadn't seen before.

SOCIAL ASPECTS OF TASK

This category includes statements that indicate that the child derives enjoyment from the interview experience itself or from the context presented by the task.

Well, there were so many different pieces and, and you, when I was picked that made me kind of feel like I was good. When I was picked out of, out of our class.

Playing it and talking about it.

Because I got to fix a game and answer some questions too.

Um, the people [the cardboard players], the, they were, they looked kind of funny. And um, and then the, now, now about it. I felt like I had people there like a companion, cause they felt like, they looked kind of funny. Cause their , their um, they were stuck in like, it, it, they looked like they were stuck in cement, so, so, and they were trying to get out, so they looked kind of funny.

Breakdown of Subject Characteristics for Q15

CATEGORY	TOTAL	GIRLS	BOYS	MIN	NON MIN	MED SES	LOW SES
INVOLVE TASK	50% 22	61% 14	38% 8	47% 14	57% 8	59% 13	41% 9
THINK/ P-S	30% 13	22% 5	38% 8	30% 9	29% 4	23% 5	36% 8
SOCIAL	11% 5	9% 2	14% 3	13% 4	7% 1	9% 2	14% 3
NON-RESP RESPONSE	9% 4	9% 2	10% 2	10% 3	7% 1	9% 2	9% 2
TOTAL[1]	100% 44	101% 23	100% 21	100% 30	100% 14	100% 22	100% 22

[1]Because of rounding, not all of the columns sum to 100%.

Responses to Q14 by Category

QUESTION 14: Was [PSA C*] interesting to you? How come?

Distribution of Responses
N=43

Thinking/Solving Task:	53%	(23)
Playing Game/Novelty:*	35%	(15)
Other:	7%	(3)
Non-Responses:*	5%	(2)

THINKING/SOLVING TASK

These statements mention the thinking or problem-solving aspect of the task.

Mm hmm. Because you have to use your mind to figure it out. And...mmm, sometimes you wouldn't get it and sometimes you will. So it's just good to try.

Well, I had to think about it to see if -- to see what was wrong with it and I just had -- what I usually don't -- you -- at school you usually don't have to do stuff that hard...It's easier. And I had to think about it more...You really have to think about things like that.

Because you had to solve -- you have to find out what you wanted -- really -- what you really wanted to -- what you really wanted to know about the game and just...The fun in it...Or what you have to do about it.

'Cause you had to do a lot of thinking and...you have to try to figure out what was wrong with it. And try to fix it.

Well, I think it's interesting, you know, because you really have to -- there was something about it, you had to find out, and you had to find out everything else about the game. Find out what was wrong with it and it was...It was just interesting finding out, you know...What was wrong with the game.

PLAYING GAME/NOVELTY

These statements indicate that playing the game, manipulating the pieces, or the novelty of the game itself is interesting.

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* One of the responses in each of these categories is negative.

It was -- well, I -- it was a different game we -- that -- that [I ever] played. I haven't really played that before.

Yes. It was interesting cause um, I like the game, the way it played and, and, because it was made out of, of things that, like the Boy Scouts would use or something. Like make out of wood and that stuff. And carve all -- the boxes and the nail the, the nails in there.

Because I never done it before and that was my first time.

Looked like I was gonna play a game. I like playing games.

Because it had all these weird things on it...Like all the -- like the way the strings were on it and um the, the way the, the, um, the little like um, little thing, it, it was something that had plus and minus...the working with the things on side, on the quarter.

<u>OTHER</u>

> These statements mention things that are not directly related to the mathematics or game aspects of the task per se; rather, they are more focused on the social or performance aspects of the task.

Because it -- it was like a challenge that I had to try and fix it...Like a job. Like he/she said that he/she's going to hire you and so I felt well I got a job now...So I better get to do my job!...And I fixed it.

It seemed easy...Because I already know it -- I already know it -- sometimes I already know about it...And then you'll make -- I'll be good at...So, if I do it again, sometime, I won't get it wrong...I'll do a good job...People can think you're good at doing things...So they won't make fun of you or something, like if you get something wrong and...you'll get good grades and things...So, when you grow up, you gotta have a good education and you wanna be something, and you would be the -- whatever you wanna be -- you could be good at the job.

That um you would think when you were doing the Dr. Game that you would think who broke into the store and messed it up...Who did that and you have to think of it as the most interesting, like...Things that in your head that um -- who did this and why did they do it?...And stuff like that...And it was kinda -- what kind of stuff -- what color was the store and stuff like that...Yeah, the way you can get a better idea of what -- what how big the store was or what did it look like...Well, because if it were a big store and then they'll probably would be the store looks like a rich store that I could break in and get all um a bunch of new games and that other people came and order, stuff like that.

Breakdown of Subject Characteristics for Q14

CATEGORY	TOTAL	GIRLS	BOYS	MIN	NON MIN	MED SES	LOW SES
THINKING/ SOLVING	53% 23	43% 10	65% 13	52% 16	58% 7	55% 11	52% 12
GAME/ NOVELTY	35% 15	43% 10	25% 5	35% 11	33% 4	35% 7	35% 8
OTHER	7% 3	9% 2	5% 1	10% 3	0% 0	0% 0	13% 3
NON-RESP	5% 2	4% 1	5% 1	3% 1	8% 1	10% 2	0% 0
TOTAL[1]	100% 43	99% 23	100% 20	100% 31	99% 12	100% 20	100% 23

[1]Because of rounding, not all of the columns sum to 100%.

APPENDIX III.J:

Codebook: Enjoyment

INTRODUCTION

The purpose of this codebook is threefold: to define enjoyment briefly as well as to explain where and how enjoyment appears in the interview; to explain the procedures for coding designated enjoyment responses; and to provide procedures for coding general enjoyment responses. More information relating to the conceptualization of these analysis schemes, which are used to assess change due to exposure to **SQUARE ONE TV**, can be found in Chapter 6.

I. DEFINITION

This section defines enjoyment, provides a brief description of the two subdimensions, and explains how it appears in the interview.

A. Definition of Enjoyment

Enjoyment pertains to children's descriptions of their feelings, their pleasure or intellectual stimulation in relation to mathematical tasks discussed in the interview. Note that the concept of enjoyment includes negative statements (e.g., lack of pleasure) as well as positive ones.

B. Different Enjoyment Analyses

Enjoyment appears in the interview in two ways; thus, two analyses are used:

o When the enjoyment statement appears as a direct response to a specific question designed to assess enjoyment, the response is called designated enjoyment.

o When the enjoyment statement is spontaneously expressed in response to a question specifically designed to assess a construct other than enjoyment, the responses is called general enjoyment.

The analyses of designated enjoyment responses and general enjoyment responses are conceptually compatible, but different. The similarities and differences will be explained in the following two sections entitled "Coding Designated Enjoyment Responses" and "Coding General Enjoyment Responses."

II. CODING DESIGNATED ENJOYMENT RESPONSES

This section sets forth procedures for coding designated enjoyment statements and describes the different steps involved.

A. Index of Designated Enjoyment Questions

Interview questions were developed to ask the children to describe their enjoyment. Two subdimensions of enjoyment were created:

o Pleasurability. These are statements in which the child indicates the excitement or pleasure he/she feels about the task or subject under discussion.

o Interest/Engagement. These are statements in which the child indicates that s/he derives enjoyment from how intellectually stimulating or engaging a particular task or experience is.

The questions developed to target pleasurability and interest are listed below:

PSA DOMAIN

14. Was the Dr. Game [PSA C*] thing interesting to you? How come?
15. Was the Dr. Game thing fun? What made it fun?
20. Was the clock/party thing [PSA B*] interesting to you? How come?
21. Was the clock/party thing fun? What made it fun?
30. Was the shirt/circus thing [PSA A*] interesting to you? How come?
31. Was the shirt/circus thing fun? What made it fun?

MATHEMATICS DOMAIN

55. Can you tell me about a time where you did something in math that you really enjoyed? What was it? What about it did you enjoy?
56. Do you usually enjoy doing mathematics? How come?
60. Can you name some fun and interesting ways to use math?
61. Can you name some fun and interesting ways to use math outside of school?

B. Overview of Coding Scheme for Designated Enjoyment

Coding responses to designated enjoyment questions involves an analysis of the reasons children provide for their enjoyment (or lack thereof) of the problem-solving activities (PSAs) and other mathematics-related activities. Coding these reasons involves three types of analyses: orientation, level, and valence. These types of analyses are described briefly below.

Orientation

Four basic orientations characterize the different ways children express their experiences of pleasure and interest. They are: "Social," "Doer", "Thinker", and "Evaluative." A detailed description of the four orientations can be found in Chapter 6.

Level.

Within each orientation, children's reasons for enjoyment can be classified into one of five levels of sophistication: low level (level A) to high level (level E). Level F, referred to as "Self-discovery," encompasses statements that can be classified independently from orientation. Statements that fall into this level are considered to be the most sophisticated statements a child can make with respect to enjoyment.[1]

Within each of the levels, there are sub-levels (ranging in number from 1 to 5).[2] Note that these sub-levels are categorical rather than ordinal. The "Orientations, Levels, and Sub-levels" chart at the end of this section provides an overview of the levels and the sub-levels within each orientation. In addition, examples of responses for each of the levels can be found in the "Coding Schemes with Examples" section of this codebook.

Valence

Valence assesses whether the affect or feeling underlying a response is positive or negative. Positive reasons for enjoyment generally express pleasure or interest. Negative reasons express lack of pleasure or interest in the task under discussion. Thus, responses are simply coded positive or negative.

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[1] Note: The text of this volume refers to level as a three-point scale consisting of "low," "medium," and "high." The development of this scale was based on the distribution of responses for all the levels. Responses coded for levels A and B were classified as "low", level C responses were classified as "medium," and levels D, E, and F were classified as "high."

[2] These sub-levels were created to make categorizing statements easier; they were not used for any subsequent analyses.

Orientations, Levels, and Sub-levels

	SOCIAL	DOER	THINKER	EVALUATIVE
A.	SOCIAL/ RELATIONAL: 1.Social Status Self Importance 2.Interview Experience/ Social Interaction	PHYSICAL ASPECTS: 1.Game Manipulatives 2.Playing the Game	INHERENT QUALITIES 1.Interest -- Low level 2.Task Valued/ Not Valued 3.Novelty/Lack of Novelty 4.Intrinsic Qualities	AVOIDANCE: 1.Avoid class 2.Break from
B.	CONTEXT: 1.Personal Interest in Context 2.Aesthetics/ Art	INHERENT QUALITIES: 1.Pleasure -- Low level 2.Familiarity/ Repetition 3.Task Limited/ Unlimited 4.Novelty/Lack of 5.Game Quality	GENERAL THINKING: 1.Act of Thinking: General	SPEED AND COMPETITION: 1.Time tests; doing tasks fast
C.	ALTRUISM: 1. Helping Others	MENTAL ACTIVITIES: 1.Prob-solving Heuristics 2.Diff Ways To "Do" Problems	SYSTEMATIC THINKING: 1.Figuring Out 2.Solving Process 3.Assess Alternate Solutions	EVALUATION CONCERNS: 1.Easy/hard Task Assess. 2.External Evaluations/ Meeting Norms 3.Getting Right Answer 4.Freedom from Evaluation
D.	REAL LIFE PROB-SOLVING: 1.Real life Prob-solving Heuristics	COMPETENCE -- TASK RELATED: 1.Task Assess: "Easy could do it" 2.Complete Task Fail to Complete 3.Accomplish More/Less	COMPETENCE -- BEYOND TASK: 1.Learn New Things 2.Discovery Process 3.Prob-solving Not Task Related: Mysteries/ Detective Work	COMPETENCE -- PERFORMANCE: 1.Assess Ability/ Performance on Task
E.	AUTHORITY/ FUTURE CONTRIBUTIONS 1.Hired to Do Things; Social Responsibility; Future Contributions	COMPETENCE -- REALIZE POTENTIAL: 1.Self-Mastery Lack of 2.Expend Effort/ Lack of Effort	CHALLENGE: 1.Challenge/ Non-Challenge	COMPETENCE -- FUTURE: 1.Prepared -- Future Tasks
F.		SELF-DISCOVERY 1.Regarding Competency 2.Personal Values		

C. Coding Procedures

This next section describes guidelines for coding responses to designated enjoyment questions. Separate coding procedures for the PSA Domain and the Mathematics Domain are provided immediately following a brief introduction to the codesheets.

Review of Codesheets

There are two codesheets: one for the Mathematics Domain and one for the PSA Domain. Data for the PSA Domain are responses to the pleasurability and interest questions: 14, 15, 20, 21, 30, and 31. Data for the Mathematics Domain are responses to fun activities questions: 55, 56, 60, 61. The question numbers are noted on the left hand side of each codesheet (see attached codesheets).

Beside each question number (SEE INSERT BELOW), columns are provided to record coding information. They are as follows:

O	X	N/A	Orientation	Level/ Sub-level	+/-	Response
14			D	A1	+	yes - I liked rolling the dice and flipping the coin - just playing the game
15		NA				

- o The "X" column is used to note when the child refers to pretest experience with the PSAs (e.g., "I did this before when you came here last time.")
- o The "N/A" column provides a space to note "NA" when a question is not asked.
- o The "Orientation" column is provided to note the orientation that a response exhibits ("S" for Social statements, "D" for Doer statements, "T" for Thinker statements, "E" for Evaluative statements, and "S-D" for Self-Discovery statements).
- o The "Level/Sub-Level" column is used to note the level of sophistication and the sub-level of the responses.
- o The "+/-" column is used to indicate whether the valence of the response is positive (positive affect) or negative (negative affect).
- o The "Response" column is provided to jot down an abbreviated version of the actual response to each question.

PSA Domain Coding Procedure

In general, coding designated enjoyment responses requires you to read each response and to code it for orientation, level and valence. The specific steps involved in this coding process are provided below. Note that a review of the four orientation coding schemes and guidelines in section G is necessary before beginning to code.

1) Print out from the database all responses to Questions 14, 15, 20, 21, 30, and 31 for each child.

2) Read each child's responses consecutively to develop a sense of the child's general approach to discussing enjoyment. This will guide you in interpreting orientation.

3) After reading through a child's packet, go back to the first response. You will then do one of three things:

   a) Write an abbreviated version of it in the space entitled "Response" that appears in the row for question 14.

   b) If the question is not asked, write "NA" in the column entitled "N/A" and move on to the next response.

   c) If the response is a flat "yes" or "no," write yes or no in this "Response" space. Then code the response for valence only in the column entitled "+/-" by marking positive ("+") for a "yes" response and negative ("-") for a "no" response. Then move on to the next response.

4) If you have completed (a) above, i.e., it is not a flat "yes" or "no" response, reread the statement, and look for clues to help you interpret the actual orientation of the statement. When interpreting orientation, you are looking to characterize what the child identifies as his "fun" or "interest." Helpful clues for the different orientations are as follows:

   a) Mention of social interaction, the context of the activity, people, real life applications, and personal values would indicate a social orientation. The following statement is an example of a Social response:

      "Fun working with ages of people and putting them at different tables and...well,looking at all the ages and thinking of what kind of party it would be. Well, a wedding or just a dinner party."

   b) When the child speaks in terms of "doing" things, such as "I like doing lots of things," "I like making different orders," "I like working with the materials," or "I can do it on my own," the statement would be considered to have a Doer's orientation. A Doer statement will often contain action verbs such as "make, fix, do, draw, sort, put," etc. In the following example, although reference is made to figuring out (which is typically a Thinker term), the physical activity of "drawing" is what the child identifies as the source of his "fun." Therefore, the statement would be considered a Doer response:

"Yes...Well, um, because um I got -- it got paper and marker and I draw the tables and then I spread out all the cards and then I got -- of the -- youngest and then the um middle, and then the oldest...Then I got to figure it out. [R: What made that fun?] Drawing the table."

c) When the child speaks in terms of "thinking", "solving","figuring out", finding things "boring" or intellectually stimulating, as in "it was interesting that two numbers can be the same," the statement would be considered to have a Thinker's orientation. The following response is an example of a Thinker response:

"That um, you get to look at the game, you get to solve and then they give you time to look for the answers...they give you time to look for the clue."

d) When the child talks about getting the right answer, being evaluated by the researcher, liking things because of ease and speed in execution, looking smart, and other externally motivating factors, the statement would be considered an Evaluative statement. For example:

"Yeah, because I thought I couldn't do it at first. Well, because before I thought of this, I thought, man, I'm only gonna think around five of them...Because well, because -- just using cards -- I don't think I could do it. That's why I am not very good at cards and stuff."

5) Once you have identified the statement's orientation based on any of the clues described above, turn to the appropriate coding scheme (Social, Doer, Thinker, or Evaluative) to determine which level of sophistication best describes the content of the response. In order to know where to look, consider the following:

a) If the response refers to simple involvement with a task (e.g., spinning the spinners in PSA C*) or to characteristics of a task that are not pertinent to problem solving or mathematics, then it is most likely a level A or B response.

b) If the response tends to refer to either more complex strategies or specific heuristics that the task under discussion requires (e.g., "putting things in order," or "trying to get the answer right"), then the response is likely to fall under level C.

c) If the response shows an extension of acquired knowledge to other situations, or a sense of a competence beyond the task, the response most likely will fall under level D or E.

6) Once you have determined the general level of sophistication, look to see which sub-level matches the response in question by reading through the descriptions and examples listed for the appropriate level within the coding scheme. Refer to the "Orientations, Levels, and Sub-levels" table on page for an overview of the levels and sub-levels.

7) Record all information pertaining to orientation, level, and sub-level on your codesheet.

8) Next, determine the valence of the enjoyment response. Positive statements

generally express pleasure or interest. Negative statements express lack of pleasure or interest in the task under discussion. Mark "+" for positive responses and "-" for negative responses in the "+/-" column. Note that when a child flatly comments that something is "fun" or "not fun" (and does not provide a reason why), the response should be coded for valence only.

9) Repeat this procedure for each of the remaining responses to the PSA questions.

Mathematics Domain Coding Procedure

In the Mathematics Domain, we do not provide children with a concrete example of mathematics to discuss as we do for problem solving in the PSA domain; children can choose to talk about any mathematical activity they find enjoyable. Thus, to make our analysis of the Mathematics domain comparable to our analysis of the PSA domain, we are only looking at the reasons children find mathematical tasks enjoyable or not, not the activities themselves.[3] For example, given the statement "I like doing area = length x width because it is easy," only the reason, "easy," would get coded.

The section below describes the coding procedure to be used for children's reasons of enjoyment within the Mathematics Domain. Essentially, the same procedure used for PSA coding described above should be followed when coding Mathematics responses:

1) Print out responses to Questions 55, 56, 60, and 61 for each child.

2) Read through each response, looking for clues, and code each reason for enjoyment in the same manner described in PSA coding procedure.

3) Note that, many times, a child will not give a reason why he/she enjoys a certain activity. When a reason is not given, the activity itself should be coded as follows:

   a) Any time a child mentions games e.g., "Mathtronics," "Quizmo," "Board Games," or "Hopscotch," the response should be coded within the Doer orientation as DB5: Game Quality.

   b) Any time a child mentions math races or competition, e.g., "math quizzes where you have to see who finishes first," "having races on the board," the response should be coded within the Evaluative orientation as EB1: Speed and Competition.

   c) Any time the child mentions an activity that relates to using mathematics in real-life situations, e.g., "at the store," "working with parents to build a fence," etc., the response should be coded within the Social orientation as SD1: Real Life Aspect of Problem Solving. Sports (e.g. "football") should also be coded as SD1.

[3] Different mathematical activities children find enjoyable were analyzed via a descriptive analysis. Please refer to Chapter 6 for further information.

D. Designated Enjoyment
Sample Codesheet[4]

Subject # 84
Coder: DB

PSAS

Q	X	N/A	Orientation	Level/ Sub-level	+/-	Response
14			T	E1	+	Yes. It was a challenge
15			D	A1	+	Yes. Liked the little characters and the way the dice felt.
20			D	B4	+	Little bit - Never done that before.. put things in order
21			T	B1	-	Not that fun - Not like a game. Didn't like that you have to use a lot of thoughts to put the numbers in order
30			S	D1	+	Yes - I was pretending to be that person that could make different colors for shirts. Thinking which were good and not good.
31			S	D1	+	Yes - Got to put things in order and I felt like I really worked in a store

[4] The Mathematics Domain codesheet is identical except for the question numbers.

E. Special Coding Guidelines and Close Calls

Since the differences between the orientations are subtle, there are times when coding statements can become difficult (this is particularly true of the Thinker and Doer distinction). Special coding guidelines for each orientation are described below, along with special tips to help you determine how to code responses appropriately.

Social Guidelines

o There are times when a child may refer to the context of an activity while discussing his/her enjoyment of it (see example below). When you come across a statement like this, you should ask yourself whether the child mentions the context as part of his description of another source of enjoyment or whether the child points to the context as the main reason for enjoying the activity. If the child merely mentions the context as part of his/her description of a different source of enjoyment, DO NOT code as SB1: "Personal Interest in Context." If it is evident that the child's source of enjoyment is the context of the activity itself, then code it as SB1. Note in the example below, "ages" (the context), is merely mentioned as part of the child's description of his main source of enjoyment, the activity of "sorting." Thus, this statement would not get coded as SB1, but as DC1: "Problem-Solving Heuristics":

Q21: "Why was [PSA B*] fun?"
S: "Just to sort out the ages."

The following statement would be coded for SB1: "Personal Interest in Context," since the main source of pleasure is the "ages":

Q21: "Why was [PSA B*] fun?"
S: "Because I liked the different ages of the people."

o When the child links problem-solving heuristics to a social context or if it is clear that the child is talking about heuristics in a real life context, the statement should get coded as SD1: "Real-Life Problem Solving." In the example below, "switching around" would normally be coded as DC1: "Problem-Solving Heuristics"; however, the child links these heuristics to the players in a real life context of "a real circus" and therefore, the response would be coded as SD1:

"Well, you can switch around the different people and think about a real circus and how they would do these things."

o Along the same lines, all real-life applications of problem solving should be coded as SD1: "Real-Life Problem Solving," e.g., "sorting laundry," "comparative pricing," etc. "Detective work" and "solving mysteries" are the only real-life applications that would not be coded within the Social orientation (these would be classified as thinker responses).

Thinker Guidelines

o When a child merely states that a PSA is interesting in response to an Interest question (Questions 14, 20, or 30), do not code the response as TA1: "Pure Interest." Since these responses are essentially the same as flat "yes" responses (i.e., "it was interesting") and "no" response (i.e., "it was boring") responses, they should be coded for valence only.

- o When a child states that he/she dislikes an activity because "all you do is [computational] skills," it seems as though he/she may be dismissing rote arithmetic computation, thereby indicating a preference for higher order thinking skills. You may therefore be inclined to code this response as TB2: "Activity is Limited" within the Thinker orientation. Note, however, a preference for "thinking" is not made explicit in this response and we can't be certain that the lack of novelty for the child is due to the absence of higher order skills. A statement should only get coded as TB2 when the child explicitly indicates a preference for, e.g., "things that make you think" over "rote skills." If this preference is not made explicit (i.e., the child just says "all you do is skills") then code as DB3: "Activity Limited" within the Doer orientation.

- o The "Thinker Novelty/Lack of Novelty" [TB3] response differs from that of "Doer Novelty" [DB4] in that the Thinker response indicates that an activity is intrinsically interesting or novel; a Doer response points to the novelty connected to the actual "doing of things" (e.g., I've never done this before.") Note in the following example the child mentions the different design as a reason for enjoying PSA C* -- an intrinsically interesting element, and therefore would be coded as TB3: "Thinker Novelty":

  "It's a different design than other games that I've played."

  "I've never seen a game like this before."

  If this distinction is not clear, read the child's responses to other questions to get an overall sense of child's orientation -- whether they are predominantly Doer or Thinker. Code for novelty in accordance with the child's general orientation. If a general orientation is not clear, code the response as DB4: Doer Novelty.

- o When a child mentions that he/she enjoyed "acting like a detective," code as TD3: "Problem Solving -- Not Task-Related." By referring to the problem-solving process as detective work, the child indicates that s/he is extending his/her thinking beyond the immediate task. The following response is an example of this type of statement:

  "It's fun...Putting it back together. It had a mystery...I like mysteries because I try to figure them out. [R: Why do you like that?] Because I wanna be a detective."

- o When a child links "figuring out" to a context other than the one designated by the task, (e.g., the child mentions that s/he enjoys figuring out "different things" as opposed to figuring out how to figure out the PSA under discussion), you should code the response as TD3: "Problem Solving: Not Task-Related" Note that the following example would be coded as TD3:

  "I think it's fun to figure different things out."

- o Typically, the TE1: "Challenge/Not Challenge" category encompasses statements that either explicitly point to the challenging aspect of an activity as a reason for enjoying it (e.g., "I like it because I like challenging things") or to the lack of challenge present in an activity (e.g., "it wasn't challenging to me"). Note however, that this category can also encompass responses in which the child states that he/she "likes things that are hard" when it is clear that the child's use of the word "hard" is synonymous for challenge (the child's definition of "hard" can be determined by reading through all of the child's responses). Note that the following statement is an example of a "challenge" statement and would thus be coded as TE1:

"Yes, because I couldn't figure out where to put the young ones and the old ones, and had to double the tables. [R: What made that interesting?] Because it was hard."

Evaluative Guidelines

o EC1: "Evaluation Concerns" encompasses responses which focus on the ease or difficulty of a task and/or where the child thinks about his/her performance on a task ("I like it because it's easy for me and I get it right"). Sheer mentions of "it was easy" or "it was hard" should also be coded as EC1. For example, the following response would be coded as such:

Q56: "Do you usually enjoy math?"
S: "Sometimes, if it's not too hard."

F. Double Coding of Statements

Children sometimes describe more than one reason for enjoyment in response to one question (i.e., more than one orientation). The coding of more than one source per response is referred to as "double coding." In order to determine when a statement should be double coded, use the guidelines provided below:

o If the reasons a child provides for his/her enjoyment of an activity are highly distinct from each other (i.e., within a given statement), the sources should be coded individually. Note that the following statements contain two distinct reasons for enjoyment, thus each reason would receive a separate code (codes are indicated in parentheses):

Q15: "Why was Dr. Game [PSA C*] fun?"
S: "To put them in order [DC1]. And, and the, the types of clocks -- clocks, the names of the clocks [SB1]."
S: "Well, there were so many different pieces [DA1] and, and you, when I was picked that made me kind of feel like I was good. When I was picked out of, out of our class...[SA1] Well, yeah, yeah, how the, how the dice were, 'cause, 'cause I have, I have this game that's like that. And, that's all [DA1]."

Thus, the first example above would get coded as DC1 and SB1. The second example would get coded as DA1 and SA1.

o Generally, when a child explains that a certain activity pertinent to a PSA makes it enjoyable and also describes why this activity is enjoyable, the response should be double coded. That is, when an activity is given as a reason for liking a task under discussion, then the activity should be coded. In cases where an activity is not a reason for liking a task under discussion, then it should not be coded.

In the example below, the child first states that he thinks PSA C* is fun because he likes multiplying (an activity). Thus, the statement would be coded for DC1: "Problem-Solving Heuristic -- Computation." He also gives the overall reason why he likes multiplying ("being timed and being the first one"). Thus, the statement would also be coded for EB1: "Speed and Competition."

"Well, I guess 'cause it's kind of fun...Well, I -- as I said I like multiplying a lot... [DC1] 'Cause uh when I first -- um multiplying looked easy but it got hard sort

"Well, I guess 'cause it's kind of fun...Well, I -- as I said I like multiplying a lot... [DC1] 'Cause uh when I first -- um multiplying looked easy but it got hard sort of, so I like doing it 'cause when sometime -- I think it was -- that was the last year but we had a different math teacher. She went away -- well -- we had to do multiplications and she would time us, and I would sometimes be the first one, except there's the other (smart guy) in the fifth grade -- he could beat me. I'm one of them that do fast -- working on it. [EB1]"

o You should not double code a statement when the sources of enjoyment expressed within a single response can be coded for different levels with the same orientation. Instead, code the entire response for the higher level code only. For example, in the following statement, the child points to the actual computations [DC1: "Problem Solving Heuristics"] as reasons for liking PSA C, yet mentions that he/she likes using the calculator [DA1: "Physical Activities and Game Conventions"]. Although two codable reasons are given, the statement should only be coded as DC1:

"Using the calculator and everything to divide them, 'cause there were, there's, there were twenty-six, they, they sat all together 'cause I counted the cards, I put them in order. And I divided by a number so I decided to divide with the middle number...I know my times tables but I still like to use a calculator to see 'cause it's helpful..."

o When both positive and negative statements appear within the same statement, you should only code the negative portion. Given that children are generally reluctant to express their negative feelings towards tasks, we assume that when they do come up, they are likely to be very strong.

Q15: "Was the Dr. Game thing [PSA C*] fun?"
S: "Because I was helping Dr. Game...Having to use my brain is boring [TC1]."

G. Orientation Coding Schemes With Examples

SOCIAL

A. Social-Relational (Not pertinent to task)

1. Social Status/Self Importance

"It was a privilege to be picked"
"Liked it because my sister was worried about me"
"Doing stuff no one else would"

2. Interview Experience -- Social Interaction

"Liked working here"
"Liked answering questions"
"Maybe if I had a partner I would like it"
"Um, my dad is good, real good at math and so I just, I like ma -- I um, he started teaching me these multiplications. I, I from my teacher she taught me too and then this is like, I like math better that any subject."

B. Personal Interest in Context of Activity/Math

1. Context of activity -- Personally like circuses, math, price tags, etc.

"Well, because I like circuses."
"Got to look at prices."
"Um, well, yeah I guess if it was my party."
Babyish -- "like my little sister's game."
"Learn more about people's ages and how old they are."

2. Making Aesthetic Statements -- Mention art, patterns, colors, etc.

"Making designs with stripes"
"Making patterns and writing them down"
"Like art"
"Coloring worksheets"

C. Altruism

1. Helping Others

"Help others who may play the game"
Help sibling learn mathematics

D. Real-Life/Social Aspect of Activity, Mathematics, or Problem-Solving Relevant to Real Life

1. **Problem-Solving Heuristics are related to real life or context of activity; heuristics inherent in the activity are either extended to some real-life situation that is distinct from the context of the PSAs or mathematics; or the child portrays him/herself as actively playing a part in the contextual "story" of the PSAs or other activities in which problem-solving is an underlying theme.**

    "Ordering things like on a supermarket shelf"
    "Sorting because it reminds me of sorting my laundry"
    "Well, you can switch around the different people and think about a real circus and how they would do these things."
    "Fix the circus so it's not boring for the people."
    "Fun working with ages of people and putting them at different tables and... well, looking at all the ages and thinking of what kind of party it would be.
    "Well, a wedding or just a dinner party."
    "That you would think when you're doing the Dr.Game that you would think who broke into the store and messed it up...who did this and why did he do it."
    "And so I started doing this and it was sort of um and I was smiling because I, I thought um, I pictured in my mind, I looked up and I was staring at the camera and I saw, um, I, I, thought I, I was in the circus and there was a lot of people around me and then I started mixing them and I pretended they were in each show and every night and stuff. Like I was dreaming that it was really happening."
    "When I'm learned how to look at prices and to find more expensive shirts."

E. Position of Authority/Social Responsibility/Future Contributions

1. Being Hired to Do Things, Future Responsibility

    "Because it -- it was like a challenge that I had to try and fix it...Like a job. Like he/she said that he/she's gonna hire you and so I felt well I got a job now...So I better get to my job!...and I fixed it!"
    "Being hired to run things. Then I'll be prepared for future job."
    "Yes, because I thought, um I'm, I'm the boss of this circus so I get to do anything with it. And so I started doing this and it was sort of um and I was smiling because I, I thought um, I pictured in my mind, I looked up and I was staring at the camera and I saw, um, I, I, thought I, I was in the circus and there was a lot of people around me and then I started mixing them and I pretended they were in each show and every night and stuff. Like I was dreaming that it was really happening."

DOER

A. Physical Aspects

1. Activities, Game Conventions, and Manipulatives

Flipping; spinning; drawing; using handwriting; making numbers with your body; using calculators; writing on the board; using stickers;

2. Playing the Game

"Got to play a game."
"Got to mess around with it."

B. Inherent Qualities of Task

1. Not Fun to Do/Just Fun -- This a very low level response in which the child basically likes/dislikes something because of pleasurability in doing the activity and nothing more.

"Just like doing it."

2. Repetition of Same Activity/Familiarity

"Doing something over and over -- sort of boring just rolling dice."

Teaching Style -- When refer to physical aspect or lack thereof present in teaching of subject matter:

No manipulative -- "they just talk at you"
"In class, you wear out your hands"
"Too many problems from teacher"
"Like it -- it's familiar"
"Like multiplication drills"

3. Activity Valued/Not Valued; Limited/Unlimited

Positive:

"Got to do a lot of stuff."
"Like working on things."

Negative:

"All you get to do is put them in order. There is nothing to play with."
"All you had to do was go from greatest to least."

4. Novelty/Lack of Novelty -- Discuss the degree of novelty or newness of an activity or experience in terms of "doing."

Positive:

"Never done this before...Never put colors onto a shirt before."
"It was -- well, I -- it was a different game we -- that -- that I ever played. I haven't really played that before."
"Doing things you haven't done."
"Well, this is the only, the only the second time I've done this, and so, I haven't done this in a long time so."
"Well you get to play around with things that you hadn't before and experience new things."

Negative:

"Already done this before"

5. Game Quality -- "Like a game/Not like a game"

Positive:

"Way the game works"
"The rules to the game"
"Tricks"
"Like an activity in a funbook"
"You get to sit right here and switch. It's like you're playing checkers or another game."

Negative:

"It's nothing like a real video game, you know it's just like, you know [a hundred] or something...you know like [in a video game] you can go in, be controlling and everything you know."

C. Mental Activities -- Although these activities involve figuring out, they are often expressed in physical terms and involve the physical aspect.

1. Problem Solving Heuristics

PSA related activities:

"Putting things in order"
"Sorting things"
"You get to fix it"
"Making twice as many"
"What made it uh so fun is when I was figuring out the um about the spinners and stuff?...It kept on spinning around the spinners to see if it -- if the -- it would come undone or not."
"Yes...Well, um, because um I got -- it got paper and marker and I draw the tables and then I spread out all the cards and then I got -- of the -- youngest and then the um middle, and then the oldest...The I got to figure it out. [R: What made that fun?] Drawing the table."
"That um I had to put'em in order and that was sort of hard to remember so I just said, 'I'll use pad and pencil and write it down so I won't do that one twice."

"Mmmm, I got to put the price tags in order from the smallest ones to the great -- a little bit greater, and to the expensive ones."

Doing Basic Computation/Dealing with Numbers:

"I like to do different things with numbers."
"I like the short cut [multiplication], you just like double or just take that number and double it by two or make it by four."

Doing Higher Mathematics Functions:

"Time we did fractions with unlike denominators fun."
"Symmetry...I could draw the other side and I could cut it out and it'll equal."

2. Different/Multiple Ways to Do It

"Because we could, you have to try to find how many orders that you can, and I was gonna try to find other orders as much as I can till like there couldn't be no more orders you know."

D. Competence -- Task Related

1. Task Assessment -- Often mention that a task is easy or hard in conjunction with the "doing of it."

Positive:

"Easy -- I could do it"
"Um, I was thinking of, 'This was fun, this easy. I know I could do it because it looks easy.' And I was thinking -- I wanna come back here a lot more times just -- not just two days, I wanna come back here more..."

Negative:

"Too hard -- can't do it"

2. Completed a Task/Failed to Complete Task

Positive:

"I fixed it"
"Got the optional"
"Like I learned how to fix clocks"

Negative:

"I couldn't fix it"
"I didn't get the optional"

3. Accomplish More Things/Accomplished Less

"Did more things than last time"
"Didn't do that much this time"

E. Competence -- Realizing Potential

1. Self-Mastery/Lack of Self-Mastery

"Do it my own way with no help"
"Now I know how to do it"

2. Expended Effort and Did All That Can/Didn't Have to Put Much into It

Positive:

"Did the best that I could"

Negative:

"Didn't have to put much into it"

THINKER

A. Inherent Qualities of Task

1. Low Interest -- Feelings about tasks/experiences that have to do with intellectual engagement. These are not elaborate.

   "It was boring."
   "It was interesting to me."

2. Activity is Liked/Not Liked; Valued/Not Valued; Limited/Unlimited

   "All you do is skills" (If not elaborated, code as Doer -- B3: Activity Limited)
   "Teach the same thing over and over."
   "Doesn't take long."
   "Takes too long."
   "I used to but not anymore...it's hard for me to learn because also my teacher is uh they say words that children don't know. Don't know the meaning of or something."

3. Lack of Novelty/Novelty -- Different from Doer's Novelty category in that child mentions that activity is conceptually new or interesting; there is no mention of the actual "doing of things." Here, kids mention "seeing things" as novel or not novel.

   Positive:

   "Never seen before"
   "Something new"
   "There's a whole bunch of different kinds of questions. It's not just money questions -- it's called Mathtronics."
   "It's a different design than other games that I've played."

   Negative:

   "It's boring when you have to study for something you already know."

4. Intrinsic Qualities of Mathematics or Task -- Have to do with tricks or intrinsic elements of the task that are intellectually interesting to the child. They often express that something looks weird, that there is a puzzle involved, etc.

   Positive:

   "Um multiplication t--um showed me like, it showed me higher numbers and you see I really didn't um, before I learned multiplication I used to like adding or subtracting and those numbers were down on like lower numbers? And then when I went to multiplication that showed me some higher numbers."
   "Interesting that two numbers can be the same."
   "More like weird...If you saw some kind of species of animal, and -- or a different kind of cat or dog, that would be interesting. If you saw some game that had way different stuff and like wouldn't play, you know, like differently than others, that's weird."

Negative:

"Don't like the way long division works."

B. Act of Thinking -- General

1. Child describes thinking or concentrating in general terms; this does not necessarily relate to problem solving.

"You get to think"
"Like thinking hard"
"Like concentrating"
"You have to use your memory a lot to remember um how -- who was in that order."

C. Competence -- Task Related/Systematic Thinking

1. Figuring Out -- Mention that figured something out.

"Figured out what's wrong"
"Find something wrong"
"Thinking about what's wrong with them."

2. Process of Reaching Solution/Solving

"Could almost solve it"
"Done a lot of things and tried to solve it"
"Look at everything"
"That um, you get to look at the game, you get to solve and then they give you time to look for the answers...they give you time to look for the clue."
"There's a catch to it. First you have to figure out something wrong, and there's so many things that you have to do."
"That there were -- that you had to put like four on each row and um twice as many as on one row and that -- made a little hard -- 'cause then you would have to put like most of the high numbers. And there were a lot of the high numbers, so on the um medium numbers, you would have to find the um medium prices and there weren't that many so you had to double that on one of 'em."
"Made it interesting about um knowing stuff, where it goes and about stuff like that."
" 'Cause colors and, you have to figure out what different combinations and, and the most to try to find the most combinations."
"It was interesting because you really had to find something wrong with it and you had to think about it, what was wrong with it."
"Well I didn't know whether, who would end up with the chips and that, the most."

3. Assessing Alternate Solutions

"Different ways to figure it out"

D. Competence -- Beyond Task

1. Learn New Things/Acquire Knowledge/Reject Learning New Things -- Also has to do with having acquired skill and knowledge, to "know it good."

Positive:

"Felt I knew stuff I didn't before."
"I enjoyed learning about it [dividing two numbers into other numbers] 'cause last year when I was in fourth grade, we had problems like that and I didn't really understand it. This year, I'm understanding more about it."

Negative:

"Don't like learning new things."
"Know it good and if I didn't know it good then I probably wouldn't enjoy it 'cause I have to be learning more and more -- and I get stuck in some parts."
"Don't enjoy when don't get it."

2. Discovery Process -- Describes process of uncovering things haven't seen before.

"Discover things I haven't before"
"...then I smile and I go, I got an idea."

3. Problem Solving -- Not Task Related

"Solve mysteries"
"Because you get to be a detective and you get to look for clues and solve what's wrong with the game."
"I think it's fun to figure different things out."

E. Challenge/Non-Challenge

1. Any time child refers to challenge, it should be coded here:

"Like things that are hard."
"Like challenging things"
"Too easy -- like a little challenge"

The following response is a negative statement about challenge:

"I guess just being able to figure it out" (child proceeds to agree with R that things that you have to struggle with are less enjoyable).

EVALUATIVE

A. Avoidance

1. Like/Dislike Something Because Miss Class.

2. Helps Get Mind Off of Other Things; Activity Seen as a Break.

B. Speed and Competition

1. Like things that involve speed or competition, but not necessarily both; when mention time tests or doing things quickly, they should get coded here:

"Doing it fast"
"Like contests that you see who finishes first"

C. Evaluation Concerns

1. Easy/Hard -- in school context where performance is concern. When no explanation is given, code assessments of task difficulty here, e.g., "It was too hard."

"Easy -- thought it was hard when everybody else learned them."
"Because it's kind of hard to -- 'cause you don't have the right piece to know which one it is...Like you don't have the correct piece and, and then, and then you have an another piece that's totally different and you don't know which is wrong or which is right."

2. External Evaluations/Keeping Up With Norms/External Rewards

"Wonder what researcher thought about what I did."
"Like this 'cause it's easier and I'll get good grades."
"It's boring; just do it to pass"
"I was nervous...About, well, he/she thought that it was -- if it was right or wrong or stuff like that."
"Well, see I hadn't, hadn't known how to do it and all my friends knew how to do it, and when I finally learned I was really happy because um, um, I finally got to have something that my friend had already known."

3. Concerns Over Getting the Right Answer

"I was wondering if I got the game right."

4. Playing for Fun -- Freedom from Evaluation

"I'd like to do something that we can do, that we don't have to do it, but we could."
"Just playing this for fun."
"[It was good] just to know that it was a game."

D. Competence -- Performance

1. Assessment of Performance/Ability/Frustration Regarding Performance

"Think I did a good job"
"Found the right answer"
"Did okay"
"Yeah, because I thought I couldn't do it at first."
"Well, because before I thought of this, I thought, man, I'm only gonna think around five of them...Because well, because -- just using cards -- I don't think I could do it. That's why I am not very good at cards and stuff."
"Well, I felt sort of good about it but I knew it wasn't right...Because, because when every -- every time I thought about it, I knew it wasn't -- I just sort of like guessing at it, because I didn't think there was really nothing wrong with the game because it looks -- because it looked all okay with me."

E. Competence -- Future/Beyond Immediate Task

1. Being Prepared for Future Tasks

"Already know what teacher asks."
"Now I know how to do it if they ask me."
"Adding fractions...because it was easy, and our teacher told us that we learned the hard stuff and not the easy stuff...You know what to do!"

SELF-DISCOVERY

Self-Discovery/Competence (Introspection)

1. Self-Discovery Regarding Competency

"It was interesting that I knew I could fix the game and I, I used to not think I could fix anything...It made me know that I could fix something."

2. Actualized Personal Values

"Thinking about what you are doing and if you really try you can do something."

III. CODING GENERAL ENJOYMENT RESPONSES

This section sets forth coding procedures for general enjoyment responses.

A. Overview of General Enjoyment

After analyzing a subset of interviews, we discovered that questions designed to assess other attitude constructs were eliciting enjoyment responses from time to time. These types of statements are referred to as "general enjoyment" responses.

Typically, general enjoyment responses are brief, spontaneous remarks about the pleasure, interest, or other feelings that a child experiences in relation to various activities (e.g., PSAs or math-related tasks). These remarks are made in their discussions of topics related to the other attitude constructs.

Two types of analyses are involved in coding for general enjoyment: identifying general enjoyment statements and coding them for valence.

Identifying General Enjoyment

Coding for general enjoyment requires you to read through each child's entire transcript looking for responses that refer to pleasurability, interest or affect. While we are not coding statements for each subdimension of enjoyment, knowing what they are will be helpful in identifying general enjoyment statements. Tips to identify these subdimensions are provided below:[5]

> To identify pleasurability, you should look for expressions such as "it was fun," "it was exciting," "math is my favorite subject," "I liked it a lot," "I hated it," etc. Note that pleasurability is usually expressed in the third person.
>
> The following response to a motivation question provides an example of general pleasurability:
>
> > Q8: "Did you talk to your parents, family, or anyone about it? What did you say?"
> >
> > R: "I haven't told anybody...The last time I did about some kind of thing that I had to do, that's all." [R: Told who?] My parents and my big brothers." [R: What did they say?] That mmm, they never been in something like that before. And they said how was I got to be picked? And I said, I don't know, they just probably picked out names. And I was chosen. And that it's fun. They do games."
>
> To identify interest statements, the coder should look for words or phrases such as, "it was interesting," "it was boring," "I really like doing it," "I don't like playing it," etc.

[5] Note that underlined portions of responses pertain to general enjoyment.

For example, the following response to a motivation question exhibits interest/engagement:

> Q47: "If you had to explain what math is to someone who had never heard of it, maybe someone from another planet who happens to speak English, what would you say that it is?"
>
> R: "It's an interesting thing for you to do and, you know, when you really grow up and you want -- you can either be a...whenever you grow up you're gonna have to do -- use math. Whatever you do, unless it's like writing or something."

To identify affect, the coder should look for words or phrases that describe a child's emotional state, such as, "I felt embarrassed," "I was happy," "I felt sad," or "I was proud." Although "okay" does not explicitly describe a child's feelings, it should still be coded as general enjoyment when it is clear that the child is identifying his/her feelings as being somewhat in the middle, e.g., "I felt okay." The response below exhibits affect:

> Q6: "When you finished and you left the room, how did you feel?"
>
> R: "I felt shaking because I was sort of nervous...so I just thought about what I was doing inside and then I came out and it just got out of my mind...So I just started feeling weird."

Valence

Valence assesses the feelings that underlie a response. Positive general enjoyment statements generally express pleasure, interest, or excitement. Negative statements express lack of pleasure or interest in the task under discussion, or lack of comfort with a given task or experience.

B. Coding Procedure

This next section describes guidelines for coding general enjoyment responses immediately following a brief introduction to the codesheets.

Review of Codesheet

The codesheets for general enjoyment contain three columns (SEE INSERT BELOW):

Q#	VALENCE	RESPONSE
5	+	It made me happy
8	-	I told her I was nervous

- o The first column is provided to write the number of the question that elicits the general enjoyment response.
- o The second column is used to indicate the valence of the response.

o The third column, entitled "Response" provides a space to jot down an abbreviated version of the response in which the general enjoyment appears.

Coding Procedure

Now that you are familiar with the ways in which to identify general enjoyment and the actual codesheets, you are ready to code for general enjoyment.

1) To begin, make sure you have appropriate codesheets available.

2) Print out full transcripts (containing responses to all questions) from the database for each child.

3) For each child's transcript, read through each question and response, and ask the following questions:

   a) Does the child's response meet the criteria of any of the enjoyment subdimensions? In other words, is the statement an evaluation of interest or pleasurability or an expression of affect? If the response does qualify for one or more of these subdimensions, ask yourself the next question.

   b) What kind of question is being asked?

   c) If you find that the question you have encountered is a designated enjoyment question (i.e., Question 14, 15, 20, 21, 30, 31, 55, 56, 60, or 61), do not code the response since these statements are coded for in our designated enjoyment analysis.

   d) If the statement is not a response to a designated enjoyment question, then the response should be coded for general enjoyment.

4) Once you have determined that the response should be coded for general enjoyment, place the statement's corresponding question number in the left hand column of the codesheet.

5) You must then code the statement for valence. Positive statements indicate positive feelings the child has about the task or about him/herself, e.g., "liked it a lot," "it was interesting," "it was fun," or "it made me happy," or "I felt proud." Negative statements indicate that an activity is not pleasurable or interesting, or even somewhat distressing, e.g., "it was boring," "it wasn't fun," "it was frustrating," or " I felt nervous," "I was glad it was over."

C. Special Coding Guidelines

Valence Tips

In cases where affective terms are ambiguous, it may not be immediately apparent whether a statement should be coded positive or negative. In these cases, certain guidelines should be followed. These guidelines are presented below:

o Neutral terms such as "okay," "fine," and "alright" should be coded positive when they appear in response to questions that directly ask for the child's feelings since these expressions indicate an absence of negativity.

o When a child expresses "relief" in response to a situation that the child acknowledges as anxiety-provoking, the statement should be coded negative, even though relief, in and of itself, is a positive affective state.

"I was relieved. I was glad it was over."

o Ambiguous expressions that should not be coded are: weird, surprised, strange, and confused. It is not clear that these terms are positive or negative.

Question Tips

Special guidelines should be used when reading responses to specific questions in the protocol. These guidelines are provided below:

o Question 35, "What kinds of things do you like to figure out?", allows children to name any kind of activity they enjoy (including things that do not pertain to mathematics or problem solving). Responses to this question should only get coded for general enjoyment when children mention mathematics, PSAs, or mysteries[6] accompanied by some explicit expression of pleasure, interest, or affect (e.g., " Mysteries, they're fun.") In addition, when children state that they don't enjoy figuring out anything in response to this question, code the statement for negative valence.

o Similarly, expressions of pleasure, interest or affect in responses to Questions 36 through 38 should only get coded when they refer to mysteries, mathematics problems, or the PSAs. For example, the following response would get coded as positive general enjoyment:

Q36: "Why do you like to figure [mysteries] out?"[7]
S: "They're fun. I like solving mysteries."

Note that responses to these questions do not get coded when the child refers to non-mathematical things, e.g., "Because I like figuring out jokes and riddles, they're fun."

o Responses to questions regarding children's preferences (Questions 32, 33, 34, and 6?) should be coded for general enjoyment when the child indicates that his/her preference for an activity is based on enjoyment. Note the following examples would be coded for positive general enjoyment:

---

[6] Mysteries are included here since children often use the term "mysteries" to describe their experience with the kind of problem solving we were interested in assessing in this study.

[7] Note that question 36 is contigent upon what the child says in response to the preceeding question (i.e., question 35 "What kinds of things do you like to figure out?"). In this case, the child said that he liked mysteries in response to question 35, therefore "mysteries" was inserted in question 36.

Q32: "Of the three things you've done with us -- the thing with Dr. Game [PSAC*], the clocks/party tables [PSA B*], and the circus performers/stripes on shirt [PSA A*] -- which one did you like best? Why?

S: "I like the Dr. Game thing best because it's the funnest.

Q63: "If you had a chance to work on another project with Dr. Game [PSA C*], or do this [division worksheet], which would you rather do?

S: "I would do the Dr. Game, 'cause it's funner than doing all those math problems."

S: "Dr. Game...it'd be more fun 'cause you get to work with a game instead of pencil and paper."

D. General Enjoyment
Sample Codesheet

Subject # 33

Coder: Dorothy

Q#	VALENCE	RESPONSE
6	+	Proud. I knew I solved the mystery
9	–	Embarassed - don't know if I got the answer right or not
13	+	I like mysteries.
19	+	Proud - think I got the answer right to that one.
22	+	More fun if I tried it Cause I'll learn more
32	+	I like putting things in order.
33	+	Like putting things in order like that.
35	+	I like mysteries.
36	+	I like it. makes you think hard.
37	+	Do puzzles just for fun of it.
39	–	Hate math .. working with numbers.
63	+	Liked (PSAC)
64	+	Like mysteries. This was more like a mystery.
66	+	Proud - at least I tried.

APPENDIX III.K:

Interrater Reliability

Interrater Reliability

This appendix presents statistics on interrater reliability for the various coding schemes presented throughout this volume. Please note that because the different analyses described in the volume have used different types of data, we have not used the same measures of reliability in each case, but rather have attempted to match each set of data to the reliability measure best suited to it.

Construct of Mathematics

To assure the replicability of the coding schemes used for Construct of Mathematics, two researchers independently coded a subset of sixteen interviews, and correlations were runbetween the number of advanced mathematics statements, practical and sophisticated problem-solving statements, and Goal III subgoals they identified in the children's responses. Recall that the first two coding systems were used for the Attitude Interview only, and that the Goal III subgoals were used to classify the children's examples of mathematics both in the Attitude Interview and in the Essay. These correlations are presented in the following table:

Analysis	r
Advanced mathematics statements:	.92
Practical & sophisticated problem-solving statements:	.89
Goal III subgoals:	.89

All of these correlations were significant ($p < .001$). Given the high correlations between the two researchers' scoring, the coding schemes used for the Attitude Interview and the Essay were considered to be clearly conceptualized and replicable.

Usefulness and Importance

The Attitude Interview. As in the Construct of Mathematics dimension, two researchers independently coded a subset of sixteen interviews to assess the reliability of the scheme. Correlations were run between the numbers of applications, future-oriented responses, and unique applications coded by the two raters. These correlations are presented in the following table:

Analysis	r
Number of applications	.89
Future & conditional responses	.84
Unique applications	.77

All of these correlations were significant ($p < .001$). Given the high correlations between the two researchers' scoring, the coding scheme was considered to be clearly conceptualized and replicable

The Essay. As the reader may recall, two Use/Importance analyses were with regard to the Essay: Types of Applications and Types of Mathematics. Two raters independently coded a subset of fifteen essays under each of these coding systems. The following table indicates the percent agreement between the two raters and Cohen's kappa (Cohen, 1960), an adjusted measure of agreement:

Analysis	Percent agreement	Kappa
Types of applications	80%	.62
Types of mathematics	80%	.59

In each case, the high agreement between raters led us to feel confident that our coding schemes were clear and reliable.

Motivation

To assure the replicability of the coding schemes used for Motivation, two researchers independently coded a subset of sixteen interviews. Correlations were run between the raters' coding of orientation, level, and valence. These correlations are presented in the following table:

Analysis	r
Orientation	.93
Level	.61
Valence	.54

All three of these correlations were significant ($p < .001$ for orientation, and $p < .05$ for level and valence), although the correlations for level and valence were somewhat lower than we would have liked. However, an examination of the data revealed that on the three-point scale for level, 14 of the 16 children all received ratings between 1 and 2, and all but one of the children received valence scores in the positive half of the range. Thus, the lower correlations for level and valence seemed to be attributable, not to disagreement between the raters, but to the low variability among the scores produced by the sample; indeed, the percent agreement between the raters was 81% for valence, even though the lowest interrater correlation was observed for this measure. Given the statistical significance of the correlations presented above and the restricted variance of the children's scores, we felt that this coding was reliable.

Enjoyment

Reliability for this dimension was assessed both for the reasons-for-enjoyment scheme used to code the children's responses to the questions in the Attitude Interview that had been designated for enjoyment and for the general enjoyment analysis that examined expressions of positive enjoyment throughout the interview.

Reasons-for-enjoyment. To assess the reliability of this coding scheme, two interviewers coded a subset of sixteen interviews for orientation, level and valence. Correlations were run between the raters' coding for each of these variables. These correlations are shown in the following table:

Analysis	r
Orientation	.81
Level	.74
Valence	.46

The correlations observed for orientation and level were significant ($p < .001$ for orientation and $p < .01$ for level), but the correlation observed for valence was only marginal ($p < .10$). However, a further examination of the data revealed that the marginality of the valence correlation was not due to a lack of agreement between the raters; indeed, there was 91% agreement between the raters' coding for valence. Rather, the lower correlation seemed attributable to the fact that the children's responses were overwhelmingly positive. The restricted variance of the children's valence scores appeared to have resulted in a lower correlation. Given this restricted variance, as well as the 91% agreement between raters, we concluded that our coding scheme for valence, like the schemes used for orientation and level, was clearly conceived and replicable.

General enjoyment. To assess reliability for the general enjoyment analysis, two researchers independently coded a subset of twelve interviews. The correlation between the number of positive statements that they identified was highly significant ($r = .90$, $p < .001$). Thus, we felt confident that the coding scheme used in the general enjoyment analysis was clear and reliable.

APPENDIX III.L:

Statistical Analyses Used

in the Analysis of Change

STATISTICAL ANALYSES USED IN THE RESULTS SECTION

This Appendix presents information on the statistical analyses used in the Results sections of the various chapters in this volume. It is divided into sections similar to those used in the Results section; each section lists the relevant statistical analyses and their results.

For the convenience of the reader, each section is labelled with the page number to which it refers in the text.

CHAPTER 3

CONSTRUCT OF MATHEMATICS AND PROBLEM SOLVING

p. 85 Categories of Mathematics and Problem Solving Analysis

Since construct responses could conceivably occur in response to any question, an analysis was conducted on 12 interviews to determine if the Categories of Mathemetics and Problem Solving Analysis was completely capturing the references to the construct of mathematics. Extremely high correlations resulted from correlating the scores for the designated construct questions with the scores obtained from coding every interview question. For the mathematics responses, the correlation of the proportions of statements was .98 ($p < .001$). For the problem solving responses, the correlations of the proportions of statements was .87 ($p < .001$). Our conclusion from this analysis was that the designated construct questions were adequate for our analysis.

p. 93 Advanced Mathematics

A two-way analysis of variance was performed on the arcsine transformation of the proportion of advanced mathematics statements made by viewers and nonviewers in the pretest and posttest. The factors used were Viewer/Nonviewer (between-groups factor) and Pretest/Posttest (within-groups factor).

The average proportions of advanced mathematics responses given by children are shown below. Standard deviations are shown in parentheses.

	PRETEST	POSTTEST
VIEWERS	.15 (.14)	.22 (.17)
NONVIEWERS	.16 (.13)	.15 (.13)

The analysis revealed a marginally significant interaction of Pretest/Posttest with Viewer/Nonviewer ($F_{1,46} = 3.75$, $p < .10$), indicating that viewers showed a somewhat greater pretest-posttest gain than nonviewers did. A Fisher Least Significant Difference indicated that viewers improved significantly from pretest to posttest ($p < .05$) and performed significantly better than nonviewers in the posttest ($p < .05$). No significant main effect was observed for Viewer/Nonviewer ($F_{1,46} = .77$, N.S.), or for Pretest/Posttest ($F_{1,46} = 2.53$, N.S.).

Analysis by Sex. A three-way analysis of variance was performed on the arcsine transformation of the proportion of advanced mathematics statements made by children, using Pretest/Posttest, Viewer/Nonviewer, and Sex as factors. The mean proportions are shown in the following tables. Standard deviations are shown in parentheses.

PROPORTION OF ADVANCED MATHEMATICS RESPONSES

BOYS

	PRETEST	POSTTEST
VIEWERS	.08 (.09)	.18 (.15)
NONVIEWERS	.09 (.07)	.09 (.06)

GIRLS

	PRETEST	POSTTEST
VIEWERS	.10 (.08)	.15 (.13)
NONVIEWERS	.10 (.09)	.11 (.10)

The analysis revealed no significant effect of Sex either as a main effect ($F_{1,44}$ = .01, N.S.) or in the three-way interaction ($F_{1,44}$ = 1.10, N.S.).

Analysis by Ethnicity. A second three-way analysis of variance was performed on the arcsine transformation of the proportion of advanced mathematics statements, using Pretest/Posttest, Viewer/Nonviewer, and Ethnicity as factors. The mean proportions of the advanced mathematics statements made by the children are presented in the following tables. Standard deviations are shown in parentheses.

PROPORTION OF ADVANCED MATHEMATICS RESPONSES

MINORITY

	PRETEST	POSTTEST
VIEWERS	.09 (.08)	.16 (.13)
NONVIEWERS	.09 (.09)	.09 (.09)

NONMINORITY

	PRETEST	POSTTEST
VIEWERS	.11 (.10)	.18 (.16)
NONVIEWERS	.10 (.05)	.10 (.05)

The analysis revealed no significant effect of Ethnicity either as a main effect ($F_{1,44}$ = 1.17, N.S.) or in the three-way interaction ($F_{1,44}$ = 0.04, N.S.).

Analysis by SES. A third three-way analysis of variance was performed on the arcsine transformation of the proportion of advanced mathematics statements, using Pretest/Posttest, Viewer/Nonviewer, and SES as factors. The mean proportions of the advanced mathematics statements made by the children are presented in the following tables. Standard deviations are shown in parentheses.

PROPORTION OF ADVANCED MATHEMATICS RESPONSES

LOW-SES

	PRETEST	POSTTEST
VIEWERS	.10 (.08)	.17 (.14)
NONVIEWERS	.08 (.10)	.08 (.09)

MIDDLE-SES

	PRETEST	POSTTEST
VIEWERS	.08 (.09)	.16 (.15)
NONVIEWERS	.10 (.06)	.11 (.07)

The analysis revealed no significant effect of SES either as a main effect ($F_{1,44}$ = 0.42, N.S.) or in the three-way interaction ($F_{1,44}$ = 0.27, N.S.).

p. 94 Practical and Sophisticated Problem Solving

The average proportions of practical and sophisticated problem-solving responses given by viewers and nonviewers in the pretest and posttest are shown in the following table. Standard deviations are shown in parentheses.

	PRETEST	POSTTEST
VIEWERS	.17 (.17)	.34 (.21)
NONVIEWERS	.26 (.22)	.26 (.14)

These data were analyzed via a two-way analysis of variance on the arcsine transformation of these proportions. The factors used were Viewer/Nonviewer (between-subjects factor) and Pretest/Posttest (within-subjects factor). A significant interaction of Pretest/Posttest with Viewer/Nonviewer was revealed ($F_{1,46} = 4.63$, $p < .05$). A Fisher Least Significant Difference test indicated that viewers changed significantly from pretest to posttest ($p < .01$). Nonviewers showed no such change. A significant main effect was found for Pretest/Posttest ($F_{1,46} = 8.48$, $p < .01$), but no significant main effect was found for Viewer/Nonviewer ($F_{1,46} = .06$, N.S.).

Analysis by Sex. A three-way analysis of variance was performed on the arcsine transformation of the proportion of practical and sophisticated problem solving responses made by children, using Pretest/Posttest, Viewer/Nonviewer, and Sex as factors. The mean proportions are shown in the following tables. Standard deviations are shown in parentheses.

PROPORTION OF PRACTICAL AND SOPHISTICATED PROBLEM-SOLVING RESPONSES

BOYS

	PRETEST	POSTTEST
VIEWERS	.17 (.18)	.34 (.19)
NONVIEWERS	.27 (.19)	.26 (.13)

GIRLS

	PRETEST	POSTTEST
VIEWERS	.16 (.16)	.34 (.24)
NONVIEWERS	.26 (.25)	.27 (.16)

The analysis revealed no significant effect of Sex either as a main effect ($F_{1,44}$ = .05, N.S.) or in the three-way interaction ($F_{1,44}$ = .20, N.S.).

Analysis by Ethnicity. A second three-way analysis of variance was performed on the arcsine transformation of the proportion of statements, using Pretest/Posttest, Viewer/Nonviewer, and Ethnicity as factors. The mean proportions of the practical and sophisticated problem-solving statements made by the children are presented in the following tables. Standard deviations are shown in parentheses.

PROPORTION OF PRACTICAL AND SOPHISTICATED PROBLEM-SOLVING RESPONSES

MINORITY

	PRETEST	POSTTEST
VIEWERS	.14 (.15)	.32 (.19)
NONVIEWERS	.25 (.21)	.28 (.16)

NONMINORITY

	PRETEST	POSTTEST
VIEWERS	.23 (.20)	.38 (.27)
NONVIEWERS	.29 (.25)	.22 (.10)

The analysis revealed no significant effect of Ethnicity either as a main effect ($F_{1,44}$ = 0.56, N.S.) or in the three-way interaction ($F_{1,44}$ = 0.00, N.S.).

Analysis by SES. A third three-way analysis of variance was performed on the arcsine transformation of the proportion of statements, using Pretest/Posttest. Viewer/Nonviewer, and SES as factors. The mean proportions of the practical and sophisticated problem-solving statements made by the children are presented in the following tables. Standard deviations are shown in parentheses.

PROPORTION OF PRACTICAL AND SOPHISTICATED PROBLEM-SOLVING RESPONSES

LOW-SES

	PRETEST	POSTTEST
VIEWERS	.11 (.11)	.33 (.18)
NONVIEWERS	.27 (.23)	.23 (.16)

MIDDLE-SES

	PRETEST	POSTTEST
VIEWERS	.22 (.19)	.35 (.25)
NONVIEWERS	.25 (.21)	.29 (.11)

The analysis revealed no significant effect of SES either as a main effect ($F_{1,44}$ = 1.55, N.S.) or in the three-way interaction ($F_{1,44}$ = 1.94, N.S.).

p. 96 Goal III Analysis in the Interview

The average numbers of types of mathematics mentioned in the interview by viewers and nonviewers in the pretest and posttest are as follows. Standard deviations are shown in parentheses.

	PRETEST	POSTTEST
VIEWERS	4.17 (1.81)	4.63 (1.64)
NONVIEWERS	4.17 (1.71)	4.13 (1.87)

A two-way analysis of variance using the factors Viewer/Nonviewer (between-subjects factor) and Pretest/Posttest (within-subjects factor) revealed no significant main effects for Viewer/Nonviewer ($F_{1,46}$ = .45, N.S.) or Pretest/Posttest ($F_{1,46}$ = .37, N.S.) and no significant interaction ($F_{1,46}$ = .53, N.S.).

Analysis by Sex. A three-way analysis of variance was performed on the number of Goal III type of mathematics responses given by the children, using Pretest/Posttest, Viewer/Nonviewer, and Sex as factors. The mean numbers of Goal III content areas mentioned by boys and girls are shown in the following tables. Standard deviations are shown in parentheses.

MEAN NUMBER OF GOAL III RESPONSES

BOYS

	PRETEST	POSTTEST
VIEWERS	3.92 (1.31)	4.17 (1.34)
NONVIEWERS	4.42 (1.08)	3.75 (1.36)

GIRLS

	PRETEST	POSTTEST
VIEWERS	4.42 (2.23)	5.08 (1.83)
NONVIEWERS	3.92 (2.19)	4.50 (2.28)

The analysis revealed no significant effect of Sex either as a main effect ($F_{1,44}$ = 1.24, N.S.) or in the three-way interaction ($F_{1,44}$ = .37, N.S.).

Analysis by Ethnicity. A second three-way analysis of variance was performed using Pretest/Posttest, Viewer/Nonviewer, and Ethnicity as factors. The mean numbers of Goal III content areas mentioned by the children are presented in the following tables. Standard deviations are shown in parentheses.

MEAN NUMBER OF GOAL III RESPONSES

MINORITY

	PRETEST	POSTTEST
VIEWERS	3.94 (1.56)	4.53 (1.74)
NONVIEWERS	4.18 (1.88)	4.00 (2.21)

NONMINORITY

	PRETEST	POSTTEST
VIEWERS	4.71 (2.36)	4.86 (1.46)
NONVIEWERS	4.14 (1.35)	4.43 (0.53)

The analysis revealed no significant effect of Ethnicity either as a main effect ($F_{1,44} = 0.81$, N.S.) or in the three-way interaction ($F_{1,44} = 0.35$, N.S.).

Analysis by SES. A third three-way analysis of variance was performed using Pretest/Posttest, Viewer/Nonviewer, and SES as factors. The mean numbers of Goal III content areas mentioned by the children are presented in the following tables. Standard deviations are shown in parentheses.

MEAN NUMBER OF GOAL III RESPONSES

LOW-SES

	PRETEST	POSTTEST
VIEWERS	4.00 (1.81)	4.92 (1.88)
NONVIEWERS	3.67 (1.30)	3.67 (2.42)

MIDDLE-SES

	PRETEST	POSTTEST
VIEWERS	4.33 (1.87)	4.33 (1.37)
NONVIEWERS	4.67 (1.97)	4.58 (1.00)

The analysis revealed no significant effect of SES either as a main effect ($F_{1,44} = 1.28$, N.S.) or in the three-way interaction ($F_{1,44} = 0.36$, N.S.).

p. 97 Distribution of Goal III Content Areas: Interview Data

The distribution of the number of children mentioning each Goal III content area in the Attitude Interview is presented below.

	Pretest		Posttest	
	Viewers	Nonviewers	Viewers	Nonviewers
A. Numbers & Counting	33	33	35	32
B. Arithmetic of Rational #s	25	28	30	29
C. Measurement	14	13	22	15
D. Num. Functions & Relations	20	18	16	13
E. Combinatorics	14	14	23	18
F. Probability & Statistics	0	3	2	6
G. Geometry	9	5	12	5

Pairwise comparisons between viewers and nonviewers were performed within each subgoal. At the Pretest, viewers and nonviewers were not significantly different within subgoals, except with respect to Subgoal F: Probability and Statistics. Nonviewers produced marginally more mentions of this subgoal than viewers did ($\chi^2 = 3.00$, $p < .10$). This difference did not hold for this subgoal at the posttest ($\chi^2 = 2.00$, N.S.).

At Posttest, viewers and nonviewers were different only in Subgoal G: Geometry, with marginally more viewers than nonviewers mentioning instances of Geometry ($\chi^2 = 2.88$, $p < .10$).

p. 97 Goal III and the Essay

The average number of types of mathematics mentioned by individual children in the essay are presented below. Standard deviations are shown in parentheses.

	Viewers	Nonviewers
Number of Types of Mathematics	2.50 (3.79)	2.28 (2.77)

A pairwise t-test revealed no significant difference between the viewers and nonviewers (t_{235} = .64, N.S.).

Analysis by Sex. A two-way analysis of variance was performed on the mean number of types of mathematics mentioned by the children, using Viewer/Nonviewer, and Sex as factors. The mean numbers of types of mathematics mentioned by boys and girls are shown in the following tables. Standard deviations are shown in parentheses.

	BOYS	GIRLS
VIEWERS	2.05 (2.59)	3.08 (3.24)
NONVIEWERS	2.25 (2.86)	2.18 (2.55)

The analysis revealed no significant effect of Sex either as a main effect ($F_{1,256}$ = 1.93, N.S.) or in the interaction of Viewer/Nonviewer with Sex ($F_{1,256}$ = 2.38, N.S.).

Analysis by Ethnicity. A two-way analysis of variance was performed on the mean number of types of mathematics mentioned by the children, using Viewer/Nonviewer, and Ethnicity as factors. The mean numbers of types of mathematics mentioned by boys and girls are shown in the following tables. Standard deviations are shown in parentheses.

	MINORITY	NONMINORITY
VIEWERS	2.94 (3.46)	2.00 (1.84)
NONVIEWERS	2.50 (3.03)	1.48 (1.60)

The analysis revealed a significant main effect of Ethnicity ($F_{1,256}$ = 5.30, $p < .05$), minority children mentioning more types of mathematics than nonminority children. The interaction of Viewer/Nonviewer with Ethnicity was not significant ($F_{1,256}$ = .77, N.S.).

Analysis by SES. A two-way analysis of variance was performed on the mean number of types of mathematics mentioned by the children, using Viewer/Nonviewer, and SES as factors. The mean numbers of types of mathematics mentioned by boys and girls are shown in the following tables. Standard deviations are shown in parentheses.

	LOW-SES	MIDDLE-SES
VIEWERS	3.70 (4.15)	2.00 (1.96)
NONVIEWERS	2.92 (3.52)	1.92 (2.05)

The analysis revealed a significant main effect of SES ($F_{1,256} = 13.25$, $p < .01$), low-ses children mentioning more types of mathematics than middle-ses children. The interaction of Viewer/Nonviewer with SES was not significant ($F_{1,256} = 1.18$, N.S.).

p. 97 Distribution of Goal III Content Areas: Essay Data

The distribution of the number of children mentioning each Goal III content area in the Essay is presented below.

	Viewers	Nonviewers
A. Numbers & Counting	58	59
B. Arithmetic of Rational #s	69	78
C. Measurement	104	69
D. N[illegible]. Functions & [illegible]lations	1	0
E. Combinatorics	0	0
F. Probability & Statistics	3	4
G. Geometry	64	45

Pairwise comparisons between viewers and nonviewers were performed within each subgoal. The two groups were significantly different only in Subgoal C: Measurement and Subgoal G: Geometry. Viewers gave significantly more Goal III Measurement responses in the essay than did Nonviewers ($\chi^2 = 7.08$, $p < .01$). Viewers also produced marginally more Geometry responses than did Nonviewers ($\chi^2 = 3.31$, $p < .10$).

CHAPTER 4

USEFULNESS AND IMPORTANCE

INTERVIEW ANALYSES

p. 125 The Interview Analysis Scheme

To determine whether the number of applications given would be related to the number of follow-up questions the interviewers asked, a correlation of the number of applications given with the number of questions asked was performed. The result indicated that the number of applications given was significantly related to the number of questions posed by the interviewer. ($r_{46} = .38$, $p < .01$). Therefore, for our analysis of the number of applications given by the children, the number of questions asked was used as a covariate.

p. 131 Applications

The average number of applications given by children are shown below. Standard deviations are shown in parentheses.

	PRETEST	POSTTEST
VIEWERS	10.08 (3.59)	13.71 (5.16)
NONVIEWERS	10.46 (4.91)	12.29 (4.48)

A two-way analysis of covariance was performed on the number of applications mentioned by viewers and nonviewers in the pretest and posttest. The factors used were Viewer/Nonviewer (between-groups factor) and Pretest/Posttest (within-groups factor). Because the number of applications could vary as a function of the number of questions asked of a particular child, the number of questions was used as a covariate.

The analysis revealed no significant main effect for Viewer/Nonviewer ($F_{1,45} = .66$, N.S.), and no significant interaction of Pretest/Posttest with Viewer/Nonviewer ($F_{1,45} = 1.37$, N.S.).

A significant main effect was found for Pretest/Posttest ($F_{1,45} = 9.58$, $p < .01$). However, because this difference collapses data across experimental groups, it is of little experimental interest and will not be discussed further.

Analysis by Sex. A three-way analysis of covariance was performed on the number of applications given by children, using Pretest/Posttest, Viewer/Nonviewer, and Sex as factors. The number of questions answered by the children was used as a covariate. The mean numbers of applications given by the children are shown in the following tables. Standard deviations are shown in parentheses.

NUMBER OF APPLICATIONS OF MATHEMATICS RESPONSES

BOYS

	PRETEST	POSTTEST
VIEWERS	10.75 (3.57)	14.42 (4.76)
NONVIEWERS	10.67 (4.56)	11.83 (4.39)

GIRLS

	PRETEST	POSTTEST
VIEWERS	9.42 (3.63)	13.00 (5.66)
NONVIEWERS	10.25 (5.43)	12.75 (4.71)

The analysis revealed no significant effect of Sex either as a main effect ($F_{1,43}$ = .26, N.S.) or in the three-way interaction ($F_{1,43}$ = .24, N.S.).

Analysis by Ethnicity. A second three-way analysis of covariance was performed using Pretest/Posttest, Viewer/Nonviewer, and Ethnicity as factors. The number of questions answered by the children was used as a covariate. The mean numbers of applications giv^n by the children are presented in the following tables. Standard deviations are shown in parentheses.

NUMBER OF APPLICATIONS OF MATHEMATICS RESPONSES

MINORITY

	PRETEST	POSTTEST
VIEWERS	9.77 (3.65)	12.82 (4.13)
NONVIEWERS	9.65 (4.74)	12.24 (4.54)

NONMINORITY

	PRETEST	POSTTEST
VIEWERS	10.86 (3.58)	15.86 (7.01)
NONVIEWERS	12.43 (5.09)	12.43 (4.69)

The analysis revealed no significant effect of Ethnicity either as a main effect ($F_{1,43}$ = 0.03, N.S.) or in the three-way interaction ($F_{1,43}$ = 1.67, N.S.).

Analysis by SES. A third three-way analysis of covariance was performed using Pretest/Posttest, Viewer/Nonviewer, and SES as factors. The number of questions answered by the children was used as a covariate. The mean numbers of applications given by the children are presented in the following tables. Standard deviations are shown in parentheses.

NUMBER OF APPLICATIONS OF MATHEMATICS RESPONSES

LOW-SES

	PRETEST	POSTTEST
VIEWERS	9.00 (3.05)	12.92 (4.94)
NONVIEWERS	7.58 (3.06)	10.67 (4.46)

MIDDLE-SES

	PRETEST	POSTTEST
VIEWERS	11.17 (3.88)	14.50 (5.47)
NONVIEWERS	13.33 (4.79)	13.92 (4.03)

The analysis revealed no significant effect of SES either as a main effect ($F_{1,43}$ = 2.32, N.S.) or in the three-way interaction ($F_{1,43}$ = .38, N.S.).

p. 133 Future-Oriented Responses

The average proportions of future-oriented responses given by children are shown below. Standard deviations are shown in parentheses.

	PRETEST	POSTTEST
VIEWERS	.39 (.20)	.45 (.20)
NONVIEWERS	.37 (.19)	.45 (.14)

A two-way analysis of variance was performed on the arcsine transformation of the proportion of future-oriented responses made by viewers and nonviewers in the pretest and posttest. The factors used were Viewer/Nonviewer (between-groups factor) and Pretest/ Posttest (within-groups factor).

The analysis revealed no significant main effect for Viewer/Nonviewer ($F_{1,46}$ = 1.72, N.S.) or Pretest/Posttest ($F_{1,46}$ = .17, N.S.), and no significant interaction of Pretest/Posttest with Viewer/Nonviewer ($F_{1,46}$ = .37, N.S.).

Analysis by Sex. A three-way analysis of variance was performed on the arcsine transformation of the proportion of future-oriented responses given by children, using Pretest/Posttest, Viewer/Nonviewer, and Sex as factors. The mean proportions are shown in the following tables. Standard deviations are shown in parentheses.

PROPORTION OF FUTURE-ORIENTED RESPONSES

BOYS

	PRETEST	POSTTEST
VIEWERS	.40 (.21)	.44 (.21)
NONVIEWERS	.43 (.17)	.53 (.12)

GIRLS

	PRETEST	POSTTEST
VIEWERS	.38 (.20)	.46 (.20)
NONVIEWERS	.32 (.20)	.38 (.12)

The analysis revealed a marginal main effect of Sex ($F_{1,44} = 3.30$, $p < .10$), boys giving marginally more future-oriented responses than girls. The analysis revealed no significant effect in the three-way interaction with Pretest/Posttest and Viewer/Nonviewer ($F_{1,44} = .06$, N.S.).

Analysis by Ethnicity. A second three-way analysis of variance was performed on the arcsine transformation of the proportion of future-oriented responses. This analysis used Pretest/Posttest, Viewer/Nonviewer, and Ethnicity as factors. The mean proportions of future-oriented responses made by the children are presented in the following tables. Standard deviations are shown in parentheses.

PROPORTION OF FUTURE-ORIENTED RESPONSES

MINORITY

	PRETEST	POSTTEST
VIEWERS	.36 (.18)	.42 (.21)
NONVIEWERS	.39 (.21)	.45 (.14)

NONMINORITY

	PRETEST	POSTTEST
VIEWERS	.45 (.24)	.51 (.15)
NONVIEWERS	.33 (.13)	.46 (.17)

The analysis revealed no significant effect of Ethnicity either as a main effect ($F_{1,44} = 0.60$, N.S.) or in the three-way interaction ($F_{1,44} = 0.02$, N.S.).

Analysis by SES. A third three-way analysis of variance was performed on the arcsine transformation of the proportion of future-oriented responses. This analysis used Pretest/Posttest, Viewer/Nonviewer, and SES as factors. The mean proportions of future-oriented responses made by the children are presented in the following tables. Standard deviations are shown in parentheses.

PROPORTIONS OF FUTURE-ORIENTED RESPONSES

LOW-SES

	PRETEST	POSTTEST
VIEWERS	.36 (.16)	.40 (.23)
NONVIEWERS	.39 (.23)	.49 (.15)

MIDDLE-SES

	PRETEST	POSTTEST
VIEWERS	.42 (.24)	.50 (.15)
NONVIEWERS	.35 (.14)	.42 (.14)

The analysis revealed no significant effect of SES either as a main effect ($F_{1,44} = 0.41$, N.S.) or in the three-way interaction ($F_{1,44} = 0.43$, N.S.).

p. 134 Unique Applications

The average proportion of unique applications given by children are shown below. Standard deviations are shown in parentheses.

	PRETEST	POSTTEST
VIEWERS	.21 (.20)	.33 (.18)
NONVIEWERS	.19 (.16)	.24 (.17)

A two-way analysis of variance was performed on the arcsine transformation of the proportion of unique applications given by viewers and nonviewers in the pretest and posttest. The factors used were Viewer/Nonviewer (between-groups factor) and Pretest/ Posttest (within-groups factor).

The analysis revealed a marginal main effect for Viewer/Nonviewer ($F_{1,46} = 3.83$, $p < .10$); however, because this effet collapses over the pretest and posttest, it is of little experimental interest and will not be discussed further. No significant interaction of Pretest/Posttest with Viewer/ Nonviewer was revealed ($F_{1,46} = .47$, N.S.).

A significant main effect was found for Pretest/Posttest ($F_{1,44} = 4.08$, $p < .05$). However, because this difference collapses data across experimental groups, it is of little experimental interest and will not be discussed further.

Analysis by Sex. A three-way analysis of variance was performed on the arcsine transformation of the proportion of unique applications given by children, using Pretest/Posttest, Viewer/Nonviewer, and Sex as factors. The mean proportions are shown in the following tables. Standard deviations are shown in parentheses.

PROPORTION OF UNIQUE APPLICATIONS

BOYS

	PRETEST	POSTTEST
VIEWERS	.23 (.21)	.37 (.18)
NONVIEWERS	.19 (.16)	.32 (.19)

GIRLS

	PRETEST	POSTTEST
VIEWERS	.18 (.19)	.28 (.17)
NONVIEWERS	.19 (.16)	.16 (.12)

The analysis revealed a marginal main effect of Sex ($F_{1,44} = 3.56$, $p < .10$), but no significant effect in the three-way interaction ($F_{1,44} = .80$, N.S.).

Analysis by Ethnicity. A second three-way analysis of variance was performed on the arcsine transformation of the proportion of unique applications given by children. The factors used in this analysis were Pretest/Posttest, Viewer/Nonviewer, and Ethnicity. The mean proportions of unique applications given by the children are presented in the following tables. Standard deviations are shown in parentheses.

PROPORTION OF UNIQUE APPLICATIONS

MINORITY

	PRETEST	POSTTEST
VIEWERS	.19 (.18)	.29 (.16)
NONVIEWERS	.17 (.16)	.24 (.17)

NONMINORITY

	PRETEST	POSTTEST
VIEWERS	.24 (.24)	.43 (.18)
NONVIEWERS	.23 (.15)	.23 (.18)

The analysis revealed no significant effect of Ethnicity either as a main effect ($F_{1,44} = 1.36$, N.S.) or in the three-way interaction ($F_{1,44} = .02$, N.S.).

Analysis by SES. A third three-way analysis of variance was performed on the arcsine transformation of the proportion of unique applications, using Pretest/Posttest, Viewer/Nonviewer, and SES as factors. The mean proportions of unique applications made by the children are presented in the following tables. Standard deviations are shown in parentheses.

PROPORTION OF UNIQUE APPLICATIONS

LOW-SES

	PRETEST	POSTTEST
VIEWERS	.15 (.15)	.31 (.16)
NONVIEWERS	.19 (.18)	.22 (.18)

MIDDLE-SES

	PRETEST	POSTTEST
VIEWERS	.26 (.23)	.34 (.20)
NONVIEWERS	.19 (.15)	.26 (.17)

The analysis revealed no significant effect of SES either as a main effect ($F_{1,44}$ = 1.20, N.S.) or in the three-way interaction ($F_{1,44}$ = .11, N.S.).

ESSAY ANALYSES

p. 135 Types of Applications

The proportion of viewers and nonviewers whose essays were coded as mentioning either specific or general applications of mathematics is shown below.

	SPECIFIC	GENERAL
VIEWERS	.60	.40
NONVIEWERS	.48	.52

A chi-square test of contingency performed on this data revealed that significantly more viewers than nonviewers wrote essays that mention specific applications of mathematics (χ^2 = 3.45, $p < .10$).

Analysis by Sex. Children's responses, analyzed as a function of Sex, are presented below.

	Boy	Girl
Specific	.47	.62
General	.53	.38

A chi-square analysis revealed a significant difference between these groups (χ^2 = 5.38, $p < .05$), with a significantly higher proportion of girls mentioning specific applications of mathematics than boys.

Responses analyzed as a function of both Viewer/Nonviewer and Sex are presented below.

	VIEWER		NONVIEWER	
	Boy	Girl	Boy	Girl
Specific	.53	.68	.42	.57
General	.47	.32	.58	.43

A chi-square analysis revealed a marginal difference between both male and female viewers ($\chi^2 = 2.81$, $p < .10$), and between male and female nonviewers ($\chi^2 = 3.20$, $p < .10$). In each case, a marginally higher proportion of girls than boys gave specific applications of mathematics.

Analysis by Ethnicity. Children's responses, analyzed as a function of Ethnicity, are presented below.

	Minority	Nonminority
Specific	.48	.55
General	.52	.45

A chi-square analysis revealed no significant differences between these groups ($\chi^2 = .82$, N.S.).

Responses analyzed as a function of both Viewer/Nonviewer and Ethnicity are presented below.

	VIEWER		NONVIEWER	
	Minority	Nonminority	Minority	Nonminority
Specific	.57	.63	.33	.49
General	.42	.37	.67	.51

Two chi-square tests of contingency revealed no significant differences between the groups for viewers ($\chi^2 = .24$, N.S.) or nonviewers ($\chi^2 = 1.86$, N.S.).

Analysis by SES. Children's responses, analyzed as a function of SES, are presented below.

	Middle-SES	Low-SES
Specific	.48	.66
General	.52	.34

A chi-square analysis revealed significant differences between these groups ($\chi^2 = 7.22, p < .01$), with a significantly higher proportion of low-SES children giving specific applications of mathematics than middle-SES children.

Responses analyzed as a function of both Viewer/Nonviewer and SES are presented below.

	VIEWER		NONVIEWER	
	Middle	Low	Middle	Low
Specific	.58	.65	.39	.67
General	.42	.35	.61	.33

A chi-square analysis revealed no significant differences between SES groups among viewers ($\chi^2 = .55$, N.S.). A significant difference was found between SES groups among nonviewers ($\chi^2 = 9.21, p < .01$), with a significantly higher proportion of low-SES children giving specific applications of mathematics than middle-SES children.

p. 136 Types of Mathematics

The proportion of viewers and nonviewers whose essays were coded as mentioning specific areas of mathematics, as opposed to general mathematics is shown below.

	SPECIFIC	GENERAL
VIEWERS	.55	.45
NONVIEWERS	.54	.45

A chi-square test of contingency performed on this data revealed no significant differences between these groups ($\chi^2 = .03$, N.S.).

Analysis by Sex. Children's responses, analyzed as a function of Sex, are presented below.

	Boy	Girl
Specific	.50	.61
General	.50	.39

A chi-square analysis revealed a marginal difference between these groups ($\chi^2 = 2.85$, $p < .10$), with a marginally higher proportion of girls mentioning specific types of mathematics than boys.

Responses analyzed as a function of both Viewer/Nonviewer and Sex are presented below.

	VIEWER		NONVIEWER	
	Boy	Girl	Boy	Girl
Specific	.51	.61	.49	.61
General	.49	.39	.51	.39

A chi-square analysis revealed a significant difference between either male and female viewers ($\chi^2 = 1.13$, N.S.), or male and female nonviewers ($\chi^2 = 1.73$, N.S.).

Analysis by Ethnicity. Children's responses, analyzed as a function of Ethnicity, are presented below.

	Minority	Nonminority
Specific	.59	.48
General	.41	.52

A chi-square analysis revealed no significant differences between these groups ($\chi^2 = 2.17$, N.S.).

Responses analyzed as a function of both Viewer/Nonviewer and Ethnicity are presented below.

	VIEWER		NONVIEWER	
	Minority	Nonminority	Minority	Nonminority
Specific	.59	.53	.42	.60
General	.41	.47	.58	.40

Two chi-square tests of contingency revealed no significant differences between the groups for viewers (χ^2 = .37, N.S.) or nonviewers (χ^2 = 2.52, N.S.), with a significantly higher proportion of minority children mentioning specific types of mathematics than nonminority children.

<u>Analysis by SES.</u> Children's responses, analyzed as a function of SES, are presented below.

	Middle-SES	Low-SES
Specific	.49	.67
General	.51	.33

A chi-square analysis revealed a significant difference in that proportionally more low-SES children wrote about specific types of mathematics (χ^2 = 6.85, $p < .01$).

Responses analyzed as a function of both Viewer/Nonviewer and SES are presented below.

	VIEWER		NONVIEWER	
	Middle	Low	Middle	Low
Specific	.55	.58	.44	.75
General	.45	.43	.56	.25

A chi-square analysis revealed no significant differences between SES groups among viewers (χ^2 = 1.02, N.S.). A significant difference was found between SES groups among nonviewers (χ^2 = 11.19, $p < .01$), with a significantly higher proportion of low-SES children mentioning specific types of mathematics than middle-SES children.

CHAPTER 5

MOTIVATION

p. 158 Performance Orientation

To determine whether a third category for ambiguous statements would be necessary, the responses of subset of 16 children were drawn from the data. These children's proportion of engagement statements were computed in two ways: once with a denominator equal to total number of unambiguous statements and once using all statements (ambiguous and unambiguous). The correlation bewteen the two was highly significant ($r = .99$, $p < .001$). Thus, it seemed a third category was not necessary.

p. 158 The relationship between orientation and Dweck's goals

In order to determine the degree to which Orientation was related to Dweck's achievement goals, a correlation between the children's choice of learning goal in the forced-choice question (Dweck's measure) and the proportion of statements in the engagement orientation (our measure). The correlation was .47 ($df = 45$, $p < .001$), indicating a highly significant positive relationship between our orientation and Dweck's achievement goals.

p. 165 Orientation

The average overall proportion of engagement statements made by children are shown below. Standard deviations are shown in parentheses.

	PRETEST	POSTTEST
VIEWERS	.56 (.24)	.62 (.26)
NONVIEWERS	.65 (.19)	.57 (.24)

A two-way analysis of variance was performed on the arcsine transformation of the overall proportion of engagement statements made by viewers and nonviewers in the pretest and posttest. The factors used were Viewer/Nonviewer (between-groups factor) and Pretest/Posttest (within-groups factor).

The analysis revealed no significant main effect of Viewer/Nonviewer ($F_{1,46} = .04$, N.S.). The interaction of Viewer/Nonviewer with Pretest/Posttest was significant ($F_{1,46} = 4.98$, $p < .05$), indicating that viewers made more engagement statements in the posttest than nonviewers. A Fisher Least Significant Difference test, however, showed that none of the pairwise comparsions of cells were significantly different.

Analysis by Sex. A three-way analysis of variance was performed on the arcsine transformation of the overall proportion of engagement statements made by the children. Pretest/Posttest, Viewer/Nonviewer, and Sex were used as factors. The mean proportions are shown in the following tables. Standard deviations are shown in parentheses.

OVERALL PROPORTION OF ENGAGEMENT STATEMENTS

BOYS

	PRETEST	POSTTEST
VIEWERS	.60 (.25)	.58 (.27)
NONVIEWERS	.59 (.15)	.48 (.23)

GIRLS

	PRETEST	POSTTEST
VIEWERS	.53 (.23)	.67 (.26)
NONVIEWERS	.71 (.21)	.66 (.22)

The analysis revealed no significant main effect of Sex ($F_{1,44}$ = 1.10, N.S.), and no significant three-way interaction with Pretest/Posttest and Viewer/Nonviewer ($F_{1,44}$ = .18, N.S.).

Analysis by Ethnicity. A second three-way analysis of variance was performed on the arcsine transformation of the overall proportion of engagement statements made by the children. The analysis used Pretest/Posttest, Viewer/Nonviewer, and Ethnicity as factors. The mean proportions of engagement statements made by the children are presented in the following tables. Standard deviations are shown in parentheses.

OVERALL PROPORTION OF ENGAGEMENT STATEMENTS

MINORITY

	PRETEST	POSTTEST
VIEWERS	.53 (.24)	.59 (.25)
NONVIEWERS	.63 (.19)	.58 (.24)

NONMINORITY

	PRETEST	POSTTEST
VIEWERS	.65 (.22)	.69 (.29)
NONVIEWERS	.68 (.19)	.54 (.26)

The analysis revealed no significant effect of Ethnicity either as a main effect ($F_{1,44} = .85$, N.S.) or in the three-way interaction ($F_{1,44} = .47$, N.S.).

Analysis by SES. A third three-way analysis of variance was performed on the arcsine transformation of the overall proportion of engagement statements made by the children, using Pretest/Posttest, Viewer/Nonviewer, and SES as factors. The mean proportions of engagement statements made by the children are presented in the following tables. Standard deviations are shown in parentheses.

OVERALL PROPORTION OF ENGAGEMENT STATEMENTS

LOW-SES

	PRETEST	POSTTEST
VIEWERS	.55 (.24)	.73 (.26)
NONVIEWERS	.67 (.15)	.57 (.22)

MIDDLE-SES

	PRETEST	POSTTEST
VIEWERS	.58 (.24)	.52 (.23)
NONVIEWERS	.62 (.22)	.58 (.26)

The analysis revealed no significant main effect of SES ($F_{1,44}$ = 1.06, N.S.), but there was a significant effect in the three-way interaction with Pretest/Posttest and Viewer/Nonviewer ($F_{1,44}$ = 5.43, $p < .05$), in that low-SES viewers showed a greater positive change than other children did. A Fisher Least Significant Difference test showed that the low-SES viewers gave a higher proportion of engagement statements at the posttest than low-SES nonviewers ($p < .05$), middle-SES viewers ($p < .05$) and middle-SES nonviewers ($p < .05$).

p. 166 Dweck's Achievement Goals

The distribution of children's responses to the Dweck forced-choice question are presented below.

	Learning Statement	Performance Statement
Viewer	13	11
Nonviewer	6	17

A chi-square test performed on this data revealed that significantly more viewers than nonviewers chose the learning statement in response to the forced-choice question (χ^2 = 3.85, $p < .05$).

Analysis by Sex. Children's responses, analyzed as a function of Sex, are presented below

	Boy	Girl
Learning Statement	8	11
Performance Statement	16	12

A chi-square analysis revealed no significant differences between boys and girls (χ^2 = 1.02, N.S.).

Responses analyzed as a function of both Viewer/Nonviewer and Sex are presented below.

	VIEWER		NONVIEWER	
	Boy	Girl	Boy	Girl
Learning Statement	6	7	2	4
Performance Statement	6	5	10	7

A chi square analysis revealed no significant differences between male and female viewers (χ^2 = .17, N.S.), and no significant differences between male and female nonviewers (χ^2 = 1.15, N.S.).

Analysis by Ethnicity. Children's responses, analyzed as a function of Ethnicity, are presented below.

	Minority	Nonminority
Learning Statement	14	5
Performance Statement	20	8

A chi-square analysis revealed no significant differences between these groups (χ^2 = .03, N.S.).

Responses analyzed as a function of both Viewer/Nonviewer and Ethnicity are presented below.

	VIEWER		NONVIEWER	
	Minority	Nonminority	Minority	Nonminority
Learning Statement	10	3	4	2
Performance Statement	7	4	13	4

A chi-square analysis revealed no significant difference between the groups for viewers (χ^2 = .51, N.S.) and no significant difference between the groups for nonviewers (χ^2 = .22, N.S.).

Analysis by SES. Children's responses, analyzed as a function of SES, are presented below.

	Middle-SES	Low-SES
Learning Statement	11	8
Performance Statement	12	16

A chi-square analysis revealed no significant differences between these groups (χ^2 = 1.02, N.S.).

Responses analyzed as a function of both Viewer/Nonviewer and SES are presented below.

	VIEWER		NONVIEWER	
	Middle-SES	Low-SES	Middle-SES	Low-SES
Learning Statement	8	5	3	3
Performance Statement	4	7	8	9

A chi-square analysis revealed no significant differences between SES groups among viewers (χ^2 = 1.51, N.S.) or nonviewers (χ^2 = .01, N.S.).

p. 167 Magnitude

The overall mean magnitude ratings given to children are shown below. Standard deviations are shown in parentheses.

	PRETEST	POSTTEST
VIEWERS	.12 (.51)	.20 (.50)
NONVIEWERS	.12 (.56)	-.08 (.58)

A two-way analysis of variance was performed on the overall mean magnitude ratings given to viewers and nonviewers in the pretest and posttest. The factors used were Viewer/Nonviewer (between-groups factor) and Pretest/Posttest (within-groups factor).

The analysis revealed no significant main effect of Viewer/Nonviewer ($F_{1,46}$ = 1.11, N.S.), and no significant interaction of Viewer/Nonviewer with Pretest/Posttest ($F_{1,46}$ = 2.93, N.S.).

Analysis by Sex. A three-way analysis of variance was performed on the overall magnitude ratings given to the children. Pretest/Posttest, Viewer/Nonviewer, and Sex were used as factors. The mean magnitude ratings are shown in the following tables. Standard deviations are shown in parentheses.

OVERALL MAGNITUDE RATINGS

BOYS

	PRETEST	POSTTEST
VIEWERS	.05 (.55)	.21 (.53)
NONVIEWERS	-.17 (.49)	-.20 (.54)

GIRLS

	PRETEST	POSTTEST
VIEWERS	.19 (.47)	.19 (.50)
NONVIEWERS	.41 (.47)	.03 (.62)

The analysis revealed no significant main effect of Sex ($F_{1,44} = 3.58$, N.S.), and no significant effect in the three-way interaction with Pretest/Posttest and Viewer/Nonviewer ($F_{1,44} = .29$, N.S.).

Analysis by Ethnicity. A second three-way analysis of variance was performed using Pretest/Posttest, Viewer/Nonviewer, and Ethnicity as factors. The mean overall magnitude ratings given to the children are presented in the following tables. Standard deviations are shown in parentheses.

OVERALL MAGNITUDE RATINGS

MINORITY

	PRETEST	POSTTEST
VIEWERS	.15 (.52)	.16 (.44)
NONVIEWERS	.07 (.58)	-.14 (.56)

NONMINORITY

	PRETEST	POSTTEST
VIEWERS	.04 (.50)	.29 (.66)
NONVIEWERS	.24 (.52)	.06 (.65)

The analysis revealed no significant effect of Ethnicity either as a main effect ($F_{1,44}$ = .47, N.S.) or in the three-way interaction ($F_{1,44}$ = .31, N.S.).

Analysis by SES. A third three-way analysis of variance was performed using Pretest/Posttest, Viewer/Nonviewer, and SES as factors. The mean overall magnitude ratings given to the children are presented in the following tables. Standard deviations are shown in parentheses.

OVERALL MAGNITUDE RATINGS

LOW-SES

	PRETEST	POSTTEST
VIEWERS	.17 (.54)	.24 (.54)
NONVIEWERS	.26 (.61)	.10 (.64)

MIDDLE-SES

	PRETEST	POSTTEST
VIEWERS	.07 (.49)	.16 (.48)
NONVIEWERS	-.02 (.48)	-.26 (.47)

The analysis revealed no significant effect of SES either as a main effect ($F_{1,44}$ = 2.55, N.S.), or in the three-way interaction ($F_{1,44}$ = .08, N.S.).

p. 168 Valence

The overall mean proportion of positive statements given by children are shown below. Standard deviations are shown in parentheses.

	PRETEST	POSTTEST
VIEWERS	.76 (.12)	.77 (.10)
NONVIEWERS	.76 (.14)	.67 (.16)

A two-way analysis of variance was performed on the arcsine transformation of the overall mean proportions of positive statements given by viewers and nonviewers in the pretest and posttest. The factors used were Viewer/Nonviewer (between-groups factor) and Pretest/Posttest (within-groups factor).

The analysis revealed no significant main effect of Viewer/Nonviewer ($F_{1,46} = .70$, N.S.), but it did reveal a marginal interaction of Viewer/Nonviewer with Pretest/Posttest ($F_{1,46} = 3.79$, $p < .10$). A Fisher Least Significant Difference Test revealed that this interaction was due to the significant decline that nonviewers showed from pretest to posttest ($p < .05$).

Analysis by Sex. A three-way analysis of variance was performed on the arcsine transformation of the overall proportion of positive statements made by the children. Pretest/Posttest, Viewer/Nonviewer, and Sex were used as factors. The mean proportions are shown in the following tables. Standard deviations are shown in parentheses.

OVERALL MEAN PROPORTIONS OF POSITIVE STATEMENTS

BOYS

	PRETEST	POSTTEST
VIEWERS	.72 (.12)	.79 (.11)
NONVIEWERS	.69 (.10)	.63 (.17)

GIRLS

	PRETEST	POSTTEST
VIEWERS	.80 (.11)	.76 (.10)
NONVIEWERS	.82 (.14)	.72 (.14)

The analysis revealed no significant effect of Sex, either as a main effect ($F_{1,44}$ = .98, N.S.) or in the three-way interaction with Pretest/Posttest and Viewer/Nonviewer ($F_{1,44}$ = .02, N.S.).

Analysis by Ethnicity. A second three-way analysis of variance was performed on the arcsine transformation of the overall proportion of positive statements made by the children. The factors used were Pretest/Posttest, Viewer/Nonviewer, and Ethnicity. The mean overall proportions of positive statements given by the children are presented in the following tables. Standard deviations are shown in parentheses.

OVERALL MEAN PROPORTIONS OF POSITIVE STATEMENTS

MINORITY

	PRETEST	POSTTEST
VIEWERS	.78 (.12)	.76 (.11)
NONVIEWERS	.76 (.14)	.65 (.16)

NONMINORITY

	PRETEST	POSTTEST
VIEWERS	.71 (.11)	.81 (.08)
NONVIEWERS	.75 (.15)	.72 (.16)

The analysis revealed no significant effect of Ethnicity either as a main effect ($F_{1,44}$ = .07, N.S.) or in the three-way interaction ($F_{1,44}$ = .23, N.S.).

Analysis by SES. A third three-way analysis of variance was performed on the arcsine transformation of the overall proportion of positive statements made by the children. The factors used were Pretest/Posttest, Viewer/Nonviewer, and SES. The mean overall proportions of positive statements given by the children are presented in the following tables. Standard deviations are shown in parentheses.

OVERALL MEAN PROPORTIONS OF POSITIVE STATEMENTS

LOW-SES

	PRETEST	POSTTEST
VIEWERS	.75 (.11)	.76 (.10)
NONVIEWERS	.76 (.15)	.72 (.16)

MIDDLE-SES

	PRETEST	POSTTEST
VIEWERS	.77 (.13)	.79 (.10)
NONVIEWERS	.75 (.13)	.63 (.15)

The analysis revealed no significant effect of SES either as a main effect ($F_{1,44}$ = .18, N.S.), or in the three-way interaction with Pretest/Posttest and Viewer/Nonviewer ($F_{1,44}$ = .48, N.S.).

p. 170 Selection of PSA C* vs. the Other PSAs

The following table shows the number of children who selected PSA C* as the PSA they would most like to do. The data is grouped by Pretest/Posttest and Viewer/Nonviewer.

	PRETEST		POSTTEST	
	PSA C*	Not PSA C*	PSA C*	Not PSA C*
Viewers	7	17	14	10
Nonviewers	11	10	5	18

Two chi-square tests of contingency were performed, one on pretest data and the other on posttest data. In the pretest, the analysis revealed no significant difference between the groups (χ^2 = 2.51, N.S.). In the posttest, however, viewers were significantly more likely than nonviewers to choose PSA C* (χ^2 = 6.53, $p < .05$)

Analysis by Sex. Children's responses, analyzed as a function of Sex, are presented below.

PRETEST

	Boy	Girl
Select PSA C*	10	8
Do Not Select PSA C*	13	14

A chi-square analysis revealed no significant differences between these groups in the pretest (χ^2 = .23, N.S.).

Children's responses in the posttest, analyzed as a function of Sex, are presented below.

POSTTEST

	Boy	Girl
Select PSA C*	12	7
Do Not Select PSA C*	12	16

A chi-square analysis revealed no significant difference was revealed between these groups in the posttest (χ^2 = 1.87, N.S.).

Responses analyzed as a function of both Viewer/Nonviewer and Sex are presented below.

PRETEST

	VIEWER		NONVIEWER	
	Boy	Girl	Boy	Girl
Select PSA C*	4	3	6	5
Do Not Select PSA C*	8	9	5	5

A chi-square analysis revealed no significant differences between male and female viewers (χ^2 = .20 N.S.), and no significant differences between male and female nonviewers (χ^2 = .04, N.S.) in the pretest.

POSTTEST

	VIEWER		NONVIEWER	
	Boy	Girl	Boy	Girl
Select PSA C*	9	5	3	2
Do Not Select PSA C*	3	7	9	9

A chi-square analysis revealed a marginal difference between male and female viewers (χ^2 = 2.74, $p < .10$), proportionately more boys choosing PSA C* than girls. No significant differences between male and female nonviewers were observed in the posttest (χ^2 = .16, N.S.).

Analysis by SES. Children's responses, analyzed as a function of SES, are presented below.

PRETEST

	Middle-SES	Low-SES
Select PSA C*	9	9
Do Not Select PSA C*	15	12

A chi-square analysis revealed no significant differences between these groups in the pretest (χ^2 = .13, N.S.).

POSTTEST

	Middle-SES	Low-SES
Select PSA C*	13	6
Do Not Select PSA C*	10	18

A chi-square analysis revealed a significant difference between these groups in the posttest (χ^2 = 4.85, $p < .05$), with more middle-SES children than low-ses children choosing PSA C*.

Responses analyzed as a function of both Viewer/Nonviewer and SES are presented below.

PRETEST

	VIEWER		NONVIEWER	
	Middle	Low	Middle	Low
Select PSA C*	3	4	6	5
Do Not Select PSA C*	9	8	6	4

A chi-square analysis revealed no significant differences between SES groups among viewers (χ^2 = .20, N.S.) or nonviewers (χ^2 = .06, N.S.) in the pretest.

POSTTEST

	VIEWER		NONVIEWER	
	Middle	Low	Middle	Low
Select PSA C*	9	5	4	1
Do Not Select PSA C*	3	7	7	11

A chi-square analysis revealed a marginal difference between SES groups among viewers (χ^2 = 2.74, $p < .10$), with middle-ses viewers choosing PSA C* more often than low-ses viewers. No significant difference was found among nonviewers in the posttest (χ^2 = 2.65, N.S.).

Analysis by Ethnicity. Children's responses, analyzed as a function of Ethnicity, are presented below.

PRETEST

	Minority	Nonminority
Select PSA C*	15	3
Do Not Select PSA C*	16	11

A chi-square analysis revealed a marginal difference between these groups in the pretest (χ^2 = 2.92, $p < .10$), with more minority children choosing PSA C* than nonminority children.

POSTTEST

	Minority	Nonminority
Select PSA C*	13	6
Do Not Select PSA C*	21	7

A chi-square analysis revealed no significant differences between these groups in the posttest ($\chi^2 = .24$, N.S.).

Responses analyzed as a function of both Viewer/Nonviewer and Ethnicity are presented below.

PRETEST

	VIEWER		NONVIEWER	
	Minority	Nonminority	Minority	Nonminority
Select PSA C*	6	1	9	2
Do Not Select PSA C*	11	6	5	5

Two chi-square tests of contingency revealed no significant differences between the groups for viewers ($\chi^2 = 1.06$, N.S.), and no differences between the groups for nonviewers ($\chi^2 = 2.39$, N.S.) in the pretest.

POSTTEST

	VIEWER		NONVIEWER	
	Minority	Nonminority	Minority	Nonminority
Select PSA C*	9	5	4	1
Do Not Select PSA C*	8	2	13	5

Two chi-square tests of contingency revealed no significant differences between the groups for viewers ($\chi^2 = .70$, N.S.), and no differences between the groups for nonviewers ($\chi^2 = .12$, N.S.) in the posttest.

p. 170 Change in Choice of PSA

An analysis of the data for changes shown by individual children appears below. The first column of the table shows viewers and nonviewers who chose PSA C* in the posttest but not in the pretest. The second column indicates the number of children who did not change (i.e., who either selected PSA C* in the pretest or did not select it at either time).

Change to PSA C*?	Yes	No
Viewer	10	14
Nonviewer	1	19

A chi square reveals a significant difference in the number of viewers who changed their choice to PSA C* in the posttest ($\chi^2 = 7.82, p < .01$).

Analysis by Sex. Children's responses, analyzed as a function of Sex, are presented below.

	Boy	Girl
Change to PSA C* at Posttest	6	5
No Change at Posttest	17	16

A chi-square analysis revealed no significant differences between boys and girls ($\chi^2 = .03$, N.S.).

Responses analyzed as a function of both Viewer/Nonviewer and Sex are presented below.

	VIEWER		NONVIEWER	
	Boy	Girl	Boy	Girl
Change to PSA C* at Posttest	5	5	1	0
No Change at Posttest	7	7	10	9

A chi square analysis revealed no significant differences between male and female viewers ($\chi^2 = 0.00$, N.S.), and no significant differences between male and female nonviewers ($\chi^2 = .86$, N.S.).

Analysis by SES. Children's responses, analyzed as a function of SES, are presented below.

	Middle-SES	Low-SES
Change to PSA C* at Posttest	8	3
No Change at Posttest	15	18

A chi-square analysis revealed no significant differences between these groups ($\chi^2 = 2.46$, N.S.).

Responses analyzed as a function of both Viewer/Nonviewer and SES are presented below.

	VIEWER		NONVIEWER	
	Middle-SES	Low-SES	Middle-SES	Low-SES
Change to PSA C* at Posttest	7	3	1	0
No Change at Posttest	5	9	10	9

A chi-square analysis revealed a marginal difference between SES groups among viewers ($\chi^2 = 2.74$, $p < .10$), with marginally more middle-SES children changing to PSA C* at the posttest. No significant difference among nonviewers was found ($\chi^2 = .86$, N.S.).

Analysis by Ethnicity. Children's responses, analyzed as a function of Ethnicity, are presented below.

	Minority	Nonminority
Change to PSA C* at Posttest	5	6
No Change at Posttest	26	7

A chi-square analysis revealed a significant difference between these groups ($\chi^2 = 4.40$, $p < .05$), indicating that, proportionally, more nonminority children than minority children showed a positive change.

Responses analyzed as a function of both Viewer/Nonviewer and Ethnicity are presented below.

	VIEWER		NONVIEWER	
	Minority	Nonminority	Minority	Nonminority
Change to PSA C* at Posttest	5	5	0	1
No Change at Posttest	12	2	14	5

A chi-square analysis revealed a marginal difference between the groups for viewers ($\chi^2 = 3.60$, $p < .10$) in that, proportionally, marginally more nonminority children than minority children changed to PSA C*. No difference between the groups was observed for nonviewers ($\chi^2 = 2.46$, N.S.).

p. 171 Choosing to pursue the most challenging PSA

The number of children at the prestest and posttest who selected to do the PSA they found to be most challenging is shown below.

	PRETEST		POSTTEST	
	Yes	No	Yes	No
Viewers	5	19	11	13
Nonviewers	6	13	2	12

Two chi-square tests of contingency were performed, one on pretest data and the other on posttest data. In the pretest, the analysis revealed no significant difference between the groups ($\chi^2 = .64$, N.S.). In the posttest, however, viewers were significantly more likely than nonviewers to choose the PSA they found to be most challenging ($\chi^2 = 6.04$, $p < .05$).

Analysis by Sex. Children's responses, analyzed as a function of Sex, are presented below.

PRETEST

	Boy	Girl
Select Most Challenging PSA	6	5
Do Not Select Most Challenging PSA	16	16

A chi-square analysis revealed no significant differences between these groups in the pretest ($\chi^2 = .07$, N.S.).

Children's responses in the posttest, analyzed as a function of Sex, are presented below.

POSTTEST

	Boy	Girl
Select Most Challenging PSA	8	6
Do Not Select Most Challenging PSA	15	18

A chi-square analysis revealed no significant difference was revealed between these groups in the posttest ($\chi^2 = .54$, N.S.).

Responses analyzed as a function of both Viewer/Nonviewer and Sex are presented below.

PRETEST

	VIEWER		NONVIEWER	
	Boy	Girl	Boy	Girl
Select Most Challenging PSA	2	3	4	2
Do Not Select Most Challenging PSA	10	9	6	7

A chi-square analysis revealed no significant differences between male and female viewers ($\chi^2 = .25$, N.S.), and no significant differences between male and female nonviewers ($\chi^2 = .69$, N.S.) in the pretest.

POSTTEST

	VIEWER		NONVIEWER	
	Boy	Girl	Boy	Girl
Select Most Challenging PSA	6	5	2	1
Do Not Select Most Challenging PSA	6	7	[illegible]	11

A chi-square analysis revealed no significant differences between male and female viewers ($\chi^2 = .17$, N.S.), and no significant differences between male and female nonviewers ($\chi^2 = .49$, N.S.) in the posttest.

Analysis by SES. Children's responses, analyzed as a function of SES, are presented below.

PRETEST

	Middle-SES	Low-SES
Select Most Challenging PSA	4	7
Do Not Select Most Challenging PSA	19	13

A chi-square analysis revealed no significant differences between these groups in the pretest ($\chi^2 = 1.74$, N.S.).

POSTTEST

	Middle-SES	Low-SES
Select Most Challenging PSA	8	6
Do Not Select Most Challenging PSA	15	18

A chi-square analysis revealed no significant differences between these groups in the posttest ($\chi^2 = .54$, N.S.).

Responses analyzed as a function of both Viewer/Nonviewer and SES are presented below.

PRETEST

	VIEWER		NONVIEWER	
	Middle	Low	Middle	Low
Select Most Challenging PSA	1	4	3	3
Do Not Select Most Challenging PSA	11	8	8	5

A chi-square analysis revealed no significant differences between SES groups among viewers ($\chi^2 = 2.27$, N.S.) or nonviewers ($\chi^2 = .22$, N.S.) in the pretest.

POSTTEST

	VIEWER		NONVIEWER	
	Middle	Low	Middle	Low
Select Most Challenging PSA	6	5	2	1
Do Not Select Most Challenging PSA	6	7	9	11

A chi-square analysis revealed no significant differences between SES groups among viewers (χ^2 = .17, N.S.) or nonviewers (χ^2 = .49, N.S.) in the posttest.

Analysis by Ethnicity. Children's responses, analyzed as a function of Ethnicity, are presented below.

PRETEST

	Minority	Nonminority
Select Most Challenging PSA	8	3
Do Not Select Most Challenging PSA	22	10

A chi-square analysis revealed no significant differences between these groups in the pretest (χ^2 = .06, N.S.).

POSTTEST

	Minority	Nonminority
Select Most Challenging PSA	10	4
Do Not Select Most Challenging PSA	24	9

A chi-square analysis revealed no significant differences between these groups in the posttest (χ^2 = .01, N.S.).

Responses analyzed as a function of both Viewer/Nonviewer and Ethnicity are presented below.

PRETEST

	VIEWER		NONVIEWER	
	Minority	Nonminority	Minority	Nonminority
Select Most Challenging PSA	4	1	4	2
Do Not Select Most Challenging PSA	13	6	9	4

Two chi-square tests of contingency revealed no significant differences between the groups for viewers (χ^2 = .26, N.S.), and no differences between the groups for nonviewers (χ^2 = .01, N.S.) in the pretest.

POSTTEST

	VIEWER		NONVIEWER	
	Minority	Nonminority	Minority	Nonminority
Select Most Challenging PSA	8	3	2	1
Do Not Select Most Challenging PSA	9	4	15	5

Two chi-square tests of contingency revealed no significant differences between the groups for viewers (χ^2 = .04, N.S.), and no differences between the groups for nonviewers (χ^2 = .09, N.S.) in the posttest.

p. 172 Change to most challenging PSA

An analysis of the data for changes shown by individual children appears below. The first column of the table shows viewers and nonviewers who chose chose to do the PSA they found most challenging in the posttest but not in the pretest. The second column indicates the number of children who did not change (i.e., who either selected their most challenging PSA in the pretest or did not select it at either time).

Change to Most Challenging PSA?

	Yes	No
Viewer	9	15
Nonviewer	1	17

A chi square reveals a significant difference in the number of viewers who changed their choice to the most challenging PSA in the posttest ($\chi^2 = 5.79$, $p < .05$).

Analysis by Sex. Children's responses, analyzed as a function of Sex, are presented below.

	Boy	Girl
Change to Most Challenging PSA at Posttest	5	5
No Change at Posttest	17	15

A chi-square analysis revealed no significant differences between boys and girls ($\chi^2 = .03$, N.S.).

Responses analyzed as a function of both Viewer/Nonviewer and Sex are presented below.

	VIEWER		NONVIEWER	
	Boy	Girl	Boy	Girl
Change to Most Challenging PSA at Posttest	4	5	1	0
No Change at Posttest	8	7	9	8

A chi square analysis revealed no significant differences between male and female viewers ($\chi^2 = .18$, N.S.), and no significant differences between male and female nonviewers ($\chi^2 = .85$, N.S.).

Analysis by SES. Children's responses, analyzed as a function of SES, are presented below.

	Middle-SES	Low-SES
Change to Most Challenging PSA at Posttest	7	3
No Change at Posttest	15	17

A chi-square analysis revealed no significant differences between these groups ($\chi^2 = 1.63$, N.S.).

Responses analyzed as a function of both Viewer/Nonviewer and SES are presented below.

	VIEWER		NONVIEWER	
	Middle-SES	Low-SES	Middle-SES	Low-SES
Change to Most Challenging PSA at Posttest	6	3	1	0
No Change at Posttest	6	9	9	8

A chi-square analysis revealed no significant differences between SES groups among viewers ($\chi^2 = 1.60$, N.S.), and no significant differences among nonviewers ($\chi^2 = .85$, N.S.).

Analysis by Ethnicity. Children's responses, analyzed as a function of Ethnicity, are presented below.

	Minority	Nonminority
Change to Most Challenging PSA at Posttest	6	4
No Change at Posttest	24	8

A chi-square analysis revealed no significant differences between these groups ($\chi^2 = .84$, N.S.).

Responses analyzed as a function of both Viewer/Nonviewer and Ethnicity are presented below.

	VIEWER		NONVIEWER	
	Minority	Nonminority	Minority	Nonminority
Change to Most Challenging PSA at Posttest	6	3	0	1
No Change at Posttest	11	4	13	4

A chi-square analysis revealed no significant difference between the groups for viewers ($\chi^2 = .12$, N.S.), but a marginal difference between the groups was observed for nonviewers ($\chi^2 = 2.75$, $p < .10$), with nonminority children being marginally more likely to change their choice to the most challenging PSA than minority children. However, only five nonminority children were included in the nonviewer group. Thus, this result should be interpreted with caution.

p. 173 Selection of PSA C* vs. Arithmetic

A table of the number of children who chose PSA C* over the arithmetic worksheet task appears below. The data is grouped by Pretest/Posttest and Viewer/Nonviewer.

	PRETEST		POSTTEST	
	PSA C*	Arithmetic	PSA C*	Arithmetic
Viewers	10	14	20	4
Nonviewers	11	13	13	11

Two chi-square tests of contingency were performed, one on the pretest data and one one the posttest data. In the pretest, the analysis revealed no significant difference between the groups ($\chi^2 = .08$, N.S.). In the posttest, however, viewers were significantly more likely than nonviewers to choose PSA C* ($\chi^2 = 4.75$, $p < .05$)

Analysis by Sex. Children's responses, analyzed as a function of Sex, are presented below.

PRETEST

	Boy	Girl
Select PSA C*	13	8
Select Arithmetic	11	16

A chi-square analysis revealed no significant difference between these groups in the pretest ($\chi^2 = 2.12$, N.S.).

POSTTEST

	Boy	Girl
Select PSA C*	15	18
Select Arithmetic	9	6

A chi-square analysis revealed no significant differences between the groups in the posttest ($\chi^2 = .87$, N.S.).

Responses analyzed as a function of both Viewer/Nonviewer and Sex are presented below.

PRETEST

	VIEWER		NONVIEWER	
	Boy	Girl	Boy	Girl
Select PSA C*	7	3	6	5
Select Arithmetic	5	9	6	7

A chi-square analysis revealed a marginal difference between male and female viewers ($\chi^2 = 2.74$, $P < .10$), but no significant differences between male and female nonviewers ($\chi^2 = .17$, N.S.) in the pretest.

POSTTEST

	VIEWER		NONVIEWER	
	Boy	Girl	Boy	Girl
Select PSA C*	9	11	6	7
Select Arithmetic	3	1	6	5

A chi-square analysis revealed no significant differences between male and female viewers ($\chi^2 = 1.2$, N.S.), and no significant differences between male and female nonviewers ($\chi^2 = .17$, N.S.) in the posttest.

Analysis by SES. Children's responses, analyzed as a function of SES, are presented below.

PRETEST

	Middle	Low
Select PSA C*	12	9
Select Arithmetic	12	15

A chi-square analysis revealed no significant differences between these groups in the pretest ($\chi^2 = .76$, N.S.).

POSTTEST

	Middle	Low
Select PSA C*	19	14
Select Arithmetic	5	10

A chi-square analysis revealed no significant differences between these groups in the posttest (χ^2 = 2.42, N.S.).

Responses analyzed as a function of both Viewer/Nonviewer and SES are presented below.

PRETEST

	VIEWER		NONVIEWER	
	Middle	Low	Middle	Low
Select PSA C*	5	5	7	4
Select Arithmetic	7	7	5	8

A chi-square analysis revealed no significant differences between SES groups among viewers (χ^2 = 0.00, N.S.) or nonviewers (χ^2 = 1.51, N.S.) in the pretest.

POSTTEST

	VIEWER		NONVIEWER	
	Middle	Low	Middle	Low
Select PSA C*	11	9	8	5
Select Arithmetic	1	3	4	7

A chi-square analysis revealed no significant differences between SES groups among viewers (χ^2 = 1.20, N.S.) or nonviewers (χ^2 = 1.51, N.S.) in the posttest.

Analysis by Ethnicity. Children's responses, analyzed as a function of Ethnicity, are presented below.

PRETEST

	Minority	Nonminority
Select PSA C*	13	8
Select Arithmetic	21	6

A chi-square analysis revealed no significant differences between these groups (χ^2 = 1.44, N.S.) in the pretest.

POSTTEST

	Minority	Nonminority
Select PSA C*	23	10
Select Arithmetic	11	4

A chi-square analysis revealed no significant differences between these groups (χ^2 = .07, N.S.) in the posttest.

Responses analyzed as a function of both Viewer/Nonviewer and Ethnicity are presented below.

PRETEST

	VIEWER		NONVIEWER	
	Minority	Nonminority	Minority	Nonminority
Select PSA C*	6	4	7	4
Select Arithmetic	11	3	10	3

A chi-square analysis revealed no significant differences between the groups for viewers (χ^2 = .97, N.S.), and no differences between the groups for nonviewers (χ^2 = .51, N.S.) in the pretest.

POSTTEST

	VIEWER		NONVIEWER	
	Minority	Nonminority	Minority	Nonminority
Select PSA C*	14	6	9	4
Select Arithmetic	3	1	8	3

A chi-square analysis revealed no significant differences between the groups for viewers (χ^2 = .04, N.S.), and no differences between the groups for nonviewers (χ^2 = .04, N.S.) in the posttest.

p. 174 Change in Selection of PSA C* vs. Arithmetic

An analysis of the change shown by individual children appears below. The first column of the table shows viewers and nonviewers who chose PSA C* in the posttest but not in the pretest. The second column indicates the number of children who did not change (i.e., who either selected PSA C* in the pretest or did not select it at either time).

Change to PSA C*?	Yes	No
Viewer	11	13
Nonviewer	4	18

A chi-square analysis revealed that significantly more viewers than nonviewers changed their changed their selection from the arithmetic worksheet to PSA C* in the posttest ($\chi^2 = 3.99$, $p < .05$).

Analysis by Sex. Children's changes in response, analyzed as a function of Sex, are presented below.

	Boy	Girl
Change to PSA C* at Posttest	4	11
No Change at Posttest	20	11

A chi-square analysis revealed that significantly more girls than boys changed to PSA C* ($\chi^2 = 5.80$, $p < .05$).

Responses analyzed as a function of both Viewer/Nonviewer and Sex are presented below.

	VIEWER		NONVIEWER	
	Boy	Girl	Boy	Girl
Change to PSA C* at Posttest	3	8	1	3
No Change at Posttest	9	4	11	7

A chi-square analysis revealed that significantly more girls than boys in the viewer group changed to PSA C* ($\chi^2 = 4.20$, $p < .05$). No significant differences were found between male and female nonviewers ($\chi^2 = 1.72$, N.S.).

<u>Analysis by SES.</u> Children's responses, analyzed as a function of SES, are presented below.

	Middle-SES	Low-SES
Change to PSA C* at Posttest	9	6
No Change at Posttest	14	17

A chi-square analysis revealed no significant differences between these groups ($\chi^2 = .89$, N.S.).

Responses analyzed as a function of both Viewer/Nonviewer and SES are presented below.

	VIEWER		NONVIEWER	
	Middle	Low	Middle	Low
Change to PSA C* at Posttest	6	5	3	1
No Change at Posttest	6	7	8	10

A chi-square analysis revealed no significant differences between SES groups among viewers ($\chi^2 = .17$, N.S.) or nonviewers ($\chi^2 = 1.22$, N.S.).

<u>Analysis by Ethnicity.</u> Children's responses, analyzed as a function of Ethnicity, are presented below.

	Minority	Nonminority
Change to PSA C* at Posttest	11	4
No Change at Posttest	21	10

A chi-square analysis revealed no significant differences between these groups ($\chi^2 = .15$, N.S.).

Responses analyzed as a function of both Viewer/Nonviewer and Ethnicity are presented below.

	VIEWER		NONVIEWER	
	Minority	Nonminority	Minority	Nonminority
Change to PSA C* at Posttest	9	2	2	2
No Change at Posttest	8	5	13	5

A chi-square analysis revealed no significant differences between the groups for viewers ($\chi^2 = 1.19$, N.S.), and no differences between the groups for nonviewers ($\chi^2 = .74$, N.S.).

p. 174 <u>Selection of the most challenging task (PSA C* versus arithmetic)</u>

A table of the number of children who chose to do the task (PSA or arithmetic worksheet) that they thought was the most challenging appears below. The data is grouped by Pretest/Posttest and Viewer/Nonviewer.

	PRETEST		POSTTEST	
	Select Challenging Task	Select Other Task	Select Challenging Task	Select Other Task
Viewers	12	12	9	7
Nonviewers	9	15	8	14

Two chi-square tests of contingency were performed, one on pretest data and the other on posttest data. No significant difference was revealed between the groups in the pretest ($\chi^2 = .76$, N.S.), or in the posttest ($\chi^2 = 1.48$, N.S.)

<u>Analysis by Sex.</u> Children's responses, analyzed as a function of Sex, are presented below.

PRETEST

	Boy	Girl
Select Challenging Task	6	15
Select Other Task	18	9

A chi-square analysis revealed a significant difference between these groups in the pretest ($\chi^2 = 6.86$, $p < .01$), with more girls selecting the challenging task than boys.

Children's responses in the posttest, analyzed as a function of Sex, are presented below.

POSTTEST

	Boy	Girl
Select Challenging Task	9	8
Select Other Task	10	11

A chi-square analysis revealed no significant difference was revealed between these groups in the posttest ($\chi^2 = .11$, N.S.).

Responses analyzed as a function of both Viewer/Nonviewer and Sex are presented below.

PRETEST

	VIEWER		NONVIEWER	
	Boy	Girl	Boy	Girl
Select Challenging Task	3	9	3	6
Select Other Task	9	3	9	6

A chi-square analysis revealed a significant difference between male and female viewers ($\chi^2 = 6.00$, $p < .05$), with girls selecting the challenging task more often than boys. No significant differences between male and female nonviewers were observed in the pretest ($\chi^2 = 1.6$, N.S.).

POSTTEST

	VIEWER		NONVIEWER	
	Boy	Girl	Boy	Girl
Select Challenging Task	5	4	4	4
Select Other Task	3	4	7	7

A chi-square analysis revealed no significant difference between male and female viewers ($\chi^2 = .25$, N.S.), and no significant differences between male and female nonviewers in the posttest ($\chi^2 = 0.00$, N.S.).

Analysis by SES. Children's responses, analyzed as a function of SES, are presented below.

PRETEST

	Middle-SES	Low-SES
Select Challenging Task	11	10
Select Other Task	13	14

A chi-square analysis revealed no significant differences between these groups in the pretest ($\chi^2 = .08$, N.S.).

POSTTEST

	Middle-SES	Low-SES
Select Challenging Task	12	5
Select Other Task	9	12

A chi-square analysis revealed marginal difference between these groups in the posttest ($\chi^2 = 2.92$, $p < .10$), with more middle-SES children choosing the challenging task than low-SES children.

Responses analyzed as a function of both Viewer/Nonviewer and SES are presented below.

PRETEST

	VIEWER		NONVIEWER	
	Middle	Low	Middle	Low
Select Challenging Task	6	6	5	4
Select Other Task	6	6	7	8

A chi-square analysis revealed no significant differences between SES groups among viewers ($\chi^2 = 0.00$, N.S.) or nonviewers ($\chi^2 = .18$, N.S.) in the pretest.

POSTTEST

	VIEWER		NONVIEWER	
	Middle	Low	Middle	Low
Select Challenging Task	7	2	5	3
Select Other Task	3	4	6	8

A chi-square analysis revealed no significant difference between SES groups among viewers ($\chi^2 = 2.05$, N.S.), and no significant difference was found among nonviewers in the posttest ($\chi^2 = .79$, N.S.).

Analysis by Ethnicity. Children's responses, analyzed as a function of Ethnicity, are presented below.

PRETEST

	Minority	Nonminority
Select Challenging Task	16	5
Select Other Task	18	9

A chi-square analysis revealed no significant difference between these groups in the pretest ($\chi^2 = .52$).

POSTTEST

	Minority	Nonminority
Select Challenging Task	8	9
Select Other Task	18	3

A chi-square analysis revealed a significant difference between these groups in the posttest ($\chi^2 = 6.50$, $p < .05$), with nonminority children choosing the challenging task more often.

Responses analyzed as a function of both Viewer/Nonviewer and Ethnicity are presented below.

PRETEST

	VIEWER		NONVIEWER	
	Minority	Nonminority	Minority	Nonminority
Select Challenging Task	9	3	7	2
Select Other Task	8	4	10	5

Two chi-square tests of contingency revealed no significant differences between the groups for viewers ($\chi^2 = .20$, N.S.), and no significant differences between the groups for nonviewers ($\chi^2 = .34$, N.S.) in the pretest.

POSTTEST

	VIEWER		NONVIEWER	
	Minority	Nonminority	Minority	Nonminority
Select Challenging Task	4	5	4	4
Select Other Task	7	0	11	3

Two chi-square tests of contingency revealed a significant difference between the groups for viewers ($\chi^2 = 5.66$, $p < .05$), with nonminority children choosing the challenging task more often then minority children. No significant differences between the groups for nonviewers was observed in the posttest ($\chi^2 = 1.92$, N.S.).

p. 177 Change to most challenging task

An analysis of the data for changes shown by individual children appears below. The first column of the table shows viewers and nonviewers who chose chose to do the task they found most challenging in the posttest but not in the pretest. The second column indicates the number of children who did not change (i.e., who either selected their most challenging task in the pretest or did not select it at either time).

Change to Most Challenging Task?

	Yes	No
Viewer	4	12
Nonviewer	3	19

A chi square analysis reveals no significant difference between these groups ($\chi^2 = .79$, N.S.).

<u>Analysis by Sex.</u> Children's responses, analyzed as a function of Sex, are presented below.

	Boy	Girl
Change to Most Challenging Task at Posttest	5	2
No Change at Posttest	14	17

A chi-square analysis revealed no significant differences between boys and girls ($\chi^2 = 1.58$, N.S.).

Responses analyzed as a function of both Viewer/Nonviewer and Sex are presented below.

	VIEWER		NONVIEWER	
	Boy	Girl	Boy	Girl
Change to Most Challenging Task at Posttest	3	1	2	1
No Change at Posttest	5	7	9	10

A chi square analysis revealed no significant differences between male and female viewers ($\chi^2 = 1.33$, N.S.), and no significant differences between male and female nonviewers ($\chi^2 = .39$, N.S.).

<u>Analysis by SES.</u> Children's responses, analyzed as a function of SES, are presented below.

	Middle-SES	Low-SES
Change to Most Challenging Task at Posttest	6	1
No Change at Posttest	15	16

A chi-square analysis revealed a marginal difference between these groups ($\chi^2 = 3.22$, $p < .10$), middle-ses children more often changing to the most challenging task.

Responses analyzed as a function of both Viewer/Nonviewer and SES are presented below.

	VIEWER		NONVIEWER	
	Middle-SES	Low-SES	Middle-SES	Low-SES
Change to Most Challenging Task at Posttest	4	0	2	1
No Change at Posttest	6	6	9	10

A chi-square analysis revealed a marginal difference between SES groups among viewers (χ^2 = 3.20, p < .10), with middle-ses children more often changing to the most challenging task. No significant differences were observed among nonviewers (χ^2 = .39, N.S.).

<u>Analysis by Ethnicity.</u> Children's responses, analyzed as a function of Ethnicity, are presented below.

	Minority	Nonminority
Change to Most Challenging Task at Posttest	2	5
No Change at Posttest	24	7

A chi-square analysis revealed a significant difference between these groups (χ^2 = 6.31, p < .05), nonminority children changing more often to the most challenging task at the posttest.

Responses analyzed as a function of both Viewer/Nonviewer and Ethnicity are presented below.

	VIEWER		NONVIEWER	
	Minority	Nonminority	Minority	Nonminority
Change to Most Challenging Task at Posttest	1	3	1	2
No Change at Posttest	10	2	14	5

A chi-square analysis revealed a significant difference between the groups for viewers (χ^2 = 4.75, p < .05), with nonminority children changing more often the most challenging task at the posttest. No significant difference between the groups was observed for nonviewers ($\chi^2 = 1.94$, N.S.).

CHAPTER 6

ENJOYMENT

p. 210 <u>Considerations in the Development of the Scheme</u>

Since enjoyment responses could conceivably occur in responce to any question, an analysis was conducted on 12 interviews to determine if the reasons-for-enjoyment scheme adequately captured the enjoyment responses. One correlation was computed for each of the three types of scores used in the scheme; Orientation, Valence and Magnitude. High correlations resulted from correlating the scores for designated enjoyment questions and the scores obtained from coding every interview question. For Orientation, the correlation between the proportions of statements was .76 ($p < .01$). For Valence, the correlation between the statements was .92 ($p < .001$). For Magnitude, the correlation between proportions of statements was .72 ($p < .01$). Our conclusion from this analysis was that the designated enjoyment questions were adequate for our analysis.

p. 213 <u>Results in the thinker orientation: Overall</u>

The average proportions of thinker statements made by children in response to all of the designated enjoyment questions are shown below. Standard deviations are shown in parentheses.

	PRETEST	POSTTEST
VIEWERS	.29 (.21)	.31 (.20)
NONVIEWERS	.32 (.26)	.21 (.20)

A two-way analysis of variance was performed on the arcsine transformation of the overall proportion of thinker statements made by viewers and nonviewers in the pretest and posttest. The factors used were Viewer/Nonviewer (between-groups factor) and Pretest/Posttest (within-groups factor).

The analysis revealed no significant main effect of Viewer/Nonviewer ($F_{1,46} = 2.01$, N.S.) or Pretest/Posttest ($F_{1,46} = 2.30$, N.S.), and no significant interaction of Viewer/Nonviewer with Pretest/Posttest ($F_{1,46} = 2.00$, N.S.).

<u>Analysis by Sex.</u> A three-way analysis of variance was performed on the arcsine transformation of the overall proportion of thinker statements made by the children. Pretest/Posttest, Viewer/Nonviewer, and Sex were used as factors. The mean proportions are shown in the following tables. Standard deviations are shown in parentheses.

OVERALL PROPORTION OF THINKER STATEMENTS

BOYS

	PRETEST	POSTTEST
VIEWERS	.32 (.26)	.39 (.19)
NONVIEWERS	.39 (.26)	.19 (.19)

GIRLS

	PRETEST	POSTTEST
VIEWERS	.27 (.15)	.22 (.18)
NONVIEWERS	.25 (.26)	.23 (.21)

The analysis revealed a marginal main effect of Sex ($F_{1,44} = 3.33$, $p < .10$), and a marginal effect of Sex in three-way interaction with Pretest/Posttest and Viewer/Nonviewer ($F_{1,44} = 2.88$, $p < .10$). A Fisher Least Significant Difference test revealed that male nonviewers declined significantly from pretest to posttest in the proportion of thinker statements they gave ($p < .05$). Additionally, the LSD showed that at the posttest male viewers gave significantly more thinker responses than male nonviewers ($p < .05$).

Analysis by Ethnicity. A second three-way analysis of variance was performed on the arcsine transformation of the overall proportion of thinker statements made by the children. The factors used were Pretest/Posttest, Viewer/Nonviewer, and Ethnicity. The mean proportions of thinker statements made by the children are presented in the following tables. Standard deviations are shown in parentheses.

OVERALL PROPORTION OF THI ER STATEMENTS

MINORITY

	PRETEST	POSTTEST
VIEWERS	.32 (.22)	.26 (.16)
NONVIEWERS	.29 (.25)	.19 (.19)

NONMINORITY

	PRETEST	POSTTEST
VIEWERS	.23 (.16)	.42 (.25)
NONVIEWERS	.39 (.31)	.26 (.22)

The analysis revealed no significant effect of Ethnicity either as a main effect ($F_{1,44}$ = .62, N.S.) or in three-way interactions ($F_{1,44}$ = 1.02, N.S.).

Analysis by SES. A third three-way analysis of variance was performed on the arcsine transformation of the overall proportions of thinker statements, using Pretest/Posttest, Viewer/Nonviewer, and SES as factors. The mean proportions of thinker statements made by the children are presented in the following tables. Standard deviations are shown in parentheses.

OVERALL PROPORTION OF THINKER STATEMENTS

LOW-SES

	PRETEST	POSTTEST
VIEWERS	.30 (.24)	.24 (.14)
NONVIEWERS	.34 (.28)	.19 (.20)

MIDDLE-SES

	PRETEST	POSTTEST
VIEWERS	.29 (.17)	.37 (.23)
NONVIEWERS	.30 (.26)	.23 (.20)

The analysis revealed no significant effect of SES as a main effect ($F_{1,44}$ = .27, N.S.), and no significant effect in the three-way interaction with Pretest/Posttest and Viewer/Nonviewer ($F_{1,44}$ = .13, N.S.).

p. 214 Results in the thinker orientation: Math Domain

The average proportion of thinker statements made by children in the Mathematics Domain are shown below. Standard deviations are shown in parentheses.

	PRETEST	POSTTEST
VIEWERS	.28 (.33)	.31 (.32)
NONVIEWERS	.30 (.34)	.22 (.25)

A two-way analysis of variance was performed on the arcsine transformation of the overall proportion of thinker statements in the Mathematics Domain made by viewers and nonviewers in the pretest and posttest. The factors used were Viewer/ Nonviewer (between-groups factor) and Pretest/Posttest (within-groups factor).

The analysis revealed no significant main effect for Viewer/Nonviewer ($F_{1,44}$ = .19, N.S.) or Pretest/Posttest ($F_{1,44}$ = .16, N.S.), and no significant interaction of Viewer/Nonviewer with Pretest/Posttest ($F_{1,44}$ = .84, N.S.).

Analysis by Sex. A three-way analysis of variance was performed on the arcsine transformation of the proportion of thinker statements made by the children in the Mathematics Domain. Pretest/Posttest, Viewer/Nonviewer, and Sex were used as factors. The mean proportions are shown in the following tables. Standard deviations are shown in parentheses.

PROPORTION OF THINKER STATEMENTS IN MATHEMATICS DOMAIN

BOYS

	PRETEST	POSTTEST
VIEWERS	.38 (.31)	.48 (.33)
NONVIEWERS	.31 (.32)	.24 (.26)

GIRLS

	PRETEST	POSTTEST
VIEWERS	.19 (.33)	.15 (.23)
NONVIEWERS	.29 (.38)	.21 (.25)

The analysis revealed a significant main effect of Sex ($F_{1,42} = 4.40$, $p < .05$), with boys producing more thinker statements than girls. However, the three-way interaction of Sex, Pretest/Posttest and Viewer/Nonviewer was not significant ($F_{1,42} = .59$, N.S.).

Analysis by Ethnicity. A second three-way analysis of variance was performed on the arcsine transformation of the proportions of thinker statements, using Pretest/Posttest, Viewer/Nonviewer, and Ethnicity as factors. The mean proportions of thinker statements made by the children in the Mathematics Domain are presented in the following tables. Standard deviations are shown in parentheses.

PROPORTION OF THINKER STATEMENTS IN MATHEMATICS DOMAIN

MINORITY

	PRETEST	POSTTEST
VIEWERS	.29 (.36)	.21 (.30)
NONVIEWERS	.28 (.37)	.19 (.24)

NONMINORITY

	PRETEST	POSTTEST
VIEWERS	.25 (.27)	.52 (.30)
NONVIEWERS	.35 (.28)	.30 (.27)

The analysis revealed no significant main effect of Ethnicity ($F_{1,42} = 1.80$, N.S.), and no significant effect in the three-way interaction with Pretest/Posttest and Viewer/Nonviewer ($F_{1,42} = 1.63$, N.S.).

Analysis by SES. A third three-way analysis of variance was performed on the arcsine transformation of the proportion of thinker statements. Pretest/ Posttest, Viewer/Nonviewer, and SES were used as factors. The mean proportions of thinker statements made by the children in the Mathematics Domain are presented in the following tables. Standard deviations are shown in parentheses.

PROPORTION OF THINKER STATEMENTS IN MATHEMATICS DOMAIN

LOW-SES

	PRETEST	POSTTEST
VIEWERS	.18 (.34)	.16 (.32)
NONVIEWERS	.30 (.41)	.18 (.23)

MIDDLE-SES

	PRETEST	POSTTEST
VIEWERS	.37 (.31)	.44 (.27)
NONVIEWERS	.30 (.29)	.26 (.27)

The analysis revealed a marginal main effect of SES ($F_{1,42} = 3.55$, $p < .10$) with middle-SES children producing marginally more thinker responses than low-SES children. However, this effect did not interact with the effects of viewing **SQUARE ONE TV** in the three-way interaction ($F_{1,42} = .00$, N.S.).

p. 214 <u>Results in the thinker orientation: PSA Domain</u>

The average proportion of thinker statements the children made in the PSA Domain are shown below. Standard deviations are shown in parentheses.

	PRETEST	POSTTEST
VIEWERS	.28 (.25)	.32 (.25)
NONVIEWERS	.33 (.29)	.21 (.23)

A two-way analysis of variance was performed on the arcsine transformation of the overall proportion of thinker statements in the PSA Domain made by viewers and nonviewers in the pretest and posttest. The factors used were Viewer/Nonviewer (between-groups factor) and Pretest/Posttest (within-groups factor).

The analysis revealed no significant main effect for Viewer/Nonviewer ($F_{1,46} = .77$, N.S.) or Pretest/Posttest (F1,46 = .85, N.S.). However, a marginal interaction of Viewer/Nonviewer with Pretest/Posttest was found ($F_{1,46} = 3.89$, $p < .10$), indicating that viewers' increase from pretest to posttest was marginally greater than nonviewers'. A Fisher Least Significant Difference Test showed that nonviewers declined significantly from pretest to posttest in the proportion of thinker statements they made ($p < .05$), and that at the posttest, viewers gave a significantly higher proportion of thinker statements than nonviewers did ($p < .05$).

Note that when either Sex or Ethnicity was controlled for, this interaction became significant ($p < .05$). This will be discussed below in the analyses by Sex and Ethnicity.

<u>Analysis by Sex.</u> A three-way analysis of variance was performed on the arcsine transformation of the proportion of thinker statements in the PSA Domain made by the children. Pretest/Posttest, Viewer/Nonviewer, and Sex were used as factors. The mean proportions are shown in the following tables. Standard deviations are shown in parentheses.

PROPORTION OF THINKER STATEMENTS IN PSA DOMAIN

BOYS

	PRETEST	POSTTEST
VIEWERS	.26 (.32)	.39 (.28)
NONVIEWERS	.42 (.29)	.17 (.19)

GIRLS

	PRETEST	POSTTEST
VIEWERS	.30 (.17)	.26 (.20)
NONVIEWERS	.24 (.28)	.25 (.27)

The analysis revealed no significant main effect of Sex ($F_{1,44}$ = .66, N.S.). Note that while the two-way analysis of variance showed a marginal interaction of Pretest/Posttest and Viewer/Nonviewer ($p < .10$), controlling for Sex in this analysis caused the interaction to become significant ($F_{1,44}$ = 4.10, $p < .05$).

Additionally, a significant effect was found for the three-way interaction of Pretest/Posttest, Viewer/Nonviewer and Sex ($F_{1,44}$ = 4.45, $p < .05$). Viewer boys produced significantly more thinker responses at the posttest than nonviewer boys did. A Fisher Least Significant Difference Test showed that at the posttest viewer boys produced significantly more thinker responses than nonviewer boys ($p < .05$). The LSD also showed that nonviewer boys thinker responses declined significantly from pretest to posttest ($p < .05$).

Analysis by Ethnicity. A second three-way analysis of variance was performed on the arcsine transformation of the proportion of thinker statements. The Factors used were Pretest/Posttest, Viewer/Nonviewer, and Ethnicity. The mean proportions of thinker statements made by the children in the PSA Domain are presented in the following tables. Standard deviations are shown in parentheses.

PROPORTION OF THINKER STATEMENTS IN PSA DOMAIN

MINORITY

	PRETEST	POSTTEST
VIEWERS	.32 (.26)	.29 (.19)
NONVIEWERS	.30 (.27)	.20 (.24)

NONMINORITY

	PRETEST	POSTTEST
VIEWERS	.19 (.22)	.40 (.35)
NONVIEWERS	.41 (.36)	.23 (.22)

The analysis revealed no significant effect of Ethnicity either as a main effect ($F_{1,44} = .08$, N.S.) or in the three-way interaction ($F_{1,44} = 1.82$, N.S.).

Note that while the two-way analysis of variance showed a marginal interaction of Pretest/Posttest and Viewer/Nonviewer ($p < .10$), controlling for Ethnicity in this analysis caused the interaction to become significant ($F_{1,44} = 5.61$, $p < .05$).

Analysis by SES. A third three-way analysis of variance was performed on the arcsine transformation of the proportions of thinker statements. Pretest/Posttest, Viewer/Nonviewer, and SES were the factors. The mean proportions of thinker statements made by the children in the PSA Domain are presented in the following tables. Standard deviations are shown in parentheses.

PROPORTION OF THINKER STATEMENTS IN PSA DOMAIN

LOW-SES

	PRETEST	POSTTEST
VIEWERS	.34 (.28)	.29 (.16)
NONVIEWERS	.36 (.30)	.20 (.24)

MIDDLE-SES

	PRETEST	POSTTEST
VIEWERS	.23 (.21)	.36 (.31)
NONVIEWERS	.30 (.30)	.22 (.23)

The analysis revealed no significant effect of SES either as a main effect ($F_{1,44} = .20$, N.S.), or in the three-way interaction with Pretest/Posttest and Viewer/Nonviewer ($F_{1,44} = .21$, N.S.).

p. 216 <u>Valence</u>

The average overall proportion of positive statements made by children are shown below. Standard deviations are shown in parentheses.

	PRETEST	POSTTEST
VIEWERS	.89 (.14)	.77 (.20)
NONVIEWERS	.84 (.14)	.77 (.24)

A two-way analysis of variance was performed on the arcsine transformation of the overall proportion of positive statements made by viewers and nonviewers in the pretest and posttest. The factors used were Viewer/Nonviewer (between-groups factor) and Pretest/Posttest (within-groups factor).

The analysis revealed no significant main effect of Viewer/Nonviewer ($F_{1,46} = .52$, N.S.), and no significant interaction of Viewer/Nonviewer with Pretest/Posttest ($F_{1,46} = .84$, N.S.).

A significant main effect was found for Pretest/Posttest ($F_{1,46} = 12.18$, $p < .01$). However, because this difference collapses data across experimental groups, it is of little experimental interest and will not be discussed further.

<u>Analysis by Sex.</u> A three-way analysis of variance was performed on the arcsine transformation of the overall proportion of positive statements made by the children. Pretest/Posttest, Viewer/Nonviewer, and Sex were used as factors. The mean proportions are shown in the following tables. Standard deviations are shown in parentheses.

OVERALL PROPORTION OF POSITIVE STATEMENTS

BOYS

	PRETEST	POSTTEST
VIEWERS	.90 (.13)	.76 (.19)
NONVIEWERS	.81 (.14)	.69 (.29)

GIRLS

	PRETEST	POSTTEST
VIEWERS	.88 (.15)	.79 (.21)
NONVIEWERS	.87 (.13)	.84 (.13)

The analysis revealed no significant main effect of Sex ($F_{1,44} = 1.06$, N.S.), and no significant effect of Sex in the three-way interaction with Pretest/Posttest and Viewer/Nonviewer ($F_{1,44} = .02$, N.S.).

Analysis by Ethnicity. A second three-way analysis of variance was performed on the arcsine transformation of the proportions of positive statements made by the children. The factors used were Pretest/Posttest, Viewer/Nonviewer, and Ethnicity. The mean proportions of positive statements made by the children are presented in the following tables. Standard deviations are shown in parentheses.

OVERALL PROPORTION OF POSITIVE STATEMENTS

MINORITY

	PRETEST	POSTTEST
VIEWERS	.90 (.12)	.84 (.14)
NONVIEWERS	.87 (.13)	.79 (.22)

NONMINORITY

	PRETEST	POSTTEST
VIEWERS	.85 (.18)	.61 (.25)
NONVIEWERS	.79 (.15)	.70 (.27)

The analysis revealed a significant main effect of Ethnicity ($F_{1,44} = 4.47$, $p < .05$), with minority children making more positive statements than nonminority children. There was no significant effect of Ethnicity in the three-way interaction with Pretest/Posttest and Viewer/Nonviewer ($F_{1,44} = 2.10$, N.S.).

Analysis by SES. A third three-way analysis of variance was performed on the arcsine transformation of the proportion of positive statements, using Pretest/Posttest, Viewer/Nonviewer, and SES as factors. The mean proportions of positive statements made by the children are presented in the following tables. Standard deviations are shown in parentheses.

OVERALL PROPORTION OF POSITIVE STATEMENTS

LOW-SES

	PRETEST	POSTTEST
VIEWERS	.89 (.13)	.83 (.15)
NONVIEWERS	.87 (.14)	.79 (.24)

MIDDLE-SES

	PRETEST	POSTTEST
VIEWERS	.88 (.16)	.72 (.23)
NONVIEWERS	.82 (.14)	.74 (.24)

The analysis revealed no significant main effect of SES ($F_{1,44} = 2.00$, N.S.), and no significant effect in the three-way interaction with Pretest/Posttest and Viewer/Nonviewer ($F_{1,44} = 1.04$, N.S.).

p. 216 Valence: PSA Domain

The average proportion of positive statements made by children in the PSA Domain are shown below. Standard deviations are shown in parentheses.

	PRETEST	POSTTEST
VIEWERS	.95 (.10)	.85 (.21)
NONVIEWERS	.84 (.17)	.75 (.28)

A two-way analysis of variance was performed on the arcsine transformation of the overall proportion of positive statements in the PSA Domain made by viewers and nonviewers in the pretest and posttest. The factors used were Viewer/Nonviewer (between-groups factor) and Pretest/Posttest (within-groups factor).

The interaction of Viewer/Nonviewer with Pretest/Posttest was not significant ($F_{1,46} = .28$, N.S.).

The analysis revealed a significant main effect for Viewer/Nonviewer ($F_{1,46} = 4.32$, $p < .05$). However, because this difference collapses data across the pretest and posttest, it is of little experimental interest and will not be discussed further. A second significant main effect was found for Pretest/Posttest ($F_{1,46} = 9.40$, $p < .01$). However, because this difference collapses data across experimental groups, it is of little experimental interest and will not be discussed further.

Analysis by Sex. A three-way analysis of variance was performed on the arcsine transformation of the proportion of positive statements made by the children in the PSA Domain. Pretest/Posttest, Viewer/Nonviewer, and Sex were used as factors. The mean proportions are shown in the following tables. Standard deviations are shown in parentheses.

PROPORTION OF POSITIVE STATEMENTS IN PSA DOMAIN

BOYS

	PRETEST	POSTTEST
VIEWERS	.97 (.08)	.86 (.20)
NONVIEWERS	.79 (.18)	.67 (.34)

GIRLS

	PRETEST	POSTTEST
VIEWERS	.93 (.11)	.83 (.23)
NONVIEWERS	.90 (.15)	.83 (.18)

The analysis revealed no significant main effect of Sex ($F_{1,44} = .74$, N.S.), and no significant effect in interaction with Pretest/Posttest and Viewer/Nonviewer ($F_{1,44} = .09$, N.S.).

Analysis by Ethnicity. A second three-way analysis of variance was performed on the arcsine transformation of the proportion of positive statements. The factors used were Pretest/Posttest, Viewer/Nonviewer, and Ethnicity. The mean proportions of positive statements made by the children in the PSA Domain are presented in the following tables. Standard deviations are shown in parentheses.

PROPORTION OF POSITIVE STATEMENTS IN THE PSA DOMAIN

MINORITY

	PRETEST	POSTTEST
VIEWERS	.96 (.08)	.91 (.12)
NONVIEWERS	.87 (.17)	.79 (.26)

NONMINORITY

	PRETEST	POSTTEST
VIEWERS	.93 (.13)	.69 (.29)
NONVIEWERS	.79 (.19)	.66 (.31)

The analysis revealed a significant main effect of Ethnicity ($F_{1,44} = 4.07$, $p = .05$), with minority children giving a higher proportion of positive statements than nonminority children. There was no significant effect of Ethnicity in the three-way interaction ($F_{1,44} = 1.48$, N.S.).

Analysis by SES. A third three-way analysis of variance was performed on the arcsine transformation of the proportion of positive statements, using Pretest/Posttest, Viewer/Nonviewer, and SES as factors. The mean proportions of positive statements made by the children in the PSA Domain are presented in the following tables. Standard deviations are shown in parentheses.

PROPORTION OF POSITIVE STATEMENTS IN THE PSA DOMAIN

LOW-SES

	PRETEST	POSTTEST
VIEWERS	.95 (.09)	.89 (.13)
NONVIEWERS	.85 (.18)	.78 (.29)

MIDDLE-SES

	PRETEST	POSTTEST
VIEWERS	.94 (.11)	.80 (.26)
NONVIEWERS	.83 (.17)	.72 (.27)

The analysis revealed no significant effect of SES either as a main effect ($F_{1,44}$ = .54, N.S.), or in the three-way interaction with Pretest/Posttest and Viewer/Nonviewer ($F_{1,44}$ = .03, N.S.).

p. 217 Valence: Math Domain

The average proportion of positive statements made by children in the Mathematics Domain are shown below. Standard deviations are shown in parentheses.

	PRETEST	POSTTEST
VIEWERS	.76 (.32)	.64 (.28)
NONVIEWERS	.87 (.21)	.81 (.23)

A two-way analysis of variance was performed on the arcsine transformation of the overall proportion of positive statements in the

Mathematics Domain made by viewers and nonviewers in the pretest and posttest. The factors used were Viewer/ Nonviewer (between-groups factor) and Pretest/Posttest (within-groups factor).

The analysis revealed a significant main effect for Viewer/Nonviewer ($F1,45 = 4.51$, $p < .05$), but no significant interaction of Viewer/Nonviewer with Pretest/Posttest ($F1,45 = .59$, N.S.).

A significant main effect was found for Pretest/Posttest ($F_{1,45} = 4.53$, $p < .05$). However, because this difference collapses data across experimental groups, it is of little experimental interest and will not be discussed further.

<u>Analysis by Sex.</u> A three-way analysis of variance was performed on the arcsine transformation of the proportion of positive statements made by the children in the Mathematics Domain. Pretest/Posttest, Viewer/Nonviewer, and Sex were used as factors. The mean proportions are shown in the following tables. Standard deviations are shown in parentheses.

PROPORTION OF POSITIVE STATEMENTS IN MATHEMATICS DOMAIN

BOYS

	PRETEST	POSTTEST
VIEWERS	.76 (.34)	.57 (.31)
NONVIEWERS	.89 (.16)	.75 (.25)

GIRLS

	PRETEST	POSTTEST
VIEWERS	.76 (.32)	.71 (.25)
NONVIEWERS	.85 (.25)	.87 (.21)

The analysis revealed no significant main effect of Sex ($F1,43 = .75$, N.S.), and no significant effect of Sex in the three-way interaction with Pretest/Posttest and Viewer/Nonviewer ($F1,43 = .00$, N.S.).

<u>Analysis by Ethnicity.</u> A second three-way analysis of variance was performed on the arcsine transformation of the proportion of positive statements using Pretest/Posttest, Viewer/Nonviewer, and Ethnicity as factors. The mean proportions of positive statements made by the children in the Mathematics

Domain are presented in the following tables. Standard deviations are shown in parentheses.

PROPORTION OF POSITIVE STATEMENTS IN MATHEMATICS DOMAIN

MINORITY

	PRETEST	POSTTEST
VIEWERS	.78 (.31)	.70 (.29)
NONVIEWERS	.89 (.18)	.83 (.22)

NONMINORITY

	PRETEST	POSTTEST
VIEWERS	.70 (.37)	.50 (.23)
NONVIEWERS	.82 (.28)	.76 (.27)

The analysis revealed no significant main effect of Ethnicity (F1,43 = 2.14, N.S.), and no significant effect in the three-way interaction with Pretest/Posttest and Viewer/Nonviewer (F1,43 = .16, N.S.).

Analysis by SES. A third three-way analysis of variance was performed on the arcsine transformation of the proportion of positive statements. The factors used were Pretest/Posttest, Viewer/Nonviewer, and SES. The mean proportions of positive statements made by the children in the Mathematics Domain are presented in the following tables. Standard deviations are shown in parentheses.

PROPORTION OF POSITIVE STATEMENTS IN MATHEMATICS DOMAIN

LOW-SES

	PRETEST	POSTTEST
VIEWERS	.78 (.33)	.69 (.33)
NONVIEWERS	.92 (.17)	.87 (.19)

MIDDLE-SES

	PRETEST	POSTTEST
VIEWERS	.74 (.33)	.58 (.23)
NONVIEWERS	.81 (.23)	.76 (.26)

The analysis revealed no significant main effect of SES (F1,43 = 2.42, N.S.), and no significant effect of SES was revealed in the three-way interaction with Pretest/Posttest and Viewer/Nonviewer (F1,43 = .31, N.S.).

p. 217 Magnitude: Overall

The average overall magnitude of the statements made by children is shown below. Standard deviations are shown in parentheses.

	PRETEST	POSTTEST
VIEWERS	.70 (.36)	.49 (.49)
NONVIEWERS	.61 (.43)	.48 (.52)

A two-way analysis of variance was performed on the overall magnitude of the statements made by viewers and nonviewers in the pretest and posttest. The factors used were Viewer/Nonviewer (between-groups factor) and Pretest/Posttest (within-groups factor).

The analysis revealed no significant main effect of Viewer/Nonviewer ($F_{1,46}$ = .20, N.S.), and no significant interaction of Viewer/Nonviewer with Pretest/Posttest ($F_{1,46}$ = .34, N.S.).

A significant main effect was found for Pretest/Posttest ($F_{1,44} = 6.58$, $p < .05$). However, because this difference collapses data across experimental groups, it is of little experimental interest and will not be discussed further.

Analysis by Sex. A three-way analysis of variance was performed on the overall magnitude of the statements made by the children. Pretest/Posttest, Viewer/Nonviewer, and Sex were used as factors. The mean magnitude ratings are shown in the following tables. Standard deviations are shown in parentheses.

OVERALL MAGNITUDE OF STATEMENTS

BOYS

	PRETEST	POSTTEST
VIEWERS	.71 (.33)	.41 (.37)
NONVIEWERS	.48 (.53)	.37 (.63)

GIRLS

	PRETEST	POSTTEST
VIEWERS	.68 (.39)	.57 (.60)
NONVIEWERS	.73 (.27)	.58 (.36)

The analysis revealed no significant main effect of Sex ($F_{1,44} = 1.71$, N.S.), and no significant effect in the three-way interaction of Sex with Pretest/Posttest and Viewer/Nonviewer ($F_{1,44} = .68$, N.S.).

Analysis by Ethnicity. A second three-way analysis of variance was performed using Pretest/Posttest, Viewer/Nonviewer, and Ethnicity as factors. The mean magnitude ratings of the statements made by the children are presented in the following tables. Standard deviations are shown in parentheses.

OVERALL MAGNITUDE OF STATEMENTS

MINORITY

	PRETEST	POSTTEST
VIEWERS	.79 (.35)	.58 (.40)
NONVIEWERS	.66 (.48)	.53 (.60)

NONMINORITY

	PRETEST	POSTTEST
VIEWERS	.45 (.26)	.26 (.65)
NONVIEWERS	.48 (.25)	.35 (.18)

The analysis revealed a significant main effect of Ethnicity ($F_{1,44} = 4.50$, $p < .05$), with minority children giving higher magnitudes than nonminority children. There was no significant effect of Ethnicity in the three-way interaction with Pretest/Posttest and Viewer/Nonviewer ($F_{1,44} = .01$, N.S.).

Analysis by SES. A third three-way analysis of variance was performed using Pretest/Posttest, Viewer/Nonviewer, and SES as factors. The mean magnitude of the statements made by the children is presented in the following tables. Standard deviations are shown in parentheses.

OVERALL MAGNITUDE OF STATEMENTS

LOW-SES

	PRETEST	POSTTEST
VIEWERS	.79 (.35)	.62 (.40)
NONVIEWERS	.67 (.50)	.67 (.63)

MIDDLE-SES

	PRETEST	POSTTEST
VIEWERS	.60 (.35)	.35 (.56)
NONVIEWERS	.54 (.36)	.28 (.29)

The analysis revealed a significant main effect of SES ($F_{1,44} = 5.04$, $p < .05$), with the mean magnitude of low-SES children's statements being significantly higher than that of middle-SES children. However, no significant effect of SES in the three-way interaction with Pretest/Posttest and Viewer/Nonviewer was found ($F_{1,44} = .45$, N.S.).

p. 217 Magnitude: PSA Domain

The average magnitude of the statements made by children in the PSA Domain is shown below. Standard deviations are shown in parentheses.

	PRETEST	POSTTEST
VIEWERS	.81 (.36)	.50 (.50)
NONVIEWERS	.62 (.55)	.38 (.70)

A two-way analysis of variance was performed on the overall magnitude ratings of the statements in the PSA Domain made by viewers and nonviewers in the pretest and posttest. The factors used were Viewer/Nonviewer (between-groups factor) and Pretest/Posttest (within-groups factor).

The analysis revealed no significant main effect for Viewer/Nonviewer ($F_{1,46} = 1.41$, N.S.), and no significant interaction effect of Viewer/Nonviewer with Pretest/Posttest ($F_{1,46} = .20$, N.S.).

A significant main effect was found for Pretest/Posttest ($F_{1,46} = 10.57$, $p < .01$). However, because this difference collapses data across experimental groups, it is of little experimental interest and will not be discussed further.

Analysis by Sex. A three-way analysis of variance was performed on the magnitude of the statements made by the children in the PSA Domain. Pretest/Posttest, Viewer/Nonviewer, and Sex were used as factors. The mean magnitude ratings are shown in the following tables. Standard deviations are shown in parentheses.

MAGNITUDE OF STATEMENTS IN PSA DOMAIN

BOYS

	PRETEST	POSTTEST
VIEWERS	.79 (.32)	.50 (.39)
NONVIEWERS	.43 (.63)	.21 (.86)

GIRLS

	PRETEST	POSTTEST
VIEWERS	.84 (.41)	.49 (.61)
NONVIEWERS	.81 (.39)	.55 (.47)

The analysis revealed no significant main effect of Sex ($F_{1,44}$ = 2.25, N.S.), and no significant effect of Sex in the three-way interaction with Pretest/Posttest and Viewer/Nonviewer ($F_{1,44}$ = .00, N.S.).

Analysis by Ethnicity. A second three-way analysis of variance was performed using Pretest/Posttest, Viewer/Nonviewer, and Ethnicity as factors. The mean magnitude of the statements made by the children in the PSA Domain are presented in the following tables. Standard deviations are shown in parentheses.

MAGNITUDE OF STATEMENTS IN PSA DOMAIN

MINORITY

	PRETEST	POSTTEST
VIEWERS	.90 (.34)	.59 (.43)
NONVIEWERS	.67 (.55)	.49 (.72)

NONMINORITY

	PRETEST	POSTTEST
VIEWERS	.59 (.32)	.26 (.62)
NONVIEWERS	.49 (.56)	.11 (.63)

The analysis revealed a significant main effect of Ethnicity ($F_{1,44} = 4.63$, $p < .05$), with minority children receiving higher magnitude ratings than nonminority children. However, no significant effect of Ethnicity was revealed in three-way interaction with Pretest/Posttest and Viewer/Nonviewer ($F_{1,44} = .22$, N.S.).

Analysis by SES. A third three-way analysis of variance was performed using Pretest/Posttest, Viewer/Nonviewer, and SES as factors. The mean magnitude of statements made by the children in the PSA Domain are presented in the following tables. Standard deviations are shown in parentheses.

MAGNITUDE OF STATEMENTS IN PSA DOMAIN

LOW-SES

	PRETEST	POSTTEST
VIEWERS	.85 (.35)	.65 (.48)
NONVIEWERS	.72 (.49)	.56 (.79)

MIDDLE-SES

	PRETEST	POSTTEST
VIEWERS	.78 (.38)	.34 (.50)
NONVIEWERS	.52 (.61)	.20 (.58)

The analysis revealed a marginal main effect of SES ($F_{1,44} = 3.36$, $p < .10$), with low-SES children receiving higher mean magnitude ratings than middle SES children. No significant effect was revealed in the three-way interaction of SES with Pretest/Posttest and Viewer/Nonviewer ($F_{1,44} = .04$, N.S.).

p. 217 Magnitude: Math Domain

The average magnitude of the statements made by children in the Mathematics Domain is shown below. Standard deviations are shown in parentheses.

	PRETEST	POSTTEST
VIEWERS	.33 (1.01)	.51 (.92)
NONVIEWERS	.63 (.82)	.67 (.80)

A two-way analysis of variance was performed on the overall magnitude of statements in the Mathematics Domain made by viewers and nonviewers in the pretest and posttest. The factors used were Viewer/Nonviewer (between-groups factor) and Pretest/Posttest (within-groups factor).

The analysis revealed no significant effect for Viewer/Nonviewer ($F_{1,44}$ = 1.19, N.S.) or Pretest/Posttest ($F_{1,44}$ = .53, N.S.), and no significant interaction of Viewer/Nonviewer with Pretest/Posttest ($F_{1,44}$ = .22, N.S.).

Analysis by Sex. A three-way analysis of variance was performed on the magnitude of the statements made by the children in the Mathematics Domain. Pretest/Posttest, Viewer/Nonviewer, and Sex were used as factors. The mean magnitude ratings are shown in the following tables. Standard deviations are shown in parentheses.

MAGNITUDE OF STATEMENTS IN MATHEMATICS DOMAIN

BOYS

	PRETEST	POSTTEST
VIEWERS	.50 (.69)	.23 (.76)
NONVIEWERS	.67 (.66)	.76 (.96)

GIRLS

	PRETEST	POSTTEST
VIEWERS	.17 (1.24)	.76 (1.00)
NONVIEWERS	.59 (.98)	.59 (.65)

The analysis revealed no significant main effect of Sex ($F_{1,42}$ = .00, N.S.), and no significant effect of Sex in the three-way interaction with Pretest/Posttest and Viewer/Nonviewer was found ($F_{1,42}$ = 2.61, N.S.).

Analysis by Ethnicity. A second three-way analysis of variance was performed using Pretest/Posttest, Viewer/Nonviewer, and Ethnicity as factors. The mean magnitude ratings of the statements made by the children in the Mathematics Domain are presented in the following tables. Standard deviations are shown in parentheses.

MAGNITUDE OF STATEMENTS IN MATHEMATICS DOMAIN

MINORITY

	PRETEST	POSTTEST
VIEWERS	.53 (.79)	.59 (.80)
NONVIEWERS	.70 (.68)	.59 (.80)

NONMINORITY

	PRETEST	POSTTEST
VIEWERS	-.14 (1.35)	.32 (1.20)
NONVIEWERS	.46 (1.14)	.85 (.83)

The analysis revealed no significant main effect of Ethnicity ($F_{1,42}$ = 1.00, N.S.), and no significant effect in the three-way interaction with Pretest/Posttest and Viewer/Nonviewer ($F_{1,42}$ = .02, N.S.).

Analysis by SES. A third three-way analysis of variance was performed using Pretest/Posttest, Viewer/Nonviewer, and SES as factors. The mean magnitude ratings of the statements made by the children in the Mathematics Domain are presented in the following tables. Standard deviations are shown in parentheses.

MAGNITUDE OF STATEMENTS IN MATHEMATICS DOMAIN

LOW-SES

	PRETEST	POSTTEST
VIEWERS	.62 (.72)	.58 (.78)
NONVIEWERS	.67 (.76)	.89 (.71)

MIDDLE-SES

	PRETEST	POSTTEST
VIEWERS	.06 (1.18)	.44 (1.06)
NONVIEWERS	.59 (.91)	.47 (.84)

The analysis revealed no significant main effect of SES ($F_{1,42}$ = 2.04, N.S.) and no significant effect in the three-way interaction ($F_{1,42}$ = 1.58, N.S.).

p. 219 General Enjoyment Analysis

A necessary first step in the general enjoyment analysis was to determine if the number of positive statements was an artifact of the number of questions each child was asked. To determine this, a correlation between the number of general enjoyment statements the children made and the number of questions asked was performed. This correlation was -.04 (N.S.), suggesting that the frequency of positive statements was not significantly related to the numberof questions asked of the children.

The average overall numbers of spontaneous positive statements made by children are shown below. Standard deviations are shown in parentheses.

	PRETEST	POSTTEST
VIEWERS	5.38 (2.89)	7.46 (3.09)
NONVIEWERS	6.46 (3.78)	6.58 (3.20)

A two-way analysis of variance was performed on the overall number of spontaneous positive statements made by viewers and nonviewers in the pretest and posttest. The factors used were Viewer/Nonviewer (between-groups factor) and Pretest/Posttest (within-groups factor).

The analysis revealed no significant main effect of Viewer/Nonviewer ($F_{1,46} = .02$, N.S.), but there was a significant interaction of Viewer/Nonviewer with Pretest/Posttest ($F_{1,46} = 4.54$, $p < .05$). A Fisher Least Significant Difference test performed on the data showed that viewers increased significantly from pretest to posttest in the number of spontaneous positive statements they gave ($p < .01$).

A significant main effect was found for Pretest/Posttest ($F_{1,46} = 5.77$, $p < .05$). However, because this difference collapses data across experimental groups, it is of little experimental interest and will not be discussed further.

Analysis by Sex. A three-way analysis of variance was performed on the overall number of spontaneous positive statements made by the children. Pretest/Posttest, Viewer/Nonviewer, and Sex were used as factors. The mean numbers of spontaneous positive statements are shown in the following tables. Standard deviations are shown in parentheses.

OVERALL NUMBER OF SPONTANEOUS POSITIVE STATEMENTS

BOYS

	PRETEST	POSTTEST
VIEWERS	5.92 (2.58)	8.33 (3.23)
NONVIEWERS	6.00 (3.77)	5.67 (3.53)

GIRLS

	PRETEST	POSTTEST
VIEWERS	4.83 (3.19)	6.58 (2.81)
NONVIEWERS	6.92 (3.90)	7.50 (2.68)

The analysis revealed no significant main effect of Sex ($F_{1,44} = .00$, N.S.), and no significant effect of Sex in the three-way interaction with Pretest/Posttest and Viewer/Nonviewer ($F_{1,44} = .72$, N.S.).

Analysis by Ethnicity. A second three-way analysis of variance was performed using Pretest/Posttest, Viewer/Nonviewer, and Ethnicity as factors. The mean numbers of spontaneous positive statements made by the children are presented in the following tables. Standard deviations are shown in parentheses.

OVERALL NUMBER OF SPONTANEOUS POSITIVE STATEMENTS

MINORITY

	PRETEST	POSTTEST
VIEWERS	5.41 (3.12)	7.82 (3.09)
NONVIEWERS	6.29 (3.77)	6.18 (3.15)

NONMINORITY

	PRETEST	POSTTEST
VIEWERS	5.29 (2.43)	6.57 (3.16)
NONVIEWERS	6.86 (4.06)	7.57 (3.36)

The analysis revealed no significant main effect of Ethnicity ($F_{1,44} = .03$, N.S.), and no significant effect of Ethnicity in the three-way interaction with Pretest/Posttest and Viewer/Nonviewer ($F_{1,44} = .92$, N.S.).

Analysis by SES. A third three-way analysis of variance was performed using Pretest/Posttest, Viewer/Nonviewer, and SES as factors. The mean number of spontaneous positive statements made by the children are presented in the following tables. Standard deviations are shown in parentheses.

OVERALL NUMBER OF SPONTANEOUS POSITIVE STATEMENTS

LOW-SES

	PRETEST	POSTTEST
VIEWERS	5.58 (2.91)	7.42 (3.29)
NONVIEWERS	5.50 (4.06)	5.58 (2.64)

MIDDLE-SES

	PRETEST	POSTTEST
VIEWERS	5.17 (2.98)	7.50 (3.03)
NONVIEWERS	7.42 (3.37)	7.58 (3.50)

The analysis revealed no significant main effect of SES ($F_{1,44} = 1.22$, N.S.), and no significant effect in the three-way interaction with Pretest/Posttest and Viewer/Nonviewer ($F_{1,44} = .05$, N.S.).