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ABSTRACT

The ideas of the nature, purpose, and scope of mathematics held by students is an issue of interest to the mathematics education community. Movement from a mathematics as discrete operations perspective to a mathematics as problem-solving perspective is a desired change in mathematics education reform. 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. Attitude data was 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. Presented in this paper are the children's constructs of mathematics and change effected by viewing SQUARE ONE TV programming, as evaluated through an Attitude Interview and an Essay. Among the results are: (1) viewers made significantly greater gains than nonviewers in the proportion of statements mentioning more complex problem solving made in the Attitude Interview; (2) viewers produced a significantly greater proportion of advanced mathematics statements than the nonviewers in the posttest; and (3) no significant main effects of sex, ethnicity or socioeconomic status (SES) occurred in any results. Findings indicated that SQUARE ONE TV had an impact on children's discrete operations constructs of mathematics. The interview questions are attached. (MDH)

If You Had to Tell an Alien What Math Is...:

Construct of Mathematics and **SQUARE ONE TV**

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Paper to be presented at the biennial meeting of the Society for Research in Child Development, Seattle, WA as part of a Symposium entitled "Problem Solving, Attitudes and Television: A Summative Study of **SQUARE ONE TV**," co-chairs, Eve R. Hall and Shalom M. Fisch, Children's Television Workshop.

Introduction

> Q: If you had to explain what math is to someone who had never heard of it, maybe some guy from another planet who happens to speak English, what would you say that it is?
>
> CHILD #1: A bunch of mixed-up numbers.
>
> CHILD #2: It's a subject that helps you learn things in, in different areas in the outside world....Like uh building fences, uh sales managing, um...A clerk, you need to know math....A cashier....A banker. Lot of other things.

These two fifth graders present, even in this short selection, very different ideas of the nature, purpose and scope of mathematics. The first child defines mathematics as numbers that seem to have a life and essence of their own: they are "mixed up." She doesn't relate these numbers to her life either in or out of school. Presumably, the task of the mathematics student would be to try to un-mix the numbers. But why? Why should the child have to do that? On the basis of this response, this child doesn't offer any reason why one would want or need to do the work of unmixing bunches of numbers.

We have called this perspective on mathematics mathematics as discrete operations because it presents mathematics as a set of memorized, rule-bound procedures usually involving numbers or counting that is done in the classroom. This discrete operations construct of mathematics has been observed by researchers to be the dominant understanding of mathematics that children develop when exposed to the drill, rote procedures and formulaic word problems of traditional mathematics pedagogy (see Ginsburg & Asmussen, 1988; Kouba & McDonald, in press; Lave, Smith & Butler, 1988; Resnick, 1988; Schoenfeld, 1988). In fact, part of the call for mathematics education reform comes from the concern that children who hold a discrete operations perspective do not understand how mathematics is useful for real-life problem solving.

The second child who described mathematics as "a subject that helps you learn things...in different areas in the outside world" presents what seems to be a different construct of mathematics. By relating mathematics to learning in the world, particularly to the adult work world, she is beginning to construct an understanding of mathematics that sounds similar to the construct of mathematics that is being suggested by proponents of mathematics education reform (see, e.g., Resnick, 1988; Schoenfeld, 1985; Carraher, Schliemann & Carraher, 1988). This mathematics, which we have called mathematics as problem solving, is mathematics as a process of figuring out, of sense-making which uses mathematical tools to solve problems in the real world. The hope is that a change in children's beliefs about mathematics from discrete operations to problem solving would result in what the National Council of Teachers of Mathematics (1989) calls "mathematical empowerment."

Methodology

This paper will describe the constructs of mathematics of 48 fifth graders in Corpus Christi, Texas who participated in a summative evaluation of SQ1TV (see Fisch, et al., 1990). A child's construct of mathematics is his or her conception of what mathematics is: what it consists of, what it is good for, and what one does with it. In addition, this paper will explore the possibility for change by presenting the effects of viewing SQ1TV on their constructs of mathematics (Debold, et al., 1990).

Our inquiry into children's constructs of mathematics was the foundation for our assessment of children's attitudes toward mathematics and the effect of SQ1TV on their attitudes. Since recent research on children's attitudes toward mathematics has indicated that children's attitudes toward mathematics are deeply tied to their conceptions of it (e.g., McLeod, 1989; Schoenfeld, 1983), we began our study of attitude by exploring children's responses to our Attitude Interview. The Attitude Interview consisted of open-ended questions that targeted four dimensions of attitude (construct of mathematics, usefulness and importance, motivation and enjoyment) within three domains of mathematical inquiry. These four dimensions of attitude were consistent with the first goal of SQ1TV ("To promote positive attitudes...").

Questions in the Attitude Interview were also categorized by domain, or section, of the interview: the Problem-Solving Activity Domain, in which questions were asked about the problem-solving activities that the children had worked with; the Figuring Out Domain, in which questions were asked about children's naive problem solving; and the Mathematics Domain, in which children were explicitly asked questions about mathematics in and out of school. We knew that the children might not recognize that our PSAs, the hands-on problem solving tasks, were mathematical in nature because the tasks were so different from the mathematics that they received in school. Given the emphasis in the mathematics reform movement both on children becoming better mathematical problem solvers and on children reconceptualizing their understanding of mathematics in terms of problem solving, we wanted to be able to understand how children think about mathematics in school and out of school as well as how they think about problem solving.

The Attitude Interview was conducted in one-on-one sessions between an interviewer and a child and lasted approximately 40 minutes. Interviewers were encouraged to follow-up the children's responses with further questions so as to capture the fullest range of the children's thinking. Questions that were designed to elicit responses indicative of children's constructs of mathematics were analyzed from the three different domains of mathematical inquiry.

We also explored children's constructs of mathematics through a written Essay which was given to all 240 children in the participating classrooms. The Essay asked them to explain why they would or would not like a job that involved mathematics.

I will be presenting results from two different and complementary analyses of children's constructs of mathematics. The first analysis, the descriptive analysis, used key questions from the designated construct questions to present an in-depth portrait of the range of the children's responses at the pretest. We derived categories for analysis from the children's responses and then interpreted those categories in light of current research. These responses were also examined for patterns of differences relating to the children's sex, ethnicity and socioeconomic status (SES).

The second analysis, the analysis of change, measured pre-test/posttest change in certain aspects of children's responses to the designated questions as well as assessing differences between viewers' and nonviewers' construct of mathematics responses to the Essay. Differences between viewers and nonviewers were tested using inferential statistics. We also explored these differences in relation to the children's sex, ethnicity and SES.

I will begin with our descriptive analysis of children's constructs of mathematics and problem solving. Next, I will explain how we assessed change as a result of SQ1TV viewing, and then present the results of our analysis of change and the implications of those results for changing children's constructs of mathematics.

The Descriptive Analysis

Mathematics

To describe their conceptions of mathematics, we examined (1) children's explicit definitions of mathematics given in response to two different questions, "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?" and "Some people say that the only thing that math is is adding, subtracting, multiplying and dividing. What do you think of that?" (2) their spontaneous uses of the term "math" in response to questions in the Figuring Out and PSA Domains that did not mention the word "math," (3) the references that children made to mathematical content areas, and (4) their responses to questions about the context of their mathematics learning, "Can you tell me where you got your ideas about math?" and "Is what you do in math class all there is to math?". We found no pattern of differences in the children's responses on the basis of sex, socioeconomic status or ethnicity.

Across all of the children's responses, we found, as one would have expected, that the discrete operations construct of mathematics dominated their thinking. Our research also indicated that the children understood that discrete operations mathematics was related to the activities of the classroom.

In response to this question which asked children to define mathematics to an alien, 75% of the children's responses defined mathematics as consisting of numbers, computational arithmetic, and other content areas of mathematics that they have been presented in school. As one child said,

> 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.

Other responses emphasized computation:

> Um, you use, 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...memorize it.

As these typical responses indicate, the discrete operations construct present mathematics as decontextualized operations done with numbers. Sometimes children would explain mathematics to the alien by invoking formulaic word problems that echo the way that they were probably taught about mathematics:

> 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.

Our second key question, which asked children to respond to a definition of mathematics as only arithmetic, gave the children the opportunity to disagree with the discrete operations construct of mathematics. While the majority -- 81% -- of the children's responses disagreed with this statement. 85% of the children's responses still spoke of mathematics as a set of discrete operations. Thus, most of the children who felt that this statement was wrong elaborated either by adding other, discrete content areas (e.g., "No, that's not all it is because there's like word problems, and place value. And all that kinda stuff.") or by alluding to there being somehow more to it than basic computation (e.g., "Well I think it's partly right and partly wrong. 'Cause you do all those things, except it's not just that."). Despite these alterations to the definition of mathematics as basic computation, the structure of children's concept of mathematics remains unchanged: it is still a set of separate numeric operations.

When the children used the term "math" spontaneously in the interview (i.e., in response to questions in the Figuring Out and PSA Domains that did not ask about "math" explicitly), they usually were referring to discrete operations. Over one quarter (27%) mentioned "math" or "math problems" with no further elaboration; over three fifths (62%) referred to "multiplication and addition" or other aspects of computation.

While we did not ask the children 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 in their responses. Using the content areas listed in the third goal of the SQ1TV as a way of organizing this information, we tallied the distribution across the content areas of mathematics (see Table 1 in Appendix). The overwhelming majority of the children's responses concerned numbers, counting or basic arithmetic. Occasionally, a child made reference to "algebra" or, in one case, "trigonometry;" although some of these children explained that an older relative had shown them this "math."

The children's discrete operations construct of mathematics is hardly surprising given the emphasis in the elementary-school curriculum on mastering arithmetic facts through drill. More than four fifths of the children responded that mathematics class was where they got their ideas; in fact, over a third stated that school was their only source. Nearly three fifths of the children also mentioned that they learned mathematics from family members or from themselves. For example, one child responded hesitantly that he learned "From my brain cells?" and then added that "you have to learn it first before you know it."

Learning mathematics, as we saw throughout the children's responses, basically concerned mastering the specific tasks 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 (see 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.

Yet, despite the dominance of this outcome-oriented, computation-driven discrete operations construct of mathematics, we also heard evidence in their discussion of mathematics of some aspects of a problem solving construct of mathematics. These elements of a mathematics as problem solving is a very positive sign for proponents of mathematics reform because it indicates that, even within the traditional curriculum, children have some sense of mathematics as useful, contextualized problem solving.

Two elements of a problem-solving concept of mathematics were present in the children's explicit definitions of mathematics. The first was mathematics as a process of thinking or figuring out: in other words, an emphasis on process rather than on outcome. The second element was mathematics as useful; because a problem-solving construct of mathematics presents mathematics as useful in solving problems, spontaneous references to applications of mathematics as part of the children's definitions of mathematics are important. One quarter of the children (25%) gave these problem-solving responses to the alien and 15% gave such responses to the mathematics-as-arithmetic question. In all, two fifths (40%) of the children made responses that defined mathematics either as a process of figuring out or as useful. For example, one child emphasized the utility of mathematics by explaining to the alien that "it's an interesting thing for you to do and, you know, um when you really grow up and you want...you're gonna have to...use math." Another child presented mathematics as a process that is about "numbers. Um...lines. Hm, how to do things in a different way. You can do it in a different way." While these children are still referring to arithmetic and numbers as the ground for their problem-solving process and use, these more problem-solving responses seem to express the possibility of a problem solving concept of mathematics.

Within the children's spontaneous references to "math" in the interview, nearly one fourth (23%) of the children described the process of learning or doing arithmetic as a process involving thinking hard and uncertainty. One child, for example, described the experience of doing the most complex PSA 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." Again, while the process that these children have described is linked to doing basic computation, as novices they find even the basics of arithmetic to be an often complicated, challenging process.

This thread of a problem solving construct of mathematics was also present in the children's responses to our two questions about the sources of their mathematics knowledge. One fifth (19%) of the children's responses to these questions included examples of the uses of mathematics as a source of mathematics knowledge. For example, one child stated that he got his ideas about mathematics "...from doing it."

Thus, despite the children's view of mathematics as discrete operations, the children's experience with these classroom arithmetic activities led some of them to speak of this as a process of figuring out. However, this "figuring out" is very different from the figuring out that Schoenfeld (1986) says is the heart of mathematics. These differences can be seen in two ways. First, the children spoke about struggling to figure out material that, eventually, they hope to commit to memory; this figuring out is 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 computation activities as difficult and challenging because doing the problems often required serious concentration. 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. This basis for understanding problem solving is troublesome because it can set up expectations of swift and certain solution as the mark of the good problem solver.

Problem Solving

While the children's discussion of mathematics provided us with some insight into their conceptions of problem solving, we conducted a further exploration of the children's constructs of problem solving. Our descriptive analysis of children's constructs of problem solving involved (1) an analysis of spontaneous references that the children made to "problem solving," (2) an inventory of the problem solving activities that they enjoy, (3) children's descriptions of problem solving and (4) their responses to two questions relating to the most complex PSA. "Would you say that you learned something from [the PSA]? What?" and "Let's say when you're in high school you take a class that teaches you how to figure out things like the [PSA], would you like to take it? What do you think you would learn?". As in the previous descriptive analysis, we observed no consistent pattern of differences in their responses relating to sex, SES or ethnicity.

When the children spoke about "problem solving" per se, they were usually referring to multi-step computation problems or arithmetic word problems. While they discussed a variety of contexts for computation (mathematics class, word problems, and buying and selling), their responses and the apparent uses for this computational problem solving did not go much further than the corner store. However, when the children described the activities that they enjoyed figuring out, that is, when they spoke about generic problem solving, their horizons expanded.

The children spoke of their enjoyment of figuring out mysteries, puzzles, and games as well as mathematics. The children enjoyed trying to figure out "who did it" before the conclusion of a mystery. They also enjoyed the experience of figuring out complicated problems, mathematics worksheets and word problems. Board games (such as Monopoly and backgammon) as well as arcade and video games, particularly Nintendo, were enjoyable for the children to figure out. Common to their description of these activities is a process of figuring out in which the child thinks very hard and is uncertain about the solution. These activities seem to present the experiential basis for what the children understood to be the essence of generic or naive problem solving, that is, problem solving that is not necessarily mathematical.

When we asked the children to explain how they go about figuring things out, that is, to define their processes of problem solving, their responses were firmly rooted in the activities that the children said they enjoy figuring out. The children used words that were evocative of these activities when describing this process of thinking hard that is their understanding of problem solving. Some of the children used words associated with solving mysteries in their descriptions, like "clues" or "find out who did it and why." Other children, fewer in number, spoke of problem solving using words such as "fixing." One child explained what he meant by figuring out by saying that "a mechanic usually has to figure out a part of a car." 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.

Only two children recognized the power of mathematics to help them figure out problems in their lives. These two children, by making the connection between mathematics in school and figuring out, described a rudimentary form of mathematical problem solving. One child explained that mathematics is important for many kinds of problem solving outside of school and was more useful than her other subjects for working with current, real-life problems. Yet, this child explained how mathematics was important in problem solving by applying computation to various problem-solving situations.

In our final assessment of the children's constructs of problem solving, we explored their understanding of what they felt that they learned from doing the most complex hands-on problem solving task. This PSA presented the children with a probability game that was broken in such a way that one player always won. The children's job was to find out what was wrong with the game and to fix it. The children's responses again echoed the experiential base of the activities that they had said that they enjoy.

One fifth of the children's responses discussed that the PSA helped them to learn about generic problem solving, that is, thinking hard to figure out something. As one child explained, learning from the PSA involved "learning more about solving things. A better way to figure them out." More than one quarter (28%) of their responses focused on the thinking that was involved without referring to solving or figuring out. Children mentioned that they learned 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." Several of the children made a connection to detective work and solving mysteries. In so doing, they described a general process of figuring out that could lead to a sense of mastery and competence. Over one tenth (13%) of the children's responses described the experience of the PSA in terms of fixing or inventing. One child said that he could "learn better ways how to fix things." Another child said that he could

> learn how to use my knowledge a little better...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.

A little more than a tenth (11%) of the children said that the PSA taught them about how to play a game. Finally, less than one tenth (7%) of the children's responses pertained to arithmetic which is interesting considering that the PSA did contain numbers and some arithmetic. A few children seemed to be limited by the simple arithmetic in the game because they did not feel that it taught them anything. Yet, by and large, working with the PSA gave most children an experience of problem solving through which they could make connections to the work of detectives, scientists, mechanics and inventors -- and, thus, was an important and purposeful experience.

When one looks across the children's responses, a pattern emerges.

The children described an experience of generic problem solving, often associated with the activities that they enjoy, that basically involved thinking hard, figuring out, solving, fixing, or struggling to find a solution. However, the construct of problem solving that emerged from their experiences with these activities did not usually involve mathematics. Even so, the children's experiences and descriptions of problem solving as a process of figuring out provide an endorsement of the problem-solving-based pedagogy being recommended by the proponents of mathematics reform (see, e.g., Willoughby, et al., in press). Both the children's general interest in figuring out and their interpretation that the complex PSA was about figuring out suggest that an emphasis in the curriculum on figuring out useful problems could stimulate children's involvement with mathematics.

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 the PSA, 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 Analysis of Change

As the descriptive analyses of the pretest responses have shown, children's conceptions of mathematics and problem solving per se are dominated by their experience with classroom arithmetic. Given this, which is supported by the available research literature, we decided to assess change in the children's constructs of mathematics in terms of changes within their discrete operations construct rather than in terms of change from a discrete operations to a problem solving construct of mathematics. We hoped that SQ1TV would be able to expand on the children's discrete operations constructs. Given that the purpose of SQ1TV is as a supplement to the curriculum, and in the absence of curriculum reform in the schools under study, we felt that such change would be a positive sign that children's constructs of mathematics are amenable to change and that SQ1TV is effective in meeting its goals.

Measures

We created two different measures of children's discrete operations constructs of mathematics. In the first, we distinguished between levels of sophistication in the children's references to mathematics and problem solving in the Attitude Interview. We categorized the children's statements about mathematics into basic (i.e., counting and arithmetic) and advanced mathematics (e.g., measurement, probability, etc.): their statements about problem solving were categorized as either generic and computational or practical and sophisticated (e.g., involving building or solving mysteries). The second analysis was designed to explore the different kinds of mathematics that the children mentioned in the Attitude Interview and in the Essay. We used the list of content areas of mathematics found in Goal III of SQ1TV as our index to different kinds of mathematics (see Table 1).

Results

In the Attitude Interview, viewers made significantly greater ($p < .05$) gains than nonviewers in the proportion of statements mentioning more complex problem solving (see Figure 2 in Appendix). The two groups did not differ significantly at the pretest, but the viewers increased significantly from pretest to posttest ($p < .01$) while the viewers did not. Further, the viewers made marginally greater gains ($p < .10$) in the proportion of mentions of advanced mathematics (see Figure 1). 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 ($p < .05$). No significant differences were observed between the number of types of mathematics mentioned in the Attitude Interview; however, marginally more viewers mentioned Geometry in the Attitude Interview and the Essay (see Table 2). Furthermore, viewers differed significantly in the number of mentions of measurement in the Essay (see Table 3). There were no significant main effects of sex, ethnicity or socioeconomic status in any of these results. The results were quite encouraging, indicating that SQ1TV can have an impact on several aspects of children's discrete operations constructs of mathematics.

Conclusions and Implications

What do these results suggest for mathematics education reform? To answer this, let us begin by considering how these changes might be related to the content of SQ1TV since the content of the series is designed in the spirit of reform. First of all, the problem solving that is demonstrated on SQ1TV involves people figuring out interesting problems; "Mathnet," for example, presents two detectives using mathematics to solve crimes. The children's descriptions of practical and sophisticated problem solving (e.g., building and fixing things or 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 discussing more of this complex problem solving. This suggests that an emphasis in the daily mathematics curriculum on real-life problem solving -- as proponents of the reform movement advocate -- might result in changes in children's constructs of mathematics.

Second, it seems that the wide range of mathematical content presented on SQ1TV helped the children to assimilate this wider world of mathematics into what they discussed. The viewers discussed marginally more examples of advanced mathematics, that is, mathematics beyond basic arithmetic. They also presented marginally more examples of geometry in both the Attitude Interview and Essay, and more examples of measurement in the Essay. It is quite remarkable that SQ1TV 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, as proponents of reform suggest, could be critical in encouraging them to expand their ideas about the subject.

Yet, at least 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 content areas most frequently mentioned by the children were numbers, counting and arithmetic. Changing the children's entire construct of mathematics from discrete operations to problem solving is a task that a supplement such as SQ1TV cannot possibly accomplish without an accompanying change in the daily mathematics curriculum. The second issue concerns children's constructs of problem solving. The 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, less number-oriented 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 constructs of mathematical problem solving.

Our research is very hopeful for the prospect of mathematics education reform. Children seem to be very willing to find more to mathematics than "a bunch of mixed-up numbers." The persistence of their attempts to find uses "in different areas in the outside world" for the arithmetic that they know, their engagement with thinking hard to figure out arithmetic and the positive effect that SQ1TV had on advancing the sophistication of the mathematics and problem solving that the children discussed, all indicate that children, perhaps more than anyone else, may be ready for mathematics education reform.

References

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 (pp. 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.

Debold, E., Hall, E., Fisch, S., Bennett, D., & Solan, S. (1990). 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**. Children's Television Workshop, New York.

Fisch, S., Hall, E., Esty, E., & Debold, E. (1990). Children's problem-solving behavior and their attitudes toward mathematics: A study of the effects of **SQUARE ONE TV**. Volume I: Introduction: Purpose and General Design of the Study. Children's Television Workshop, New York.

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.

Kouba, V.L., & McDonald, J.L. (in press). What is mathematics to children? Journal of Mathematical Behavior.

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.

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.

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

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, and Reston, VA: National Council of Teachers of Mathematics.

Willoughby, S.S., Bereiter, K., Hilton, P., & Rubenstein, J.H. (in press). Real Math. Peru, IL: Open Court.

Appendix

Construct Interview Questions

The following interview questions were used for the analyses of children's constructs of mathematics. The numbers indicate their sequence in the Attitude Interview protocol.

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?

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? 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?

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 where 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?

Table 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

Figure 1

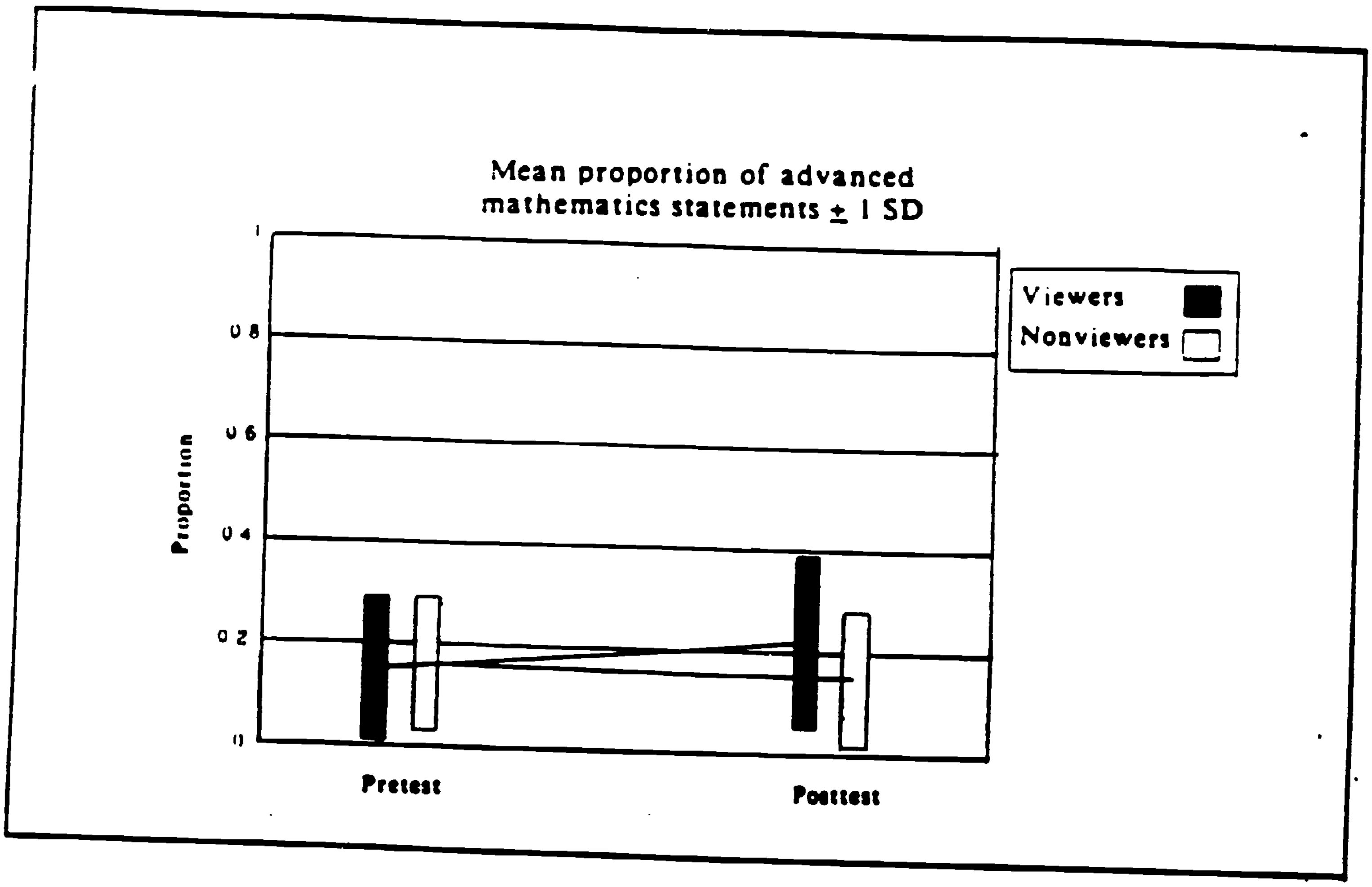
Mean proportion of advanced mathematics statements ± 1 SD
Viewers
Nonviewers
Proportion
0
0 2
0 4
0 6
0 8
1
Pretest
Posttest

Figure 2

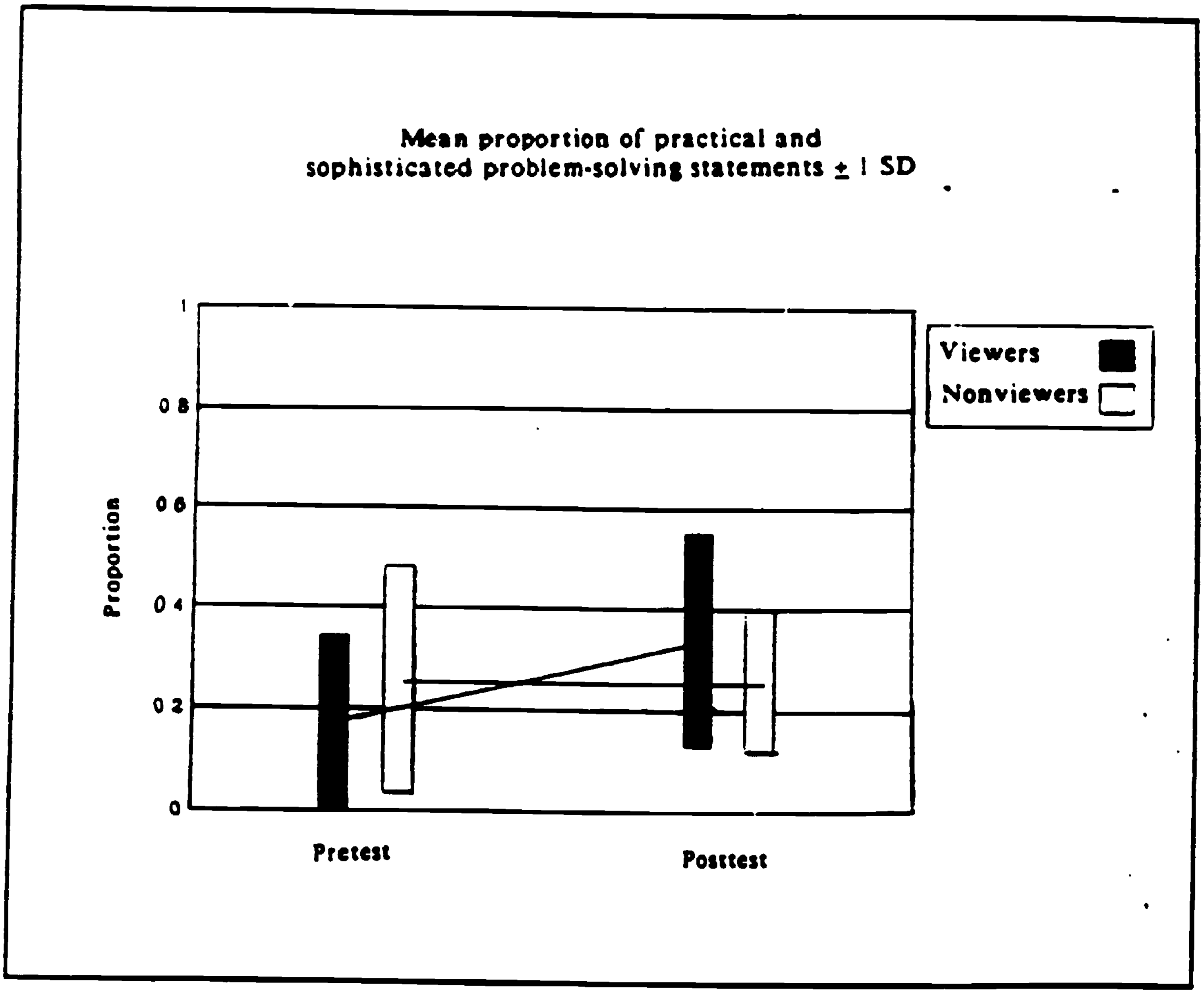
Mean proportion of practical and
sophisticated problem-solving statements ± 1 SD
Proportion
1
0 8
0 6
0 4
0 2
0
Pretest
Posttest
Viewers
Nonviewers

Table 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

Table 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