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ABSTRACT

This issue of the journal contains abstracts and critiques of ten research reports. They address such topics as: (1) characterizing the Van Hiele levels of development in geometry; (2) children's ideas about commutativity in the early elementary arithmetic program; (3) two children's anticipations, beliefs and motivations about mathematics; (4) a beginning teacher's view of problem solving; (5) the understanding of number concepts by 7-9 year olds; (6) the effects of adjusting readability on the difficulty of mathematics story problems; (7) parent attitudes and student career interests in junior high school; (8) effective teaching, student engagement in classroom activities, and sex-related differences in learning mathematics; (9) strategy training and attributional feedback with learning disabled students; and (10) mathematics achievement of Chinese, Japanese, and American children. Research reports and articles listed in "Resources in Education" (RIE) and "Current Index to Journals in Education" (CIJE) for April-June, 1986, are also listed. (TW)

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Fall 1986

Burger, William F. and Shaughnessy, J. Michael. CHARACTERIZING THE VAN HIELE LEVELS OF DEVELOPMENT IN GEOMETRY. Journal for Research in Mathematics Education 17: 31-48; January 1986.

Abstract and comments prepared for I.M.E. by EDWIN McCLINTOCK, Florida International University.

1. Purpose

To answer the following questions:

A. Are the van Hiele levels useful in describing students' thinking processes on geometry tasks?

B. Can the levels be characterized operationally by student behaviors?

C. Can an interview procedure be developed to reveal predominant levels of reasoning on specific geometry tasks?

2. Rationale

Other studies have:

A. Looked at the hierarchical nature of van Hiele levels.

B. Measured geometric abilities as a function of van Hiele levels.

C. Investigated the effects of instruction on a student's predominant van Hiele level.

This study seeks to broaden the scope by using students from kindergarten through college mathematics and to operationalize the aspects of van Hiele levels in terms of both behavioral characteristics and interview procedures. It also studied characteristics of van Hiele levels in geometric reasoning tasks. The specific tasks, like many other U.S. studies involving van Hiele levels are on geometric tasks relating to triangles and quadrilaterals.

3. Research Design and Procedures

The study used a clinical interview technique with students from grades K through 12, together with one college mathematics major. Eight tasks were used in the interview, each involving concepts from topics of triangle and quadrilateral geometry. Data for analysis included audio-taped interviews, student writing and drawings, and interviewers' notes. The interviews ranged from 40 to 90 minutes in length. The tasks ranged from drawing, identifying and defining, sorting, and determining mystery shapes, to using axioms, theorems, and doing proofs. On these tasks, 14 of 45 taped interviews were selected for analysis.

4. Findings

By coding and analyzing the taped protocols, the reviewers were able to make a variety of observations from the data. The finding of Mayberry and Fuys et al. of the hierarchial nature of van Hiele levels was confirmed. Similarly, the findings of Usiskin of the difficulty of assigning students in transition between levels, and of many students never reaching the level of formal deduction, were collaborated. The findings also suggest that students who appear to reason at different levels used different language and different problem-solving processes, thus confirming the difficulty in communication between persons operating on different van Hiele levels.

The study produced a set of behavioral indicators for each of van Hiele's levels. For example, the use of imprecise properties in drawing comparisons and the inability to conceive of an infinite variety of types of shapes as a characteristic of Level 0; the explicit lack of understanding of mathematical proof and sorting on single attributes as characteristic of Level 1; explicit references to definitions and confusion between the roles of axiom and theorem as characteristic of Level 2; and frequent conjecturing with attempts to verify conjectures deductively and the implicit acceptance of the postulate of Euclidean geometry as characteristic of Level 3.

5. Interpretations

The researchers found that each of their research questions could be answered positively. Of significance, as viewed by the authors, is the behavioral characterization of van Hiele levels. This characterization is viewed by the authors as perhaps a minimal, initial set of behaviors. Further, these behaviors, the interview script and accompanying analysis packet are suggested as tools to use with the van Hiele model of development in geometry and as a basis for constructivist teaching experiments in geometry.

The authors did express some reservations about the theorized discrete structure of the van Hiele levels. In fact, they question the discrete nature of the levels and provide some evidence to support their concern. They suggest that the levels appear to be dynamic rather than static and of a more continuous than discrete nature. Are the van Hiele levels, then, discrete or continuous? How useful are the characteristics of levels if they are on a continuum rather than of a discrete nature?

Another significant interpretation of the research involves the observation of secondary school students about their incomplete notions of basic geometric shapes and properties of these shapes. The authors wondered how students with such incomplete notions could reason in formal ways; they suggest the lack of well-formed concepts as reasons students memorize geometry as their only recourse. They refer to these incomplete concepts as contributing to the frustration of students and teachers in secondary school geometry courses.

Abstractor's Comments

Burger and Shaughnessy have looked at a longitudinal view of van Hiele levels in a clinical interview process with a small number of students. They have confirmed the findings of several other researchers who have looked more at a cross-sectional view of these levels. Their products are more clearly delineated interview and analysis packets, more behaviorally oriented characteristics of levels, and additional notions of the inherent difficulties with the use of a single secondary school deductive geometry course as the sole (at least predominant) treatment of geometry in the U.S.

This abstractor would enjoy a better understanding of the process that led to the conclusion that the three research questions were answered affirmatively. Of particular interest were evidences and understandings that suggested the more continuous nature, rather than discrete nature, of the levels, along with derived behavioral characteristics associated with the specified four discrete levels.

Inherent in other studies are the notions that as students progress from one level to another, they develop a sense of a need for definition and a need for deduction. Though not a part of the characterization of the levels as described by the authors, there is some indirect reference to this phenomena through behavioral indicators. The examples noted are the rephrasing of ambiguous questions into precise language and the use of proof as the final authority. It would be informative to know how these authors view this "need to define" and "need to prove," as well as whether they found evidence of the development of such values among their subjects.

Another point of interest is the conclusion by the authors that the drawing tasks and the sorting tasks could not or did not elicit reasoning beyond Level 2. What sort of evidence might have been expected? Would such constructions (drawings) as triangles with 1 side of irrational length, exactly two sides of irrational length, or all three sides of irrational length have been a possibility? Were the structured interviews designed to allow or elicit such results? Or are they and their corresponding justifications even relevant?

In general, the study that Burger and Shaughnessy described involved careful, time-consuming examinations of van Hiele's levels and their implications for development of reasoning with concepts in geometry. Their interview techniques, the behavioral characterizations of levels (suggested by the authors as minimal, initial characterizations), and their surfacing of important questions about the adequacy of our current geometry program and about the adequacy of van Hiele levels (as discrete structures) to characterize development of geometric reasoning are important contributions to the literature. Their challenge to those of us who care about geometry is to examine the implications of the study and to extend the study in the direction of other important geometric concepts.

Callahan, Leroy G. and Charles, Desiree. CHILDREN'S IDEAS ABOUT COMMUTATIVITY IN THE EARLY ELEMENTARY ARITHMETIC PROGRAM. Focus on Learning Problems in Mathematics 7: 1-10; Spring 1985.

Abstract and comments prepared for I.M.E. by EDWARD C. RATHMELL, University of Northern Iowa.

1. Purpose

The purpose of this study was to collect data on the "degree and character" of young children's misapplication of the commutative idea to subtraction situations.

2. Rationale

It has been well documented that many young children make reversal errors when subtracting, that is, subtracting the top number from the bottom number when the top number is smaller. Since this error is often systematic, it might be due to a misunderstanding that subtraction is commutative. The study was designed to determine the extent to which children entering first grade with high, middle and low number skills apply and explain addition and subtraction exercises by using commutative ideas, both one year and two years after the second semester of first grade.

3. Research Design and Procedures

The subjects for this study were 14 trios of children selected from an original pool of 1200 students in a large urban school district. Each trio consisted of children of the same gender and all three were in the same classroom with the same teacher during first grade.

The 14 trios were each individually administered a number skill performance assessment when they entered first grade. The student of each trio with the highest score was assigned to the high number performance group (HNP). The student of each trio with the lowest score was assigned to the low number performance group (LNP). The other student in each trio was assigned to the intermediate number performance group (INP).

Each of the subjects was interviewed both one year and two years after the second half of the first-grade experience. Most of the children were in the second semester of second and third grades at these times; however, a few of them had been retained.

At each interview the children were presented several addition and subtraction combinations written on cards in vertical format and placed on six different task boards. The first four task boards each had two cards. They included simple addition, 6 + 3 and 3 + 6; difficult addition, 49 + 84 and 84 + 49; simple subtraction, 9 - 3 and 3 - 9; and difficult subtraction, 64 - 37 and 37 - 64. There were also some addition and subtraction problems that involved zero. The fifth task board included six cards with the problems 8 + 0, 29 + 0, 284 + 0 and 0 + 8, 0 + 29, 0 + 284 for addition and the sixth task board included six cards with the problems 8 - 0, 29 - 0, 284 - 0 and 0 - 8, 0 - 29, 0 - 284 for subtraction.

For each of the task boards without zero combinations, the student and the interviewer discussed how the pair of problems were alike and how they were different. Then the interviewer asked the student to answer the first problem of each of the pairs listed above. The card with this problem was then put through a function machine that showed the answer on the opposite side of the card. This either confirmed or corrected the student response. The students were then asked what they thought the answer would be if the card with the other problem were put through the function machine. They were also asked to explain their response.

For the task boards with zero combinations, the interviewer and the student discussed how the problems were alike, how they were different, and how the first three problems were different from the last three. Then the student was asked to answer the problem on one of the first three cards. That card was put through the function machine to check or correct the student response. The student was then asked to answer the other two problems on the first three cards. If a response was incorrect, that card was also put through the function machine. Finally, the students were asked what they thought the answers would be if the last three cards were put through the function machine. They were also asked to explain their answers. Students were given credit for a correct response to a problem of the form 0 - n if they indicated in some way that there is no answer. Zero was also considered a correct response because in all cases the explanations seemed to indicate that students were aware that a larger number was being subtracted from a smaller number and "apparently the zero was used for lack of a better symbol."

4. Findings

For the simple addition task board, all students in all three levels of number skill performance were able to correctly answer both 6 + 3 and 3 + 6 during both interviews. For the difficult addition task board, none of the students in any of the three levels of number skill performance were able to correctly answer 49 + 84 during the first interview. However, all but one student in the LNP group correctly answered the second problem on the task board, 84 + 49. During the second interview a few of the students were able to correctly answer 49 + 84 and all of them correctly answered 84 + 49. Once the correct answer to the first problem was either figured out or provided by the function machine, the students were able to use that information to answer the second problem. The explanations that were given were similar across all three levels of number skill performance and during both interviews. Typical responses were, "Because they are both the same numbers," or "Because they are the same numbers but in different ways."

For the simple subtraction task board, nearly all students during both interviews responded correctly to the problem 9 - 3 and nearly all students incorrectly answered 3 - 9. For the difficult subtraction task board, only a few students were able to correctly answer either problem, 64 - 37 or 37 - 64, during either interview. Exceptions for incorrect responses to the first problems were generally from the LNP group and exceptions for correct responses to second problems were generally from the HNP group. Students who gave incorrect responses to the second problems (3 - 9 and 37 - 64) generally thought the answers were 6 and 27, the correct answers to the corresponding first problems. Their rationale was, "Because they are the same numbers." The explanations given by students who correctly responded included, "Because nine is bigger than three," "It doesn't make sense," "Because if you had 37 things, you couldn't take 64 away."

For the addition task board with zero combinations, all but two responses were correct for all the problems during both interviews. About 30% of the students used a commutative argument to explain during both interviews, that is, 0 + 39 is the same as 39 + 0 "Because it's the same as the other card except the numbers are turned around." About 35% of the students used zero as an identity argument for their explanations during both interviews, that is, 0 + 8 is the same as 8 + 0 "Because zero doesn't add anything." The remaining students used these same arguments, but interchanged them for the two interviews. There were no differences among groups in the use of a particular rationale.

For the subtraction task board with zero combinations, the students correctly answered the first problems (8 - 0, 29 - 0 and 284 - 0) during both interviews with few exceptions. Also with only a few exceptions, the students incorrectly answered the second group of problems (0 - 8, 0 - 29 and 0 - 284) during both interviews. When asked to explain, 75% of those giving incorrect answers used zero as an identity argument. Only a few used a commutative explanation.

5. Interpretations

Students in all three levels of number skill performance were able to use commutative ideas to explain and answer both simple and difficult addition problems. However, the quality of their responses indicated they were "basing their rationales on surface features of the situation." They mentioned that the numbers were the same, but did not refer to the operation.

Students in all three groups misapplied the commutative idea to subtraction with little improvement from one interview to the next, one year later. Again their responses appeared to be based on surface characteristics of the situation. The students referred to the numbers but not the operation. The few students in the HNP group who did correctly respond to the commuted subtraction examples seemed to have a different quality in their responses. For example, for the problem 37 - 64, they discussed the numbers as wholes referring to 37 and 64. The other students often discussed parts of the problem like 7 - 4 and 3 - 6.

The tasks that included zero elicited different rationales. The students were far more likely use the identity characteristics of zero rather than commutative ideas to explain their answers.

The misapplication of commutative ideas to subtraction situations appears to be quite common. However, the students appear to have only a superficial understanding of commutativity. Since little development was evident from one interview to the next, it appears that "once a surface or syntactic procedure is in place it tends to be quite resistant to change." In order to avoid this minimal or surface understanding, "the idea of commutativity may well be a concept that should receive attention in early developmental instruction with whole-number addition and subtraction."

Children also need to consider the numbers in multi-digit addition and subtraction problems holistically. "Only after there is assurance that students see these as wholes, and have developed meaning for them as wholes, should there be a movement to the processing of the parts of the two numbers in the tens and ones place."

Abstractor's Comments

The selection procedures for the subjects in this study were not disclosed. Since there was an analysis based on three levels of number skill performance, how were these students selected? Random selection from each classroom would permit a student assigned to the LNP group from one classroom to have higher scores than a student from a different classroom who was assigned to the HNP group. Also, no indication of what high or low number skill performance meant was given. What were the items on the number skill performance assessment and how did they relate to the tasks in this study? The three levels of number skill performance add little if anything to this study. Even if there had been differences among the groups, the procedure for assigning students to these groups would not permit much generalization.

This study does indicate the extent to which young children are able to apply commutative ideas to solve addition problems. For example, although they generally were unable to correctly answer the problem 49 + 84, they nearly all were able to correctly answer the problem 84 + 49 after the answer to the first problem was given. The students obviously were able to use some commutative ideas to correctly answer the second problem. The researchers indicated that the children were responding on the basis of surface characteristics rather than on the basis of deep understanding of the operation and the properties of it. That appears to be a subjective judgment based on limited evidence. While the students did seem to refer to the numbers and not to the operation, further tasks seem to be needed to sort out the extent to which students understand commutativity of addition.

The study also indicates the extent to which young children incorrectly assume that the answer to n - m is the same as the answer to m - n. In the cases where neither number is zero, their explanations focused on the fact that the same numbers were involved. Is that because the children assume that subtraction is commutative or do they just not realize that the order of the symbols is important when writing subtraction problems? It might be the case that children would correctly indicate that taking nine things away from three things is not the same as taking three things away from nine things; however, they still might not realize that the order of the written symbols is important. If so, do they have a lack of semantic understanding of the commutative property as it applies to subtraction or do they simply not understand symbolic syntax? This study does not clearly provide evidence that the student responses are due to lack of understanding commutativity. Further information about the students' knowledge of symbolic syntax and how it relates to understanding of the commutative property is needed.

For the subtraction problems that involved a zero there appears to be a different factor of interest. Since about 75% of the students who gave incorrect responses to problems of the form 0 - n explained their responses by using a zero as an identity argument, does that provide evidence of the lack of understanding of commutativity as it relates to subtraction? Perhaps it indicates a lack of understanding of zero as an identity or a lack of knowledge about symbolic syntax.

The suggestions that are made about using a holistic approach to teaching addition and subtraction and the early consideration of the commutative property and how it relates to addition and subtraction are excellent suggestions for further research. These ideas seem reasonable, but much more evidence is needed before a rational decision can be made.

It should be noted that children who have been introduced to addition and subtraction using a part-part-whole concept tend to know that, in subtraction, you start with the whole and remove a part to get the other part. There is some evidence that these children have a better knowledge of symbolic syntax. Perhaps that would affect their answers and explanations for problems like those in this study.

Cobb, Paul. TWO CHILDREN'S ANTICIPATIONS, BELIEFS AND MOTIVATIONS. Educational Studies in Mathematics 16: 111-126; May 1985.

Abstract and comments prepared for I.M.E. by LINDA JENSEN SHEFFIELD, Northern Kentucky University, Highland Heights, Kentucky.

1. Purpose

The purpose was to discuss the relationships among anticipation, belief and motivation in young children's mathematical problem solving and to describe an increasingly general hierarchy of anticipations using examples from two case studies of children involved in a teaching experiment.

2. Rationale

Several theories and studies support "the need to consider children's beliefs about the nature of mathematics when attempting to make sense of their mathematical behavior" (p. 111). From a Piagetian cognitive viewpoint, from the analysis of scientific investigation, and from a metacognitive standpoint, beliefs seem to be related to problem-solving behaviors. Beliefs about mathematics appear to create certain expectations about the problems which will be encountered and the heuristics which should be used to solve those problems. These in turn could affect children's motivation, confidence, persistence, initiative and satisfaction in problem solving. This study uses examples of children's problem-solving behaviors and other theories to develop and support a proposed general hierarchy of anticipations.

3. Research ign and Procedures

Six childre re studied as part of a two-year teaching experiment. In this article, the problem-solving activities of two of the children are described as illustrations to support Cobb's conjectures about the relationships among anticipations, beliefs and motivations. The children were judged to have similar arithmetical concepts, but different beliefs about the activity of doing mathematics. Because of the topic of the paper, an analysis of the children's addition and subtraction concepts was not presented. One child believed "that doing mathematics involved constructing relationships between numbers," while the other child believed that mathematics is "an activity in which one finds unrelated rules for solving unrelated problems." The first child was described as focusing on means and the second child as focusing on ends. Both children were beginning first graders at the start of the study.

4. Findings

Focus on Means: Tyrone. Several protocols were described which illustrated that Tyrone actively searched for meaning when solving problems. This was then related to other problem-solving behaviors. For example, Tyrone frequently used a known sum or difference when attempting to find an unknown sum or difference. He was not content to stop at getting a correct answer. He wanted to know why answers were related. If he were unable to see a relationship, he often spontaneously used counting to solve a problem. His work was generally described as persistent and confident. He was described as task-involved, that is, interested in learning for its own sake and not for the sake of appearing smart. He judged his performance relative to earlier work and not relative to other children. He seemed to genuinely enjoy working with problems. He would initiate problems and ask the teacher to give him harder work. He viewed failure as a challenge, an opportunity for fresh insights.

Focus on Ends: Scenetra. Examples of protocols were given which showed that Scenetra was concerned only with getting the correct answer and not with understanding why an answer was correct. This was then related to several other problem-solving behaviors which were in direct contrast to the behaviors of Tyrone. Scenetra rarely used a previously found sum or difference. She was capable of using them, but she believed she was cheating or using an immature method if she relied on earlier work. She was insulted if the teacher asked her to refer to earlier problems; she believed each problem should be independent of any other. Scenetra was content to stop working on a problem when the teacher approved of her answer. She did not look for meaning behind the answers. She was often inflexible in her methods. If the first method did not work, she had difficulty understanding an alternative method suggested by the teacher. Her method often focused on superficial aspects of number names and counting sequences. She was not confident when working problems and rarely took the initiative in problem solving. She gave up easily when her usual methods did not work. Scenetra was described as ego-involved; that is, she was preoccupied with herself and a desire to appear smart or to avoid looking stupid. She viewed problems as a threat to her self-esteem. Failure led to self-doubt about her competence.

5. Interpretations

Cobb stated that "Scenetra's and Tyrone's case studies suggest that children's mathematical problem-solving behavior can be viewed as an expression of an increasingly general hierarchy of anticipations." He proposed that their beliefs about mathematics affect both their expectations about what could count as a problem and what are acceptable methods of solution. This in turn affected the children's flexibility and motivation. "Scenetra's ego-involvement was compatible with her focus on ends rather than means and her belief that mathematical knowledge was primarily instrumental in quality. Tyrone, a task-involved child, strove to achieve relational rather than instrumental understanding" (p. 124). This was also related to the children's construction of knowledge. During the last few months of the teaching experiment, Tyrone, the task-involved child, took only one month to construct certain concepts of tens, multiplication, and division which took Scenetra, the ego-involved child, three months to construct. It was proposed that this is because the construction of knowledge results from an attempt to make sense of experience, and a task-involved child would make faster progress at this than an ego-involved child.

Abstractor's Comments

The effects of children's belief systems on their mathematical problem-solving behaviors have been acknowledged and studied by the mathematics education community over the last ten to fifteen years. This study adds interesting new insights to that work.

Because the article reported only limited protocols from two of the six children involved in a teaching experiment, it is difficult to critique. The examples cited from the children's work do support the author's hierarchy of anticipations. The author also noted several examples from other education theories and research as well as from the fields of artificial intelligence and the philosophy of science which support his contention that the two children's behavior's may be generalized to wider populations. It is hoped that this will be the beginning of much more research along those lines. Other children should be identified who believe either that mathematics is a set of unrelated rules or that mathematics has an underlying structure. These children should then be interviewed to determine if the proposed hierarchy of beliefs holds true for them.

Because these children were part of a two-year teaching experiment, it is interesting to note that the children's beliefs do not seem to have changed over the course of the experiment. It appears as though Scenetra continued to believe that mathematics was a series of unrelated facts even after being led to solve several related problems. Cobb stated that the more global anticipations are the most stable, but any research on how to lead children to believe that mathematics has an underlying structure would be most useful to teachers. If these beliefs indeed have the implications for other problem-solving behaviors noted by Cobb, it would appear to be crucial for teachers to influence the beliefs.

Other protocols from the teaching experiment with Scenetra are described in an article by Steffe which looked at children's algorithms as schemes (1983). In this article, Scenetra is described as using an operative counting scheme which was planned in advance and personally constructed. Understanding of a unit of ten was used to extend her existing numerical scheme. This does not seem to fit with Cobb's contention that Scenetra relied on number word sequences rather than a real numerical significance (p. 114). Perhaps this would be clarified in a description of the children's addition and subtraction concepts.

Cobb stated that "problem solving involves making one's anticipations work" (p. 113). He quoted Knorr (1980) in saying that scientific investigations are prompted by unrealized solutions rather than hypotheses. Unrealized solutions are not tried against data but are made to work by the scientists who construct the results to fit the anticipated solutions. Perhaps Cobb's theory falls into the category of an unrealized solution rather than a hypothesis. The protocols he selected fit his theory very neatly. This is not to say that this is bad. However, more research is needed to confirm his hierarchy. This is a promising area of research, and educators can hope for more research to follow. Research which would help teachers identify children's beliefs and the corresponding problem-solving behaviors and research which would indicate teaching behaviors to fit or shape these beliefs and behaviors would be most helpful.

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Steffe, Leslie P. (May, 1983). CHILDREN'S ALGORITHMS AS SCHEMES. Educational Studies in Mathematics 14: 109-125.

Cooney, Thomas J. A BEGINNING TEACHER'S VIEW OF PROBLEM SOLVING. Journal for Research in Mathematics Education 16: 324-336; November 1985.

Abstract and comments prepared for I.M.E. by JOANNE ROSSI BECKER, San Jose State University.

1. Purpose

The main purpose of this study was to investigate a beginning mathematics teacher's beliefs about problem solving and to determine how they were affected by the first months of teaching and the reality of experiences in the classroom.

2. Rationale

As Cooney points out, numerous recent studies have focused on how students solve problems, but little research has focused on how teachers teach problem solving in the classroom or how they view its role in the curriculum.

The assumption is made that there is a potential conflict between the requirements of a problem-solving orientation in one's teaching and the abilities of a beginning teacher to structure such a classroom environment. A problem-solving orientation would imply an inquiry approach to instruction and a change in the typical teacher-centered classroom environment. However, teachers, particularly new ones, may not have the requisite skills to envision or cope with such a setting, even though their belief structure might encourage them to try. This research was designed to investigate this potential conflict through a study of one beginning teacher.

3. Research Design and Procedures

One teacher was selected for this study. He had exhibited strengths during his preservice education which led the author to classify him as intelligent and insightful.

Fred was interviewed seven times while he was enrolled in a master's degree program in mathematics education. He had enrolled right after receiving an undergraduate degree in cross-cultural communication. Hypothetical episodes were presented to Fred during these 45-minute interviews to elicit his beliefs about mathematics and its teaching.

Fred was asked to review transcripts of the first four interviews and to identify statements he felt best represented his beliefs. In the next interview he was asked to take his own statements, group them into categories of his choosing, and provide headings and descriptive statements for each cluster. A final interview focused on factors contributing to Fred's beliefs as identified in the earlier interviews.

A report based on the seven interviews was shared with Fred after he began his first teaching job. Then Fred was observed by two observers on nine consecutive days, using field research techniques. Additional interviews were conducted with Fred after the observations. Also, several students from Fred's classes were interviewed.

4. Findings

During his preservice experience, Fred described problem solving as the main purpose for teaching mathematics. His love of mathematics seemed tied to recreational problems and puzzles; he was less interested in real-world applications or the usefulness of mathematics in other fields. He expressed the desire to motivate his students through use of recreational problems and to avoid the typical mathematics class format.

However, observations the following school year revealed little problem solving taking place. His manner of conducting class was casual, but followed a typical routine of discussion of homework, explanation of new material, then seatwork. Fred said he had little time to deal with genuine problems; it was much easier to teach the book and leave out heuristics. He also found the students unmotivated even when he posed recreational problems for them. Only the more advanced students seemed to appreciate his puzzles. Fred seemed unable to accommodate his teaching style to less motivated students. And his use of problem solving was restricted to extracurriculum problems that were not integrated into the existing curriculum.

5. Interpretations

The author used the metaphor of missionary to describe Fred's concept of teaching. Fred is a person who enjoys mathematics and expects his students to do so as well. He sees his role as one of providing interesting beginnings of lessons to captivate the students, especially using recreational problems and puzzles. The fact that these did not interest most students was attributed by Fred to their lack of internal motivation. He was bringing the "word" to students, but they did not enthusiastically embrace it. This left Fred frustrated and unsure how to motivate the students.

Fred's notions of problem solving seem to represent a feature one adds on to the existing curriculum to make it more interesting, rather than an integral part of the curriculum, despite his rhetoric that problem solving forms the essence of mathematics. He found it time-consuming and difficult to create this add-on feature, and much easier to teach by the book when students did not respond positively.

At this stage in his first year of teaching, Fred showed a dualistic view of teaching. One either used an authoritarian approach, teaching by the book, or used recreational puzzles to motivate students.

Abstractor's Comments

The study is of special interest for two reasons: its methodology, and its attempt to focus on the conflict between a beginning teacher's idealism and the reality in the classroom.

The qualitative methodology used was designed to keep a check on the initial interpretation of the data by sharing findings with the subject. An innovative feature was to have the subject identify the key elements of his beliefs about mathematics and the teaching of mathematics from the transcripts and cluster them into general categories. One reservation I have concerning this feature is that the subject has, presumably, not had any experience analyzing qualitative data. In the one specific example below, the descriptive statement for the category does not seem to me to describe the clustered statements very well. A categorization is not, of course, unique, but I doubt if I would have grouped the five statements listed together.

"Verbatim statements clustered together:

* Math is essentially problem solving.
* To me, math is fun.
* Some parts of math may not have real-life applications, like art may not.
* That it's fun is enough justification for me to study and teach it.

* My adjectives to describe math are useful, logical, axiomatic, fun, hard.

Heading: DESCRIPTION OF MATHEMATICS

Descriptive statement: The principal activity of mathematics is solving problems" (Cooney, p. 327).

It seems in this, the only example given in the paper, that the subject in retrospect may have wanted stress put on that statement which is most impressive and more closely in concert with current thinking in mathematics education. How the accuracy of the informant's categorizations was checked, other than with Fred himself, is not discussed in the paper. Did anyone attend a parent open house and hear him describe his view of mathematics? Were any syllabi given to students which might have shed light on his beliefs? How did students describe his view of mathematics? It seems important to ask these questions because the conclusion of conflict between Fred's ideals and classroom reality depends on acceptance of his words, with little substantiation by other data.

In fact, it is not clear what Fred meant by problem solving in his initial interviews. Given the lack of evidence in his teaching of problem-solving behavior, and his claim later to have forgotten about teaching heuristics, it seems possible that Fred never really intended to pursue a problem-solving orientation in his teaching. That is, rather than his behavior being inconsistent with his voiced beliefs, as the author states, perhaps the subject did not really understand problem solving to mean what the researcher did. The author himself feels that Fred saw problem solving as an added feature, not an integral part of the curriculum.

Thus I interpret the main finding of the research to be the muddled thinking about problem solving on the part of a beginning teacher. I am not sure this study has shown an instance of conflict between idealistic beliefs and classroom reality, or a shift in priorities of a beginning teacher once she/he enters the classroom. Such a conflict may well exist. But I think this study more clearly points out the difficulty in communicating our objectives for teaching problem solving to preservice teachers. That crucial first step in understanding seems not to have been taken by this beginning teacher.

A further comment about the subject's level of involvement in the research: it is unclear how far this was carried once Fred was teaching and was observed by the researchers. Would Fred have described the inconsistency between his rhetoric and his behavior as the author did? Did Fred remain in a quasi-researcher role, or did he become more of a traditional subject? How did he view his level of involvement in the research? More importantly, how did the author view Fred's role? As we break new ground in research methodology, particularly qualitative, I would like to read research reports which discuss the methodological difficulties which may have arisen.

Finally, although I think subjects may form part of the research team and shift role, much as a participant-observer does, during the course of the research, I do think any such subjects must have some training in qualitative research methodologies.

Denvir, B. and Brown, M. UNDERSTANDING OF NUMBER CONCEPTS IN LOW ATTAINING 7-9 YEAR OLDS: PART I. DEVELOPMENT OF DESCRIPTIVE FRAMEWORK AND DIAGNOSTIC INSTRUMENT AND PART II. THE TEACHING STUDIES. Educational Studies in Mathematics 17: 15-36; February 1986 and 17: 143-164; May 1986.

Abstract and comments prepared for I.M.E. by JAMES M. MOSER, Wisconsin Department of Public Instruction.

1. Purpose

The major arms of the investigation were:

a. to find a framework for describing low attainers' acquisition of number concepts;
b. to develop a diagnostic instrument for assessing children's understanding of number; and
c. to design, carry out, and evaluate a remedial teaching program.

2. Rationale

The rationale developed as a result of both authors' involvement in the (British) School Council's project, "Low Attainers in Mathematics 5-16." Visits to a large number of schools demonstrated a need for diagnostic assessment linked to prescriptive teaching. This need was supported by a recent study showing that teachers are frequently unsuccessful in matching number tasks to the conceptual stages of six- and seven-year-olds.

3. Research Design and Procedures

Data in the assessment part of the study were gathered from individual interviews with children aged 7 to 9. Work was carried out in three stages:

a. The pilot study (five subjects) helped identify which skills it was appropriate to assess. This involved six interviews over a three-month period.

b. The main assessment study (seven subjects) extended and defined more precisely the skills to be assessed. Items to measure these skills were developed and refined. This involved six interviews over a three-month period.
c. The Diagnostic Assessment Interview (DAI) was tried out with 41 subjects.

Children's performance on the 47 skills tested by the DAI led to two basic outcomes:

a. The skills were grouped into levels defined by a particular range of facility so that every pupil who had succeeded in 2/3 of the skills at any level had also succeeded in 2/3 of the skills at every preceding level.
b. A descriptive framework suggesting a hierarchical ordering of the 47 skills was formulated.

The DAI was used to examine changes in performance of seven pupils (the same seven involved in the main assessment study) interviewed approximately every six months over a two-year period.

Two teaching studies were carried out:

a. A pilot study with the same seven pupils mentioned above. This lasted three months, occurring after the initial main assessment interviews, but mostly before the periodic administrations of the DAI. Each child was taught individually.
b. The main study involved twelve pupils. This also lasted three months and took place about one year after the pilot teaching study. Five pupils from one school and seven from another were taught in group settings.

The manner in which students were selected for these teaching studies is not described in the articles.

4. Findings

In the assessment part of the study, the authors found problem solving behaviors similar to those reported by American researchers Carpenter, Moser, Fuson, Steffe, and Resnick. Fairly primitive counting and modeling behaviors were exhibited with problems involving two-digit numbers, because it appeared place value concepts were not well developed in the subjects of the study. When the DAI was used longitudinally over a two-year period with the seven original subjects of the pilot study, it was found:

a. All children made progress, but it was very slow.
b. The match between each pupil's skill performance at each interview and the hierarchical framework was extremely good. Only three skills were at any time acquired "out of order."

Results for the teaching studies are given in two parts:

a. In the pilot study, all students "improved in performance." (No statistical evidence of significant improvement is presented.) Most of the taught skills were learned but some were not. The individual teaching of each student was not as successful as anticipated. Some subjects were shy and hesitant about responding.
b. In the main study, even though subjects were encouraged to focus on process and relationships, most conversations were between adult and child, only very rarely between two children. Yet, in the group instruction, the children were more relaxed than in the pilot study, were able to learn by watching other children, and were more eager to use physical materials, often responding to questions with actions rather than words. Children in the main study made, on the average, larger gains in the number of skills acquired than the children in the pilot study.

5. Interpretations

If one assumes that there is a developmental aspect to children's learning of numbers, useful prescriptive teaching arising from diagnostic assessment needs to take into account three different aspects of learning:

a. the orders in which children learn, i.e., a framework describing acquisition;
b. where each individual child is within the framework;
c. how the individual progresses from one skill to another, i.e., how individuals learn.

Based upon results from the two teaching studies, the authors conclude:

a. In order to learn, the child needs to engage with ideas in a manner and at a level which is meaningful.
b. While older children may perceive relationships which are not made explicit, the low attainer may need to engage in both practical activities and discussion which explicitly draw attention to such relationships.
c. The hierarchical framework can describe children's present knowledge and suggest which further skills they are most likely to acquire and thereby inform the design of teaching activities. However, it cannot predict which skills or how many skills each child will acquire, so the teaching should not be too prescriptive or rigid in its assumptions about what may be learned.
d. There appeared to be no relationship between a child's pre-test level on the hierarchy and the number of gains made. The best predictor of the number of gains made seemed to be the child's engagement with the given tasks and the degree to which the tasks were regarded as acceptable mathematical tasks.

Abstractor's Comments

Despite the overall length of the two combined articles, there is a dearth of really useful information. Other than age, there is no characterization of the subjects--in particular, what qualifies them as "low attainers?" No information is provided on the number of kinds of tasks used in the assessment instrument. This reviewer has some serious reservations about both the validity and reliability of the instrument. This is of particular concern since the instrument appeared to be the determining factor in the formulation of the hierarchical model. Finally, not a great deal is known about the actual teaching that took place during the teaching studies.

At the risk of sounding too negative, it should be pointed out that the results and conclusions are not too startling. They tend to confirm common knowledge about working with "low attainers," such knowledge coming from folklore and from classroom practice as well as empirical research.

On the positive side, the authors are to be commended for their interest in weaker students. All the world knows we have many such students around us. The more information we have to help us better serve these students, the better off we are.

Paul, Douglas J.; Nibbelink, William H.: and Hoover, Hiram D.
THE EFFECTS OF ADJUSTING READABILITY ON THE DIFFICULTY OF MATHEMATICS STORY PROBLEMS. Journal for Research in Mathematics Education 17: 163-171; May 1986.

Abstract and comments prepared for I.M.E. by SANDRA PRYOR CLARKSON, Hunter College of CUNY.

1. Purpose

Paul, Nibbelink, and Hoover explored the use of common formulas to determine readability levels of story problems. They asked whether altering the readability levels, as defined by these formulas, affected performance on problem solving.

2. Rationale

There has been some pressure by teachers for lowering the readability levels of text materials to help raise student performance on solving story problems. A critical review of the literature seemed to indicate that items used in studies in which it was found that lower readability in problems resulted in improved problem-solving performance may not have been controlled for other important variables that may have affected difficulty levels. This study attempted to better isolate readability level as a factor in problem-solving performance.

3. Research Design and Procedure

Fifteen computational problems were developed that were deemed representative of problems used in standardized tests and textbooks for grades 4 and 5. Each computational problem was given a verbal context and adjusted for three levels of readability using two different methods, vocabulary control (using Harris Jacobson formula 1 or 2) and sentence control (using the Dale-Chall or Spache Formulas). Tests included an equal number of high, medium, and low readability items. There were essentially six different forms of each problem. The items were distributed randomly according to computational method and then distributed in a balanced fashion according to readability levels so each test was deemed equally difficult.

The tests were given to 1238 students in grades 3, 4, 5, and 6 in seven Iowa schools.

4. Findings

A mixed fixed-effects four-way analysis of variance was used to analyze the data, with the factors being readability level, problem type, grade, and readability method. The following results were observed:

1. Students in the higher grades performed better.
2. Addition and subtraction problems were easier than multiplication, division, or multiple-step problems.
3. The interaction between grade and problem type was significant at the .01 level.

5. Interpretation

The authors found that "whether a story problem has a readability level a few grades below, at, or above grade level, there is no substantive effect of the student's ability to solve it." They found no results that indicate that formulas used to determine readability can separate problems into grade-appropriate levels.

Abstractor's Comments

I would like to comment on the readability level of the research article. Often I read research that is vague and abstract. This is neither. The problem is clearly stated; the literature search is clear, relevant, and justifies the research presented. The entire article was well written and interesting. Research like this can be read and understood by teachers of all levels. I think that research will become effective when we stop talking to ourselves and speak to the classroom teacher and the layman. This article does precisely that. I enjoyed doing this review.

Pedersen, Katherine; Elmore, Patricia; and Bleyer, Dorothy. PARENT ATTITUDES AND STUDENT CAREER INTERESTS IN JUNIOR HIGH SCHOOL. Journal for Research in Mathematics Education 17: 49-59; January 1986.

Abstract and cor nts prepared for I.M.E. By CLYDE A. WILES, Indiana University Northw.st, Gary.

1. Purpose

The purposes were two: 1) "to investigate parent attitudes and student career interests relative to their contribution to a theoretical model of mathematics achievement in junior high school;" (2) "to investigate the multivariate relationship between student attitudes and parent attitudes, between student attitudes and student career interests, and between parent attitudes and student career interests."

2. Rationale

The variables chosen for the models to be used to explain student achievement were selected on the basis of their importance in other studies of achievement correlates. At the junior high level, these included attitudes towards mathematics, spatial visualization ability, and sex. The variables identified as important at the senior high level did not include sex, but did include parents' attitudes, career interests, and participation in mathematics courses. The evidence for the importance of parent attitudes and student career interest was viewed as being inadequate. It was believed that this study "would contribute to an understanding of (a) the part that these variables play in explaining mathematics achievement in junior high school and (b) the relationship(s) among student attitudes, parent attitudes, and student career interests in junior high school."

3. Research Design and Procedures

The 974 seventh-grade and 1008 eighth-grade subjects were chosen from 13 small, Midwestern, rural junior high schools. Numbers of boys and girls involved in the study were about equal, and minorities in some schools were as high as 35% of the total enrollment. National norm percentiles on the standardized achievement test used by the various schools were taken as measures of student achievement. Spatial visualization ability was measured by a standard test, sex in the obvious way, student attitude by the nine-subscale test of Fennema and Sherman (1976), and parent attitudes by the "Math as a Male Domain Scale" and by adaptations of the "Mother Scale" or "Father Scale" of the Fennema and Sherman attitude test that the students took. Student career interests were measured by the Unisex ACT Interest Inventory (UNIACT) (American College Testing Program, 1977).

Student data were obtained by one of three teams who did on-site testing and reviewed school files. Parent data were obtained by sending forms home with the children, who then returned the completed instruments to the school; return rates by school were in excess of 85%.

The data were discussed in terms of six variables: 1) parent attitudes, 2) student career interests, 3) spatial visualization ability, 4) student attitudes, 5) sex, and 6) the "dependent variable", mathematics achievement. Variables 1, 2, and 4 were actually families of variables.

A regression analysis was done to determine the total amount of variance accounted for in the dependent variable by all five of the other variables. The five variables were then eliminated in turn from the model, and the reduction in R^2 resulting from the elimination of each was tested for significance. The two variables of particular interest, parent attitudes and student career interests, were then both dropped from the analysis, and again the reduction in R^2 was tested for significance.

Further analysis using canonical correlation analysis was done on three sets of variables. Student Attitudes were related to Parent Attitudes, Student Attitudes were related to Student Career Interests, and Student Career Interests were related to Parent Attitudes. Significant canonical variates were sought for each analysis.

4. Findings

The regression analysis showed that the only reduction in R^2 not found to be significant was the reduction resulting from dropping the variable sex from the analysis. The variance accounted for by parent attitudes and student career interests, apart from the variance already accounted for by sex, student attitudes, and spatial visualization ability was also significant. The authors report their belief that variance resulting from the variable sex was hidden within that of the other variables; they do not believe that this variable is a non-predictor of student achievement.

The order of the variables in terms of the greatest reduction of the total R^2 variance was: spatial visualization (.093), student attitudes (.092), parent attitudes and student career interest taken together (.021), student career interest (.010), parent attitudes (.010), and sex (.000). The total R^2 variance accounted for by all the variables was .375.

Three canonical variates were found for each of the first two sets of variables, but only one was found for the third set. The interpretations given to the canonical variates were as follows:

I. student attitudes vs. parent attitudes:

1st: a student self-concept factor within parent attitudes.
2nd: a judgmental factor on sex-typing of mathematics
3rd: a father's-influence factor

II. student attitudes vs. student career interests:

1st: student attitudes and careers in science, services, and business

2nd: high male math-domain implies low interest in business and technology

3rd: high math anxiety correlates with interests in arts and technology

III. student career interests vs. parent attitudes

1st: student interests in science and business correlates with parents' perceptions of child as a learner of mathematics.

5. Interpretations

Both parent attitudes and student career interests of junior high students make a significant contribution to the variance of mathematics achievement over and above that accounted for by other variables commonly used for prediction. Questions remain about how these variables are related to those at the senior high level and to participation in mathematics courses at the senior high school level.

It was believed that an understanding of the relationships between student attitudes and parent attitudes requires that attention to relationships among students' self-concept, sex-typing of mathematics, and a father's-influence factor. The other canonical variates and possible relationships of parents' and students' attitudes with student career interests need further study.

Abstractor's Comments

The study was carried out and reported in a disciplined manner. The attempt to relate this study with other studies of prediction of achievement was articulated well. An understanding of the meaning of this study is facilitated by the use of familiar instrumentation. The findings do support the plausibility of student career interest and parent attitudes as having important effects upon a junior high school student's achievement in mathematics.

The use of percentiles as the measure of student achievement presents some problems. But, as noted by the authors, the effect is thought to be the weakening of the power of the tests to discover relationships. I expect a relatively large measurement error in measuring achievement in this fashion that also works against the purposes of the authors.

The choice of independent variables was a bit arbitrary from my view. How can we neglect measures of ability other than spatial visualization when we are looking for known correlates of mathematics achievement? The fact that the entire set of variables accounts for something less than 40% of the total variance calls into question the adequacy of this selection of predictor variables. This selection of independent variables seems to be better suited on the face of it for researching differential expectations for boys and girls rather than for general prediction of achievement in mathematics. Several comments throughout the report suggest that this is a major concern of the authors. If it is, I wonder how they relate what they found to this concern.

The representativeness of the sample is a worry. The attitudes and expectations of junior high students in small rural communities, presumably in Southern Illinois, may be thought to be more than a little special. I at least would expect both their attitudes and those of their parents to be of the most traditional variety. If we were ever to find the variable of gender to be differently related to attitude, I would expect it to be here. While the authors do make a case that sex differences are "nested within" the other variables, I suppose that the argument is as valid for predicting a nesting of career interests or parent attitudes within the other variables. But, this was not the case. In fact, the joint reduction in R^2 for parent attitudes and student career interests taken together is about what one would expect if the two sets were independent of each other (which, incidently, the canonical analysis shows they surely were not).

Maybe all this is related to my concerns about statistical power, significance, and importance. The size of the population (about 2,000 observations) produces a great deal of statistical power against any null hypothesis. A measure of this is that a reduction of .010 in R^2 is significant beyond the .001 level. However, this reduction is only about 1% of the total variance. While the authors refer to this difference as a substantial contribution, and it is a statistically significant contribution, I have strong doubts about its real importance.

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Fennema, E., and Sherman, J. (1976). Fennema-Sherman mathematics attitude scales. Psychological Documents, 6 (2), 31, (Ms. No. 1225).

American College Testing Program. (1977). Unisex ACT Interest Inventory. Iowa City, IA; Author.

Peterson, Penelope L. and Fennema, Elizabeth. EFFECTIVE TEACHING, STUDENT ENGAGEMENT IN CLASSROOM ACTIVITIES, AND SEX-RELATED DIFFERENCES IN LEARNING MATHEMATICS. American Educational Research Journal 22: 309-335; Fall 1985.

Abstract and comments prepared for I.M.E. by RUTH ANN MEYER, Western Michigan University.

1. Purpose

The purpose of this study was to identify classroom activities that were related to the low cognitive level and high cognitive level mathematics achievement of boys and girls. The investigators were especially interested in whether these activities differed for boys and girls.

2. Rationale

Although research has identified variables associated with sex-related differences in mathematics (Fox, 1981), little is known about teacher and classroom activities that contribute to these differences. This study focused on identifying some of these activities. It also investigated the effect of participation in classroom activities on high cognitive level and low cognitive level achievement of boys and girls.

3. Research Design and Procedures

Four questions were investigated:

1. Do fourth-grade girls and boys differ significantly in mathematics achievement on low level and high level items, and do they differ significantly in their achievement gains over a six-month period?

2. Do fourth-grade boys and girls differ significantly in the percentage of time that they are engaged in various types of activities during mathematics class?
3. Do significant relationships exist between the type of mathematics classroom activity in which girls and boys are engaged and their low level and high level achievement, and do these relationships differ significantly for boys and girls?
4. Are there significant sex-related differences in engagement in classroom activities between classes that show low level and high level mathematics achievement gains that are greater for boys than girls, greater for girls than boys, and do not differ for boys and girls?

Fourth-grade teachers and their 36 classes participated in the study. A pretest and a posttest, each consisting of 14 low level (LL) and 14 high level (HL) mathematics items from the National Assessment of Educational Progress, were administered to the students. Between administrations of the pretest and posttest, trained observers, using an engaged time observation instrument, observed for three weeks the engagement/nonengagement in mathematics activities of six randomly selected students of each sex in each class.

To analyze the data, means and standard deviations of the target girls' and boys' pretest and posttest mathematics achievement scores and residualized gain scores were computed. Analyses were run separately for the subtest scores on the LL and HL items. Means and standard deviations of the scores on the engaged-time observations were also computed. These two sets of data were used to investigate questions one and two.

To examine the relationship between girls' and boys' engagement in classroom activities and their mathematics achievement on LL and HL items, partial correlations between scores on engaged-time observation categories and posttest mathematics achievement, controlling for pretest mathematics achievement, were computed.

To investigate the fourth question, two scatterplots, one for LL achievement gains and another for HL achievement gains, were constructed. For each plot, the averaged residualized achievement gain for girls in each class was plotted against the averaged residualized achievement gain for boys. Three groups were identified for each scatterplot. One group consisted of classes in which girls clearly achieved greater gains than boys. The second group consisted of the classes in which boys definitely achieved greater gains than girls. No difference classes constituted the third group.

The means on the engaged-time observation categories for each of the three groups of classes and for girls and boys within each group were computed. The investigators did three pairwise comparisons for groups using Tukey's HSD method, based on a familywise alpha of .05, and three additional pairwise comparisons using Tukey's method to test the Sex X Group interaction.

4. Findings

Boys and girls did not differ significantly in their mathematics achievement on pretest or posttest or in their residualized gain in mathematics achievement. Neither did boys and girls differ in the percentage of times they were engaged in various activities during mathematics classes.

There were several significant partial correlations between scores on engaged-time observation categories and posttest mathematics achievement controlling for pretest achievement. Table 1 contains the correlations which differed significantly from zero at $p < .05$.

Table I

Significant Partial Correlations Between Scores on Engaged-Time Observation Categories and Posttest Mathematics Achievement Controlling for Pretest Mathematics Achievement (N = 36 Classes)

Engaged-time observation category	Math Achievement Lower Level		Math Achievement High Level	
	Girls	Boys	Girls	Boys
Expected activity: Social	-.30	-.38	-.43	
Setting of Activity				
Small group-Different sex			.41	
Teacher-student	-.53[a]			-.34
Engaged in mathematics		.34	.31	.30
Math-symbolic		.29		
Being helped by teacher		-.35		
No helping		.37	.32	.30
Competitive	-.40[a]			
Neither competitive nor cooperative		.30	.30	.29
Nonengaged in mathematics		-.35	-.30	-.30
Social	-.37	-.41	-.34	
Waiting for help			-.30[a]	
Off-task		-.34		-.32

[a]Girls and boys differently significantly on this category. ($p < .05$)

For the LL achievement gain groups, the Engaged-time categories, Engaged in mathematics: no helping by teacher or other student and Competitive were significant in favor of boys.

For the HL achievement gain groups, the significant Engaged-time categories were

Expected activity: Social

Setting of activity: Teacher-student alone

Engaged in mathematics: No helping by teacher or other student
Neither competitive nor cooperative

Nonengaged in mathematics: Social
Waiting for help
Off-task

5. <u>Interpretations</u>

The results of the study showed that student engagement and nonengagement in mathematics activities in the classroom are related to mathematics achievement. They also demonstrated that engagement in competitive mathematics activities was significantly negatively related to the LL mathematics achievement of girls and slightly positively related to the LL mathematics achievement of boys. The authors suggested that the boys of the study may have benefitted from the "Around the World" game which was often played in the classrooms, whereas girls' LL mathematics achievement may have been debilitated by participation in this competitive game. It appeared that the girls benefitted more from cooperative activities. Nevertheless, the most positive correlations were found for engagement in mathematics achievement that was neither competitive nor cooperative. According to the authors, their findings suggest that using mathematics activities that are neither competitive nor cooperative may be the best way to teach mathematics.

The findings for off-task behaviour and social activities suggested to the authors that to maximize boys' mathematics achievement, the teacher's task might be one of control and minimizing off-task behaviour. To maximize girls' mathematics achievement, the important task for the teacher might be to minimize the amount of time that is spent during mathematics class on activities where the topic is a social or a personal one.

Abstractor's Comments

Overall the study was carefully done. Much time and energy obviously went into conducting it. This research will contribute significantly to the literature on sex-related differences in mathematics. Implications of the results provide insights into some classroom activities that may have different influences on girls' and boys' learning in mathematics.

Although the design was well-conceived, I would like to comment on one of its components. I personally think that tables could have been used more effectively than scatterplots to identify Boy Gain, Girl Gain, and No Difference Mathematics Achievement Groups.

References

Fox, L. H. (1981). "The problem of women and mathematics." New York: Ford Foundation.

Schunk, Dale H. and Cox, Paula D. STRATEGY TRAINING AND ATTRIBUTIONAL FEEDBACK WITH LEARNING DISABLED STUDENTS. Journal of Educational Psychology 78: 201-209; June 1986.

Abstract and comments prepared for I.M.E. by DOUGLAS EDGE, University of Western Ontario.

1. Purpose

There were two stated purposes: to determine how verbalization during cognitive-skill learning and how sequence of effort-attributional feedback influenced students' self-efficacy and skills.

2. Rationale

Self-efficacy, defined as "one's perceived performance capabilities in a given activity," is believed to influence a range of behaviors such as choice of activities, effort expended, persistence, and task accomplishments (p. 201). Learning disabled students when faced with difficult tasks often are inattentive and appear lazy. It is possible that these behaviors are observed in part because these students believe that they cannot be successful with the specific task. Hence strategies which promote student self-efficacy may ultimately result in improved performance.

One strategy that may assist students involves verbalizing aloud while completing examples or working on problems. This verbalization may facilitate learning as it helps focus attention on key aspects of the task at hand. Further, students often associate their successes and failures with certain attributes: ability, effort, task difficulty, and luck (p. 202). One of these, effort, is under the control of the student. Linking effort feedback with school success, especially with learning disabled students, should promote the students' self-efficacy and skills.

Two hypotheses result: (1) Either of two verbalization conditions (verbalization across all sessions or verbalization across the first half of the sessions only) would develop higher self-efficacy and skills than that of a third condition of no verbalization. (2) Either of two effort-providing feedback conditions (feedback during the first half of the sessions only or feedback across the second half of the sessions only) would promote higher self-efficacy and skills than that of the condition of no effort feedback.

3. Research Design and Procedures

Ninety students (51 boys, 39 girls; grades 6 through 8; aged 11 years 2 months to 16 years 2 months) participated in the study. All students were classified following state guidelines as learning disabled in mathematics. They were selected for the study from a group of students identified by their teachers as having difficulty learning subtraction with regrouping.

This study had three stages: pretest, treatment sessions, and posttest. The pretest consisted of an attributions measure as well as the self-efficacy and subtraction skills measures. The attributions measure comprised four scales, each ranged in 10-unit intervals from 0-100. The four scales were labelled "good at it" (ability), "worked hard" (effort), "easy problems" (task), and "lucky" (luck). From previous research with this measure, the test-retest reliability coefficient was 0.80. To complete this attributions measure the students were asked to imagine a situation when they did well (achieved a high score) on a mathematics test and to "suppose why that might happen."

The self-efficacy assessment was accomplished by showing students 25 pairs of subtraction problems for 2 seconds each. The students were shown one pair at a time and asked to make a judgment as to how well they thought they could solve that problem and to record their belief on a scale ranged in 10-unit intervals from 10 to 100. The test-retest reliability coefficient was 0.82.

The subtraction skill test contained 25 questions, one each on separate sheets of paper. Students answered one at a time. Their score was the total number of correctly solved examples. The examples all focused on regrouping: "regrouping once, regrouping caused by a zero, regrouping twice, regrouping from one, and regrouping across zeros" (p. 203).

Following the pretest, the students were assigned randomly (within gender and school) to one of nine groups based on a 3 X 3 crossed factorial experimental design (Verbalization: continuous, discontinuous, or none X Effort Feedback: first half, second half, or none). The training sessions (45 minutes each on 6 consecutive days) were conducted by proctors from outside the school. The subtraction training program for each of the nine groups all followed the same format. The only differences in presentation were to accommodate the appropriate verbalization instructions (if applicable).

During the continuous-verbalization condition sessions the students were asked to think out loud: "say out loud what you're thinking about, just like I did while I was solving problems" (p. 204). At the beginning of each subsequent session students were reminded to think out loud. For the discontinued-verbalization condition, students at the start of the fourth session were asked to solve their problems without talking out loud although "I'm sure you'll be thinking and working just like before" (p. 204).

With respect to the effort-feedback treatment, all students received monitoring by their proctor while they were individually solving their examples. During each of the sessions, approximately every 6 or 7 minutes, for a total of five times, the proctor noted the performance of each of her students. The proctor asked each student what page he or she was working on. After the student response, the proctor then answered with the appropriate treatment response. With the students in the first-half-effort feedback groups, the proctor responded with "You've been working hard." During the last three sessions performance feedback such as "That's fine", rather than effort feedback, was provided. For the students in the second-half-effort-feedback groups, performance feedback only was given during the first three sessions; effort feedback was provided during the latter three sessions.

The posttest was more or less identical to the pretest. The attribution measures were assessed immediately after the last training session. The self-efficacy and subtraction skill measures were taken on the following day.

4. Findings

Preliminary analysis: There were no significant between-condition differences on any pretest or subject measure.

Self-efficacy and skill: All three verbalization and all three effort conditions made significant improvements from pretest to posttest in both self-efficacy and subtraction skill. Using corresponding pretest measures as covariates, posttest self-efficacy and skill were analyzed with a 3 X 3 (Verbalization X Effort Feedback) multivariate analysis of covariance (p. 205). The MANCOVA yielded two significant main effects--for verbalization, Wilk's lambda = .642, $F(4,156) = 9.69$, $p < .001$, and for effort feedback, Wilk's lambda = .740, $F(4,156) = 6.34$, $p < .001$.

Planned comparisons for the posttest self-efficacy measure showed the following: verbalization conditions led to higher self-efficacy than no-verbalization condition, $t(80) = 2.46$. $p < .05$; continuous verbalization led to higher self-efficacy than discontinued verbalization, $t(80) = 4.11$, $p < .01$ (p. 206).

For the posttest skill measure, the planned comparisons indicated similar conclusions: the verbalization conditions had higher subtraction performance than the no-verbalization condition, $t(80) = 3.37$, $p < .01$; continuous verbalization promoted skill more than the discontinuous verbalization, $t(80) = 4.81$, $p < .01$; and effort feedback increased skill measures more than no feedback, $t(80) = 5.14$, $p < .01$ (p. 206).

Attributions: With pretest attributions as covariates, the four posttest attributions were analyzed with a MANCOVA. A main effect for effort feedback resulted; Wilk's lambda = .746, $p\ (8, 148) = 2.92$, $p < .01$. The verbalization main effect was non-significant. From the planned comparisons applied to the posttest measure of effort attributions, two conclusions were that providing effort feedback results in higher effort attributions than not providing feedback, $t(80) = 4.15$, $p < .01$, and that students who received feedback during the first half of their training sessions believe effort is more important to their success than did students who received the feedback during the second half of the training, $t(80) = 2.68$, $p < .01$ (p. 206).

Training performance: From analyzing the number of problems completed, comparisons indicated that higher performance resulted from the verbalization conditions rather than the no-verbalization condition, $t(81) = 2.61$, $p < .05$; and, similarly, more rapid problem solving resulted from the students who received the effort feedback than from those who didn't, $t(81) = 2.74$, $p < .01$. These results were not obtained at the expense of accuracy (p. 206).

Correlational analysis: From the product-moment correlations computed among posttest self-efficacy, skill, and the four attribution measures, self-efficacy was found to be positively related to skill, ability and effort attributions, and training performance. Skill was positively related to ability and effort attributions and with training performance.

5. Interpretations

Overt verbalization was found to facilitate task performance, self-efficacy, and skills. A comparison between the two verbalization conditions showed that the continuous verbalization condition resulted in a higher achievement outcome than did the discontinuous condition. This was contrary to an original prediction. It was thought that with the overt verbalization strategy instilled, further verbalization could be discontinued without any decreases in performance. It was expected that students could shift this strategy to a covert level. This did not happen. It is possible that students reverted to some other, better known or seemingly more useful, strategy. Or, simply, the students may have chosen to abandon the think-aloud strategy when it was no longer required.

This study also found that providing students with effort feedback resulted in their having higher self-efficacy and subtraction skills. The comparison between the two effort-feedback conditions revealed that there was no difference between the two conditions. This was somewhat surprising in that it was felt that providing early effort feedback would be viewed as credible by students whereas providing later effort feedback might lead students to question their capabilities, wondering why they still had to work so hard to succeed (p. 207).

Several implications for teaching result: Verbalizing aloud while solving problems and receiving feedback linked to successful problem solving benefited learning disabled students who were deficient in subtraction skills (p. 208). Other questions result. Could this overt verbalization be faded to a covert level? Might ability-feedback also improve students' self-efficacy?

Abstractor's Comments

The reporting of this study is exemplary. The article is well crafted. The writing is clear and concise. Purposes, rationale, methodology and so on are all appropriately described.

Still, there are concerns which have to do with the study itself. For example, although very detailed information is supplied by the authors to convince the reader that the students involved in the study were learning disabled in mathematics, the authors report that the students selected were chosen by mathematics teachers who reported that these "were students who had encountered difficulties learning subtraction with regrouping skills" (p. 202). Presumably these students would have been taught this topic several times before, over at least a three-year period. Some may have had instruction that included manipulation of concrete materials. Others may have had experiences where they were asked to explain how or why the algorithm works the way it does. It is possible that most of these students were now ready to have algorithmic, consolidation-oriented instruction. However, it is also possible that in other samples "students having difficulty learning subtraction with regrouping" may have had very different subtraction experiences and hence would respond quite differently.

Further, the value of the generalization concerning the usefulness of the think aloud and effort feedback procedures may be related to what extent the topic was being retaught compared to its being fairly recently taught. Hence knowledge of the topic-specific background of the students is critical. It affects how one views other concerns such as the generalizability of this topic to other topics in mathematics, the appropriateness of the duration of this study, and/or the relevancy of the training strategy adopted.

As a final comment, the authors routinely describe the work assigned to the students as problems to be solved. This study has little to do with problem solving. The students were asked to develop algorithmic skill. Think aloud techniques may be very helpful in skill-oriented work; it is not clear whether such techniques would be helpful in situations requiring problem solving.

Stevenson, Harold W.; Lee, Shin-Ying; and Stigler, James W.
MATHEMATICS ACHIEVEMENT OF CHINESE, JAPANESE, AND AMERICAN CHILDREN.
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Abstract and comments prepared for I.M.E. by HAROLD L. SCHOEN,
University of Iowa.

1. Purpose

The authors conducted a large-scale study to determine why American elementary school children lag behind children in China and Japan in reading and mathematics as early as kindergarten and continue to perform less effectively during the years of elementary school. This article reports and discusses the results from that study which concern achievement in mathematics.

2. Rationale

Poor scholastic performance by American children compared to children of other countries has focused attention on improving secondary school mathematics and science education. Yet the problems arise as early as kindergarten, suggesting that more must be involved than inadequate formal educational practices. Furthermore, the concentration of remedial efforts on secondary schools may come too late in the academic careers of most students to be effective. Research efforts are needed to better understand the bases for the poor performance of young American children and to insure that remediation programs proceed in fruitful directions.

3. Research Design and Procedures

The Minneapolis metropolitan area was chosen for the study since it was a large city with a good mix of cultural backgrounds but without the complicating problems of multiple languages and major economic disadvantage often found in large urban settings. If educational problems were found in Minneapolis, they would probably be compounded in other American cities. The cities chosen to be most comparable to Minneapolis in the other two countries were Sendai, Japan, and Taipei, Taiwan (China). Ten schools from each city were selected to provide a representative sample of the city's elementary schools. Two first-grade and two fifth-grade classrooms were randomly chosen from each of these classrooms, resulting in a sample of 240 first-graders and 240 fifth-graders from each city. In addition, a random sample of 288 kindergarten children was chosen from 24 representative kindergarten classrooms in each city.

A team of bilingual researchers from each of the three countries constructed tests and other research instruments with the aim of eliminating as much as possible any cultural bias. Mathematics tests were based on the content of the textbooks used in the three cities. The tests included items assessing computational skills, understanding of basic concepts, and application of mathematical principles to story problems. Tests were administered to one child at a time six months after the beginning of the school year. Reading achievement and cognitive abilities tests were also administered. Further data were gathered concerning the learning environments in the classrooms (from 1200 to 1600 hours of classroom observations), amount of homework, and attitudes and beliefs about schools and learning of the students, teachers, and parents.

4. Findings

The American children's mathematics scores were lower than those of the Japanese children in kindergarten and grades 1 and 5, and lower than those of the Chinese children's at grades 1 and 5. The Japanese children's performance was consistently superior and the Chinese children improved rapidly from kindergarten through fifth grade, while the scores of the American children displayed a consistent decline relative to those of the other two countries. While there was a high degree of overlap in the distribution of scores for first-grade classrooms in the three cities, by fifth grade the highest average score of an American classroom was below that of the Japanese classroom with the lowest average score. Another measure of the poor performance of American fifth-graders is that of the 100 highest fifth-grade scorers, only one was American. On the other hand, among the fifth-graders receiving the 100 lowest scores there were 67 Americans.

On the reading and cognitive abilities tests, the Americans compared well with the other children. Average reading scores for the American children consistently were in the middle, below those of the Chinese but above those of the Japanese. On many of the cognitive abilities tasks, American children obtained the highest scores during kindergarten and first grade, and by the fifth grade there was no overall difference in the total cognitive ability scores received by the children in the three cities.

Life in the American classrooms, especially by fifth grade, was very different from that in China and Japan. For example, fifth-grade American Children spent 64.5 percent of their classroom time in academic activities, Chinese children spent 91.5 percent, and Japanese children, 87.4 percent. Taking into account the longer school week in China and Japan, American fifth graders spend an estimated 19.6 hours per week in academic activities, less than half of the 44.1 hours spent by Chinese children and not much more than half of the 32.6 hours spent by Japanese children. Furthermore, about 40 percent of time in American fifth-grade classes was spent on language arts compared to 17 percent on mathematics, and these times varied tremendously from classroom to classroom. In China and Japan, about 25 percent of class time each was spent on mathematics and language arts, and there was relatively little variability between classes. A third important difference was that in the Asian fifth-grade classrooms the children were led by the teacher, with the teacher imparting information, much more than in American classrooms (nearly 90 percent of the time in Taipei, more than

70 percent of the time in Sendai, and less than half of the time in Minneapolis). It was also noted that on 18.4 percent of the visits to the American classrooms, at least one student who was known to be at school was not present in the classroom. This almost never happened in the Asian schools.

Time spent on homework differed by country more at fifth grade than at the other levels, and these differences are summarized here. Estimates made by mothers of the children indicate that American children spend much less time on homework (about 46 minutes per weekday and 18 minutes on weekends) than the Chinese (114 minutes per weekday and 156 minutes on weekends) and the Japanese (57 minutes per weekday and 66 minutes per weekend). Consistent with these results, American teachers rated the importance of homework at 4.4 on a 9.0 point scale, Chinese teachers rated it at 7.3, and Japanese teachers, at 5.8. Another interesting result is that regardless of the amount of time devoted to homework, 70 to 80 percent of mothers in all three countries thought that the amount of homework their children were assigned was "just right." In spite of more demanding homework assignments in their schools, over 60 percent of the Chinese fifth graders chose a smiling or neutral face to express their attitude toward homework compared to about 15 percent of the American fifth graders. Sixty percent of the American fifth graders chose a frowning face.

The preceding rather negative findings notwithstanding, American parents rate the job that their children's school is doing much more positively than parents in the Asian countries do, and they also express much greater satisfaction with their child's academic performance. Another variable on which there is a marked difference by country is the parents' ratings of factors contributing to their children's academic success. More often than American parents, Asian parents rate effort as the most important factor, while American parents are more likely than Asian parents to attribute academic success to the child's innate ability.

The American teachers frequently complained of having too many nonacademic functions and too little time for teaching. Classroom observations tended to lend support to the teachers' arguments. Even though American and Asian teachers spend about the same number of hours per week teaching (28 - 30 hours), teachers in the Asian countries have more time in school to prepare and do academic work. The Chinese teachers are in school 47 hours and the Japanese teachers, 51 hours compared to 42 hours per week for the American teachers. Such problems for the American teachers are not due to larger class sizes, for the average class size was 21 in Minneapolis, 39 in Sendai, and 47 in Taipei.

5. Interpretations

The findings presented in this article are directly in line with those from national studies of mathematics achievement of older children such as the Second International Mathematics Study. The relatively poor performance of American children that begins in kindergarten is maintained through the later grades. The lack of time spent teaching mathematics in the elementary schools may be a reflection of the view of American parents and teachers that education in elementary school is synonymous with learning to read. While it may seem clear to many that a plan to remediate this situation is needed, impetus for change comes from widespread dissatisfaction with the present state of affairs. At present, parents and elementary school teachers fail to perceive that American elementary school children are performing ineffectively in mathematics and that there is a need for improvement. If an effective plan to improve American students' performance in mathematics is to be mounted, it must be designed with an awareness of the importance of the elementary school years. Furthermore, its success will depend not only on improving schools but also on developing a greater awareness and an increased willingness by American parents to be of direct assistance to their children.

Abstractor's Comments

The study reported in this article adds to our understanding of American children's consistently poor mathematics achievement when compared to children of many other countries, including China and Japan. The record of mathematical achievement of eighth- and twelfth-grade children in Japan, in particular, was well documented in the Second International Mathematics Study, and this article provides evidence that younger Japanese children are also more mathematically able than their American age peers. Evidence from this study also challenges the myth that the hard work and high standards required of Chinese and Japanese children causes them a great deal of stress and unhappiness. On the contrary, these children's attitudes about school and about homework are far more positive than those of American children. Chinese and Japanese teachers also have fewer complaints than American teachers about the conditions of their jobs, in spite of longer work weeks and class sizes nearly double those in American schools.

Some have argued that countries like Japan have sacrificed creativity for an undue emphasis on test performance. The Ministry of Education in Japan shares that concern, and it is often pointed out in support of this position that there have been few exceptionally creative Japanese mathematicians. However, one eminent American mathematician whom I asked disagreed, noting that there are many outstanding Japanese mathematicians. In his opinion, Japan has become surprisingly successful in mathematics considering the short time the nation has been involved in this historically western discipline. Furthermore, the level of mathematical knowledge of the average Japanese citizen is superior to that of the average American. This is evidenced by the fact that newspapers and popular magazines in Japan routinely include subject matter of a more mathematical nature than is possible in America (Taylor, 1983).

If a research and development project in this country reported such amazing success and the skeptics who would naturally arise could be quieted, educators would be scrambling to adopt the methods and materials. The curriculum and teaching methods of Japan and China will not be transportable intact into our culture, but they deserve the careful study they are beginning to receive. Like American businessmen, American educators can no longer afford to ignore practices that are successful in other parts of this global village.

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