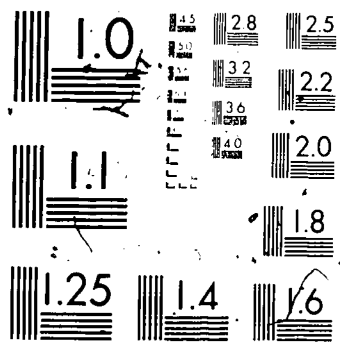

MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

DOCUMENT RESUME

ED 168 852 SE 026 930

AUTHOR	Proudfit, Linda
TITLE	Mathematical Problem Solving Project Technical Report V: The Development of a Process Evaluation Instrument. Final Report.
INSTITUTION	Indiana Univ., Bloomington. Mathematics Education Development Center.
SPONS AGENCY	National Science Foundation, Washington, D.C.
PUB DATE	May 77
GRANT	NSF-PES-74-15045
NOTE	23p.; For related documents, see SE 026 911-934
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	Elementary Education; *Elementary School Mathematics; *Evaluation; *Mathematics Education; *Problem Solving; *Tests; *Thought Processes
IDENTIFIERS	*Mathematical Problem Solving Project

ABSTRACT

The efforts of the Mathematical Problem Solving Project, MPSP, to develop a paper-and-pencil instrument which could be used to assess processes used by children in attempting to solve nonroutine mathematical problems is described. A brief review of related literature is given and the development of the first and second instruments described. Details of the administration of the two instruments and the analyses of the results are given. (MP)

MATHEMATICAL PROBLEM SOLVING PROJECT

MPSP

A Project of the
MATHEMATICS EDUCATION DEVELOPMENT CENTER

Project Supported by
National Science Foundation Grant PES74-15045

MATHEMATICAL PROBLEM SOLVING PROJECT

POLICY BOARD

George Immerzeel
Donald R. Kerr, Jr.*
John F. LeBlanc, *project director*
George Springer, *co-principal investigator*
Maynard Thompson
David W. Wells*

* *acting co-directors, 1975-76*

ADVISORY BOARD

Robert P. Dilworth, *California Institute of Technology*
James F. Gray, *St. Mary's University*
John L. Kelley, *University of California at Berkeley*
Jeremy Kilpatrick, *Teachers College, Columbia University*
Eugene D. Nichols, *Florida State University*

UNIVERSITY OF NORTHERN IOWA CENTER
Cedar Falls, Iowa

George Immerzeel, *center director*
Joan E. Duea
Earl G. Ockenga
John E. Tarr
Jack D. Wilkinson

INDIANA UNIVERSITY CENTER
Bloomington, Indiana

John F. LeBlanc, *center director*
Marilyn Hall Jacobson
Donald R. Kerr, Jr.**
Frank K. Lester, Jr.
George Springer
Arthur H. Stengel
Maynard Thompson
Norman L. Webb

***acting center director, 1975-76*

OAKLAND SCHOOLS CENTER
Pontiac, Michigan

David W. Wells, *center director*
Stuart A. Choate
Douglas W. MacPherson

Project Graduate Students: Randall I. Charles, Fadia F. Harik, Tom S. Hudson, Barbara E. Moses, Gary Post, Linda A. Proudfit

FINAL REPORT
MATHEMATICAL PROBLEM SOLVING PROJECT
TECHNICAL REPORT V:
THE DEVELOPMENT OF A PROCESS EVALUATION INSTRUMENT

Report Prepared By

Linda Proudfit

Under the Direction of

Donald R. Kerr, Jr.
Evaluation Director
Project Assistant Director

John F. LeBlanc
Project Director

MATHEMATICS EDUCATION DEVELOPMENT CENTER
Indiana University - Bloomington
May 1977

TABLE OF CONTENTS

	Page
REVIEW OF RELATED LITERATURE	3
DEVELOPMENT OF FIRST INSTRUMENT	5
First Student Interviews	5
First Instrument	6
Administration of the Instrument	7
Analysis	8
DEVELOPMENT OF SECOND INSTRUMENT	10
Problem Statement	10
Second Instrument	10
Administration of the Instrument	12
Analysis	12
SUGGESTIONS FOR FURTHER INVESTIGATION	15
REFERENCES	17

The Development of a Process Evaluation Instrument

Linda Proudfit

One area of evaluation which has received much attention is that of classroom testing. Traditional testing instruments, normally standardized or criterion-referenced, have been developed to assess final outcomes. What these instruments do not evaluate are the processes which children use to make decisions or to reach conclusions. The area of mathematical problem solving is one in which the evaluation of processes is of particular importance.

Little has been done to develop instruments which evaluate complex behaviors such as problem-solving processes. In 1961, the National Council of Teachers of Mathematics noted their concern about this inadequacy.

> The committee would have liked to include material on the appraisal of mental processes in the learning of mathematics. As teachers of mathematics, we are deeply concerned about developing skill in productive thinking. Too often, many of us find ourselves knowing little about the relations between the solutions given by our students and the thought processes that add to those solutions. However, tests for appraising higher mental processes such as concept formation, problem solving, and creative thinking in mathematics do not exist. (Johnson, 1961, pp. 2-3)

More recently, the National Advisory Committee on Mathematics Education (1975) stated that evaluation of efforts to apply mathematics to a variety of problems is needed. Kilpatrick (1976) summarized the situation as follows:

> A common complaint in the literature on evaluation in mathematics education has been that we lack instruments to measure such constructs as problem-solving ability and creativity in mathematics. Certainly if instruments were available to measure these constructs they could be used by teachers to measure a child's mathematical development as well as by evaluators of curriculum projects to measure how successful the project had been in developing these qualities in children. (p. 18)

The purpose of this report is to describe the efforts of the Mathematical Problem Solving Project to develop a paper-and-pencil instrument which could be used to assess processes used by children in attempting to solve nonroutine mathematical problems. The term "process" is used here in a rather broad sense. By process, we mean all thinking done to determine what the problem is asking, what information should be used, how a solution might be obtained, how a plan of attack should be implemented, and how the solution might be verified.

If a paper-and-pencil instrument could be developed which would identify these aspects of the processes used in problem solving, this would certainly be an aid to the teacher in helping his/her students improve their problem-solving ability. This instrument would assist the teacher in identifying processes which the student would not normally write while solving the problem. Since this instrument could be administered to a large group of students or to individual students, the teacher should be able to obtain more knowledge about the students' processes by combining this information with his/her observations.

In addition, the instrument might be used to focus the students' attention on the processes used in problem solving.

Gurova (1969) found results which indicated that making students more aware of the reasoning processes that they used improved their problem-solving performance. In working with fifth- and sixth-grade students, he used questions, apparently similar to those suggested by Polya, to encourage students to analyze their own thinking. He stated,

> "One necessary factor in the ability to solve a relatively complex problem requiring logical reasoning is an awareness of one's mental operations in the problem-solving process."

Such an instrument might also:

1. identify some approaches which students are inclined to use, either efficiently or inefficiently, and suggest approaches which need to be reinforced or clarified and approaches which need to be introduced; and
2. indicate growth of a class in certain aspects of problem-solving ability.

Review of Related Literature

To study problem-solving processes, various methods have been used in an attempt to obtain observable evidence of those processes. Kilpatrick (1967, pp. 4-6) cited studies which use mechanical or manipulative devices such as wire puzzles, jars of water, and light boards, and tests which present alternatives which allow an observer to follow the path used to obtain a solution. These tasks, however, do not accurately represent mathematical problem solving since the choices available at each step are more structured than those available in a mathematical problem-solving situation.

One instrument which has been used to assess general problem-solving ability is the Purdue Elementary Problem-Solving Inventory (Feldhusen, Houtz, and Ringenbach, 1972). The inventory was designed to assess twelve skills considered to be the basis for general problem-solving ability. These twelve skills are:

*1) sensing that a problem exists,
*2) defining the problem,
3) asking questions about the problem
4) clarifying the goal in the problem situation,
5) guessing causes,
*6) noticing relevant details,
*7) using familiar objects in unfamiliar ways,
*8) seeing implications,
9) solving problems with only one solution,
10) solving problems which have several possible solutions,
11) verifying solutions, and
12) judging if there is sufficient information presented to solve a problem.

It was determined that this inventory did assess those skills marked with an asterisk (Speedie, Houtz, Ringenbach, and Feldhusen, 1973). The inventory includes 47 multiple-choice items in which situations are presented by means of models, cartoons on slides or contained in the test booklets, or verbal descriptions. For each situation, children are asked to perform various tasks which correspond to the twelve skills mentioned above. This inventory has been reported to measure some aspects of general problem solving and does not really focus on the measurement of processes that are more specific to mathematical problem solving.

Asking a subject to analyze his/her own thought processes used in solving a problem is another method which has been used in attempting to determine problem-solving processes. Kilpatrick (1967, pp. 4-5) mentioned two such approaches--introspection and retrospection. Introspection is done while the problem is being solved. The accuracy of this method, however, is not known and it may inhibit the solution process since the problem solver must continually interrupt himself/herself to analyze his/her thinking. Retrospection, which asks the subject to recall his/her thought processes after the problem has been solved, presents the problem of remembering all the approaches which were considered or employed.

One method which does not require the subject to analyze his/her own thinking is to have the subject think aloud as (s)he attempts to solve a problem. Kantowski noted (1975) some limitations of this method:

> The method itself may be unreliable since an individual might remain silent during moments of deepest thought. Moreover, a verbalized solution could be essentially different from one effected silently. The presence of an observer could put constraints on a problem solver in that he might not attempt solutions which might be considered foolish to someone else but which he would try if he were not being observed.

In spite of these limitations, it appears that this is a viable method, and it has been used by many in researching problem solving. Many of those using the thinking-aloud method have used observations and audio- or video-taped interviews, sometimes followed by a protocol coding procedure of one form or another. This, however, is time consuming and impractical from the standpoint of a classroom teacher.

An initial effort to develop a test which would assess one aspect of the mathematical problem-solving process has been made by Vos (1976). The Problem Solving Decision Test focuses on three organizers of information--making a drawing, approximating and verifying, and constructing a table or chart. For six problems, students are asked to decide which of these approaches could be used to solve the problem. At the present time, insufficient data is available concerning the effectiveness of this instrument.

At the present time, instruments designed to assess problem-solving processes are either too limited in scope or too general in nature to provide useful information concerning mathematical problem-solving. Other procedures, such as interviews, are impractical for continual use by a classroom teacher. For this reason, the Mathematical Problem Solving Project began the development of an instrument which would attempt to access the processes used in mathematical problem solving and which would be practical for classroom use.

Development of First Instrument

First Student Interviews

In developing the paper-and-pencil instrument to evaluate processes, an initial attempt was made to develop questions which would help to identify processes used by children to solve six problems. Before these six problems were identified, interviews with elementary children were begun during the fall of 1975 to gather information on what strategies children might use while attempting to solve problems. From a fourth-grade class, six children were selected by the teacher to provide a range of ability levels. After several group sessions were held to acquaint the children with the three interviewers and to establish an informal setting for the problem-solving sessions, the interviews were begun on a one-to-one basis. Over the course of the interviews, each child was asked to solve twelve problems (see Appendix A). The child was asked to "think aloud" while solving the problems, and the interviewer asked questions throughout the session in an attempt to obtain more information about any strategies being used and to obtain statements which could be used as possible responses to questions which might be included in the instrument. These interviews were tape recorded, and these recordings, along with the students' written work, were used in determining the six problems to be included in the instrument and in developing the corresponding questions.

First Instrument

The first instrument (see Appendix B) contained questions corresponding to the four stages of the problem-solving process: comprehension, planning, carrying through the plan, and evaluation. For each of the six problems, the responses to the corresponding questions were written primarily using two formats--one asking the children to answer yes or no to each response and one using multiple choice. This produced twelve sets of questions, two for each of the six problems. The comprehension questions were written to determine what information given in the problem was used in the solution and how some aspects of the problem were interpreted. The question concerning initial planning was written as a ranking question on both forms and was identical on each set of questions. To answer this question, the children were asked to indicate what they did first, second, and third after reading the problem. To determine how the solution was obtained or sought, the next type of questions presented several possible methods of solution. The children were asked to indicate which method or methods were most like what they thought about or what they did. Lastly, the evaluation questions were concerned with the checking of the solution and the degree of confidence that the student had in his/her solution. Since all possible responses could not be anticipated, most questions included the option of writing in the correct response if it was not included in the list.

Administration of the Instrument

The first instrument was administered to a class of 26 children. Since each child was asked to solve three problems and to answer three sets of questions, the class was divided into four groups--two groups answering yes-no questions and two groups answering multiple-choice questions, as shown in Table 1.

Table 1

Grouping of Problems for Administration of First Instrument

Group	Form	Problems
1	yes-no	AY1, AY2, AY3
2	yes-no	BP1, BP2, BP3
3	multiple choice	AW1, AW2, AW3
4	multiple choice	BG1, BG2, BG3

After the first set of problems had been randomly distributed, each child attempted to solve the problem, handed his/her work to one of the proctors, and received the corresponding questions. After completing the first set of questions, the student was given the second problem, the second set of questions, etc., in a similar manner.

Analysis

The students' responses were analyzed to determine whether or not their responses to the questions were consistent with the work shown on the solution page and whether or not their responses were consistent within th[illegible] questions. This was done by comparing the method(s) indicated by [illegible] responses to the questions with the method(s) shown on the solution page. In addition, the responses to items within the set of questions which were repetitive were compared to determine consistency. This analysis indicated that approximately 70% of the students answered the questions in a manner which appeared to be consistent on both counts.

An additional concern was to determine what information was revealed by the instrument which could not be inferred from the solution page. Some responses to comprehension questions indicated misinterpretations, conditions which were ignored, and the use of incorrect information in the solution of the problems. For example, one student gave the correct answer to the Caterpillar Problem, Problem BG1 and BP1, by solving it incorrectly and focusing on the wrong information. She indicated in the first comprehension question that she used the width of the jar, rather than its height. By assuming that the caterpillar would climb 2 inches each day, she concluded that it would reach a height of 6 inches in 3 days. One would not have discovered this by looking only at the solution page. Responses to the comprehension questions concerning the Candy Problem, Problem AY3 and AW3, indicated that some of the conditions of this problem were ignored or misinterpreted. Many students seemed to focus on the fact that Ted received the first and last pieces of candy and did not allow the possibility of his receiving more than two pieces. Knowing how a student had interpreted a problem provided useful information in analyzing the solution.

The planning question did not provide much information about this aspect of the problem-solving process. Although most of the responses seemed consistent with the work shown on the solution page and with the other parts of the instrument, they did not provide any significant in- [illegible] students' in[illegible] Responses to the next questions, concerned with the actual solution approaches, provided information concerning approaches not shown on the solution page and explanations of calculations which were difficult to interpret. Most of those students who wrote only the answer on the solution page indicated that they had used approaches which appeared to be consistent with their answers. Observations of the children while solving the Caterpillar Problem validated the responses in some instances. Students who indicated that they used a ruler to solve the problem did, in fact, use a ruler.

Responses to the evaluation questions provided some information about this phase. However, the responses contained in the list were sometimes too general to give significant data.

This analysis of the first instrument indicated that students could provide some information concerning the processes used in arriving at a solution. However, not all parts of the instrument were considered to be satisfactory. Further work on the instrument was guided by the following conclusions:

- The comprehension questions were appropriate and provided necessary information in analyzing the solution.
- The questions regarding solution approaches were informative, yet they did not allow students to indicate all methods used.
- The evaluation questions were too general and somewhat inappropriate.

Development of Second Instrument

In an attempt to determine if more information regarding processes could be obtained through the use of a paper-and-pencil instrument, a revision of the questions concerning one of the six problems, the Caterpillar Problem, was begun. This problem was selected because of the variety of methods that children had used in attempting to solve it and the awareness of those methods that children had exhibited.

Problem Statement

In the first trial, some ambiguity was found in the problem statement. In the second version (see Appendix C), the jar has a lid. This made it physically impossible for the caterpillar to climb beyond 8 inches. Also the width of the jar was changed from 6 inches to 7 inches. It would then be more apparent if the student focused on the width since 7 inches would not appear at any stage of a correct solution approach.

Second Instrument

The format of questions on the second instrument (see Appendix C) was modified multiple-choice, where children were asked to check one or more of the possible responses. Again, the option was provided in some of the questions to write in responses other than those listed.

Although this instrument contained questions corresponding to each of the four stages of the problem-solving process as did the first instrument, the organization was somewhat different following the first page. The first questions concerning comprehension were left essentially unchanged. The only differences were those necessitated by the changes in the problem statement.

The next two pages contained questions regarding the approaches or strategies that were used by the children. The first of these two pages displayed pictures and calculations representing four different approaches which children have used in attempting to solve the problem. The children were asked to select from the four approaches or to describe a fifth to indicate what they had done while attempting to solve the problem--what they had thought about, what they had done first, and what they had done to get an answer. The first instrument had merely asked the children to indicate how they had attempted to solve the problem. It was hoped that this refinement would allow the children to identify methods they had considered or employed during various stages of the solution process.

On the next page was a list of responses which indicated various strategies. Some statements reiterated methods shown on the previous page and served as a reliability check; others were included to obtain more information about mental processes.

The fourth page was concerned with initial planning. The children were asked to mark the statement(s) which described what they did as soon as they had read the problem. It was intended that their choices would indicate whether the student attempted a plan of attack immediately after reading the problem or required a certain amount of "messing around" time. The first instrument had contained some of these statements and others under the planning question. These statements were divided and expanded in the second instrument. Those responses which represented strategies which might have been used during later stages of the solution process were included on the previous page.

On the next page were questions to determine not only if the student attempted to solve the problem using one or more than one method, but also why one method was decided to be sufficient or insufficient. These questions were added to the second instrument to determine further the children's awareness of the various methods that they had employed and to serve as a reliability check of their responses on page 2 and the following page.

The final set of questions asked the children to indicate whether or not they had checked their answers and how the checking was done or why they decided not to check. This differed from the first instrument which only asked if the student had checked the solution.

Administration of the Instrument

This second instrument was administered by five interviewers to 32 fourth-, fifth-, and sixth-grade children in the Oakland County school district in Michigan. These children were selected from experimental classes, classes which used the MPSP materials, and from control classes. Children were also selected from high-, average-, and low-ability groups determined by combined pretest scores on the Stanford Achievement Test and a problem-solving scale, X023, used in the National Longitudinal Study of Mathematical Abilities. After attempting to solve two other problems, the children were asked to solve the Caterpillar Problem while doing their thinking aloud. After finishing their work on the problem, the children completed the set of questions concerning the Caterpillar Problem. These interviews were tape recorded and these recordings were used in the analysis of the results.

Analysis

An analysis of the students' responses on the second instrument was performed in the same manner as the analysis of the first instrument. In addition, the tape recordings were used to validate the consistency of the responses to the questions with the solution page and the consistency of the responses within the instrument. This analysis indicated that approximately 45% of the students responded in a manner which was considered consistent in both respects, approximately 30%

responded in a manner which sometimes appeared to be consistent, and approximately 25% responded in a manner which appeared to be almost totally inconsistent or arbitrary. An analysis of these three groups of students will be presented to illustrate the strengths and weaknesses of the second instrument.

The responses which appeared to be consistent either verified what one might have inferred from the solution page or provided additional information which further explained the work shown on the solution page. One student made a drawing which resembled a ruler on the solution. She indicated on the instrument that this had been used at first, but she reached the solution by adding and subtracting mentally. The recording of the interview verified that the solution page showed only the picture which helped her to understand the problem and that the instrument accurately indicated the processes used to reach the solution.

Another example is shown by the first set of responses in Appendix D. Susan's solution page shows some calculations, which alone do not indicate a clear solution method. She clarified this somewhat on page 2 of the instrument by marking the two methods that were similar to what she had done and by writing a more organized set of calculations. She indicated on page 5 that she considered these methods as one approach, rather than separate approaches. The recording of the interview showed that this was the case (see Appendix D).

The instrument does not give as complete an explanation of Susan's thinking as does the interview, but it does give a more complete picture than is shown on the solution page.

Other students, while providing some information about their method of solution, were not as consistent as those mentioned above. The second set of responses found in Appendix D provides an example. Eddie marked on page 2 that he first thought of a rule [illegible] he multiplied [illegible] get the answer. He als[illegible] a number of days and checked to see if the number was correct. The recording of the interview verified this (see Appendix D).

His responses on page 5, however, were not consistent. He marked that the first time he tried to solve the problem, he knew he was right. Yet he also marked that he tried a second way because he wasn't sure that the first way was right.

When students gave both consistent ~~and~~ inconsistent responses, most of the inconsistencies were found on pages 5 and 6. These conflicting responses regarding confidence in and checking of the answer may have resulted, in part, from misinterpretations of the questions.

Other students gave responses to the questions which were almost totally inconsistent and provided little or no information concerning their method of solution. An example of this is provided by the third example in Appendix D. Trudy indicated on page 3 that she made a drawing, yet no drawing was shown on the solution page. On pages 5 and 6, she indicated that she checked her answer and saw that the first way was wrong, and that she did not check her answer. The recording of the interview seemed equally confusing (see Appendix D).

Other students responding in this manner gave conflicting responses to the comprehension and approach questions. Some indicated that they did not use information which was used on the solution page. Others marked that they used almost every possible approach while solving the problem. These students tended to mark many more responses than those students who appeared to be consistent.

In this case, the instrument does not give an accurate picture of the solution process. However, one does not require the interview to discover this. The interviews did verify that those papers which did not provide useful information concerning problem-solving processes could be determined by the inconsistent responses found in the instrument.

The analysis of student responses and the interviews allow several conclusions to be drawn:

- The instrument can provide information which explains unclear procedures found on the solution page and additional information concerning approaches which were not written on the solution page.

- The instrument provides sufficient means of determining the reliability of the responses. Erroneous or arbitrary responses can be discovered by examining those responses to items which should be consistent.

- Responses to questions contained on the first four pages of the instrument indicate that these questions are correctly interpreted by most students and that they are appropriate with respect to the comprehension, planning, and solution stages of the problem-solving process.

- The misinterpretations of the questions on the final two pages of the instrument indicate that these questions need to be reworded or presented using a different format.

Suggestions for Further Investigation

Although there are some weaknesses in the ~~two~~ instruments which have been described, it appears that they do provide useful information concerning the processes used by children to solve mathematical problems. However, further investigation and refinement is suggested by the results of the second administration.

First, additional questions might be included. General impressions concerning the various approaches which children used were obtained; however, more specific questions are necessary to identify the approaches which are considered and the reasons for accepting or rejecting a particular approach. In addition, questions concerning preferences of approaches or strategies might be included. If responses to these questions are consistent over a period of time, these may provide insight into a student's problem-solving style.

Secondly, the organization of the instrument requires some alteration. In the first instrument, the questions proceeded in a rather systematic manner through the various stages of the problem-solving process. The questions were ordered in much the same way as a student might have ordered his/her own thinking. In the second instrument, it appears that the student was asked to consider the solution process in a nonchronological order. The student was asked to indicate what information was used, what was thought about first, what was done to get an answer, what was done immediately after reading the problem, etc. This may have been confusing to some students.

If this instrument can be refined and developed for other problems, it should be a valuable tool for the classroom teacher. Since many of the items could be identical for all problems, it could be easily adapted to many problems which the teacher might wish to use. It appears that it has great potential as a diagnostic instrument, to assist in determining which types of problems pose difficulties for a student and what aspects of a particular problem prevent the student from solving it. The refinement of this instrument should be a useful aid to teachers in assisting children to become better problem solvers.

REFERENCES

Feldhusen, J.F., Houtz, J.C., and Ringenbach, S. "The Development of a New Measure of Problem-Solving Ability of Disadvantaged Children." Psychological Reports, 1972, 31, 891-901.

Gurova, L.L. "Schoolchildren's Awareness of Their Own Mental Operations in Solving Arithmetic Problems." In J. Kilpatrick and I. Wirszup (Eds.), Problem Solving in Arithmetic and Algebra. Soviet Studies in the Psychology of Learning and Teaching Mathematics, Vol. 3. Stanford School Mathematics Study Group, 1969.

Johnson, D. Introduction. Evaluation in Mathematics. Yearbook, National Council of Teachers of Mathematics, 1961, 26, 1-6.

Kantowski, M.G. "Processes Involved in Mathematical Problem Solving." Paper presented at the Problem-Solving Research Workshop, Georgia Center for the Study of Learning and Teaching Mathematics, University of Georgia, Athens, May 1975.

Kilpatrick, J. "Analyzing the Solution of Word Problems in Mathematics: An Exploratory Study." (Doctoral Dissertation, Stanford University, 1967). Dissertation Abstracts, 1968, 28, 4380-A. (University Microfilm No. 67-6442).

Kilpatrick, J. "Methods and Results of Evaluation with Respect to Mathematics Education." Paper presented at the Third International Congress on Mathematical Education, Karlsruhe, West Germany, August 1976.

National Advisory Committee on Mathematical Education. Overview and Analysis of School Mathematics: Grades K-12. Washington, D.C.: Conference Board of the Mathematical Sciences, 1975.

Speedie, S.M., Houtz, J.C., Ringenbach, S., and Feldhusen, J. "Abilities Measured by the Purdue Elementary Problem Solving Inventory." Paper presented at a joint session of NCME-AERA, New Orleans, 1973.

Vos, Kenneth E. "The Effects of Three Key Organizers on Mathematical Problem Solving Success with 6th, 7th and 8th Grade Learners." Unpublished paper, 1976.

APPENDICES TO

TECHNICAL REPORT V: PROCESS EVALUATION

APPENDIX A: Interview Problems

APPENDIX B: First Instrument

APPENDIX C: Second Instrument

APPENDIX D: Student Responses to Second Instrument and Transcripts of Interviews

(Appendices Under Separate Cover)