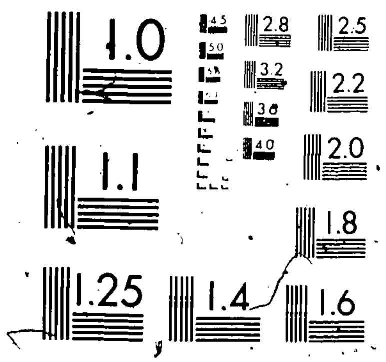
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ABSTRACT

Instructional materials used in two pilot studies are presented. Appendix A contains components of the problem-solving bulletin board. Eighteen problems are stated along with suggestions for solving each problem. Problems 1-10 contain questions extending the original problem. Teacher answer sheets are given for problems 4-18. Appendix B contains observation sheets and interview forms used by the researchers. (MP)

TECHNICAL REPORT II: INSTRUCTIONAL MATERIALS

PART D: LEARNING TO SOLVE PROBLEMS BY SOLVING PROBLEMS

APPENDICES A and B

APPENDIX A: Components of the Problem Solving Bulletin Board

APPENDIX B: Observation and Interview Forms

MATHEMATICAL PROBLEM SOLVING PROJECT

MPSP

A Project of the
MATHEMATICS EDUCATION DEVELOPMENT CENTER

Project Supported by
National Science Foundation Grant PES74-15045

TECHNICAL REPORT II: INSTRUCTIONAL MATERIALS

PART D: LEARNING TO SOLVE PROBLEMS
BY SOLVING PROBLEMS

APPENDIX A: Components of the Problem
Solving Bulletin Board

APPENDIX A: Components of the Problem Solving Bulletin Board

Explanatory note:

All problems utilized in both pilot studies follow. They have been arranged in the following order:

Nos. 1- 3: Used in Pilot 1 only

Nos. 4-10: Used in both Pilots 1 and 2

Nos. 11-18: Used in Pilot 2 only

Problems used in Pilot 1 have the section called "Here's Some More... Interested?" which was eliminated in Pilot 2 as noted earlier.

Also note that Problems 4-18 which were used in Pilot 2 are the only ones with teacher answer sheets. This change was also noted in the body of the report.

In this appendix, in the interest of saving paper, three parts of the bulletin board have been typed on one page. These parts are:

"The Problem"

*"Will This Help?"

*"Here's Some More...Interested?"

The "What Others Have Tried" is omitted.

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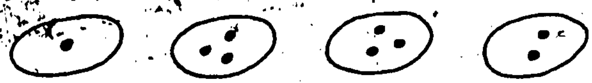
* On the bulletin board each individually numbered item was on a separate half-sheet of paper so that the students saw the items one at a time.

(PROBLEM 1)

THE PROBLEM

1. Show the ways that 9 marbles can be put into 5 cups so that each cup has a different number of marbles.

WILL THIS HELP?

1. How many cups do you have?
2. Could a cup have zero (0) marbles in it?
3. Would drawing cups and marbles help you work this problem?
4. How many ways are there to solve this problem?
5. Tom wrote this: 

   What do you think about Tom's answer?

HERE'S SOME MORE...INTERESTED?

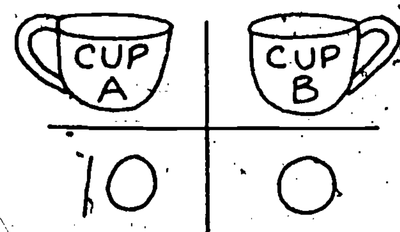
1. What is the fewest marbles you would need to get a different number of marbles in each cup if you had 6 cups?
2. How many marbles would you need to work the five cup problem?
3. If you had 12 marbles and four cups, show the ways you could put a different number in each cup.
4. If you had 21 marbles, what is the largest number of cups that you could fill if you put a different number in each cup?

THE PROBLEM

2. At Cathy's party there was a guessing game. There were 10 chips divided into 2 cans. You won a prize if you guessed the correct number of chips in each can. Show all the different guesses you could make.

WILL THIS HELP?

1. Is there more than one answer to this problem?
2. Would six chips in one cup and 5 chips in the other be one answer to this problem?
3. If you want to, how many ways would you guess there are to do this problem?
4. Making a drawing like this might help.

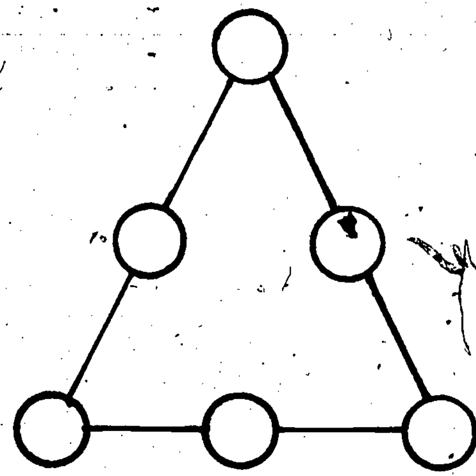


5. Would you like to play this game?
6. When cup A has 10 chips, then cup B has 0 chips. Also, when cup B has 10 chips, cup A has 0 chips.
7. 5 chips in cup A and 5 chips in cup B can only be counted as one way.

HERE'S SOME MORE...INTERESTED?

1. Show the ways you could put 11 chips into 2 cans.
2. Show how many ways you could put 12 chips into 2 cans.
3. Do you see a pattern? If you do, guess how many ways you could put 13 chips into 2 cans. Then, see if you can find that many...or more... or less.

(PROBLEM 3)



THE PROBLEM

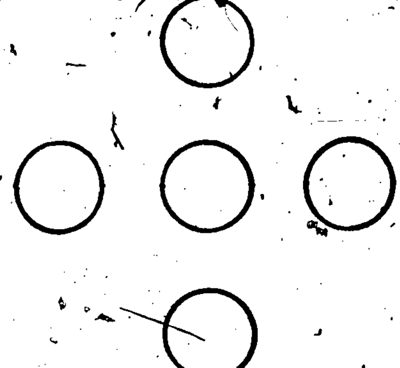
3. To make this a magic triangle, put one of the numbers 1-6 in each circle so that each side of the triangle adds up to 10.

WILL THIS HELP?

1. How many numbers can you use in this problem? What are they?
2. It might help to put "5" in one corner or at the top.
3. What number should each side add up to?
4. How many ways are there to do this problem?
5. With "5" at the top, try "3" in one of the corners. (If you put "5" in one corner, put "3" in the other corner or at the top.)
6. How could this be a magic triangle?

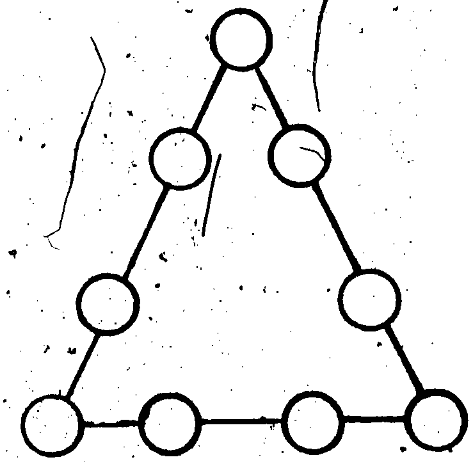
HERE'S SOME MORE...INTERESTED?

1. Show how to put one of the numbers 1, 2, 3, 4, 5, 6 in each circle so that each side adds up to 9.
2. Using the same numbers, show how you can make each side of the triangle add up to 11. Then see if you can make it work for any other number.



3. Using 1, 2, 3, 4, 5 once each, make the row and the column add up to 9.

4. Show how one of the numbers 1, 2, 3, 4, 5, 6, 7, 8, 9 can make each side of this triangle add up to 17.



(PROBLEM 4)

THE PROBLEM

4. Some children are seated at a large round table. They pass around a box of candy containing 25 pieces. Ted takes the first piece. Each child takes one piece of candy as the box is passed around. Ted also gets the last piece of candy, and he may have more than the first and last pieces.

WILL THIS HELP?

1. Who gets the first piece of candy?
2. Who gets the last piece of candy?
3. Can you guess how many children there could be?
4. Could there be 25 children?
5. Do you think there is more than one answer to this problem?

HERE'S SOME MORE...INTERESTED?

1. If Ted got four pieces of candy altogether, how many children were seated at the table?
2. Suppose the box only had 23 pieces of candy in it. Now, how many children could be seated around the table?
3. In another room, some children are seated in a circle. They pass around a box of candy containing 20 pieces. Linda got the first piece of candy and 2 altogether. This time the second piece was not the last piece in the box. How many children could be seated around the table?

PROBLEM #4

There are several answers to the "25 pieces of candy" problem. There could be: 24, 12, 8, 6, 4, 3, or 2 children.

The children's work will probably not look like this. That's OK.

****

REMEMBER

1. *Make sure everyone understands the problem.*

2. *Working on the problem is more important than getting a solution. Let the children "mess" with the problem.*

3. *Encourage children to talk with each other and work together if they want.*

4. *Allow and encourage as much use of the bulletin board as possible.*

****

(PROBLEM 5)

THE PROBLEM

5. Tom and Judy both work part-time in a cafeteria which is open 7 days a week. Tom works one day and then has three days off before he works again. Judy works one day and then has four days off. Tom works this Monday and Judy works this Tuesday. Show the days in 3 weeks that Tom and Judy will work on the same day.

WILL THIS HELP?

1. How many days are there in 3 weeks?
2. Have you thought of making a calendar for three weeks?

   Sunday Monday Tuesday Wednesday Thursday Friday Saturday
3. Is this problem hard?
4. If Tom first works Tuesday, he next works Saturday. After that, he next works ____________.

   Judy first works ____________. She next works ____________. After that, she works ____________.
5. Do you like to eat in a cafeteria?

HERE'S SOME MORE...INTERESTED?

1. How many days in 6 weeks will Tom and Judy be working together? What will those days be?
2. How many days in 9 weeks will Tom and Judy be working together? What will those days be?
3. Suppose the cafeteria is closed on Sunday. Tom works one day and is off three working days before he works again. Judy works one day and is off four working days before she works again. Tom works Tuesday and Judy works Thursday. Show the days in 3 weeks they will work together.

PROBLEM #5

One way to answer the "Tom and Judy" problem is:

Sun	Mon	Tue	Wed	Thu	Fri	Sat
	T	J			T	
		T			J	
			(JT)			

When they will work on the same day.

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****

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****

THE PROBLEM

6. There were 8 people at a party. If each person shook every other person's hand, how many handshakes were there?

WILL THIS [illegible]

1. How [illegible] e were at the party?
2. If Joe [illegible] there, how many people would he shake hands with?
3. Is this problem interesting?
4. You can make up names for people at the party.
5. If Joel shook hands with Cheryl, then Cheryl would not have to shake Joel's hand.

HERE'S SOME MORE...INTERESTED?

1. If everyone at your house shook hands, how many handshakes would there be?
2. If everyone in your class shook each other's hand, how many handshakes would there be?
3. If there were 10 handshakes at a party, and you knew everybody shook everybody else's hand once, how many people were at the party?
4. Make up a problem like this one and ask a friend to try solving it. (You may want to try the problem at home, too!)

PROBLEM #6

One way to answer "8 people, how many handshakes" is:

People	Whose hands they shake	# Handshakes
John	Sandy, Lin[illegible] Gert, Tom, Randy	7
Sandy	Linda, Norm, Barb, Gert, Tom, Randy	6
Linda	Norm, Barb, Gert, Tom, Randy	5
Norm	Barb, Gert, Tom, Randy	4
Barb	Gert, Tom, Randy	3
Gert	Tom, Randy	2
Tom	Randy	1
Randy	———	0
		28 Total

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****

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****

THE PROBLEM

7. Show the ways that 15 pennies can be put into 4 piles so that each pile has a different number of pennies.

WILL THIS HELP?

1. How many pennies do you have to work with in this problem?
2. Kevin wrote "0, 10, 3, 2" for an answer. Joannie said, "If you didn't have any pennies, there wouldn't be a pile." What do you think?
3. If you want, guess how many ways there are to do this problem. Now, see how close your guess is.
4. Is "3, 7, 3, 2" one answer to this problem?
5. Is this problem fun?
6. What would happen if the problem read, "Show the ways to put 15 quarters into 4 piles so that each pile has a different number of quarters"?
7. Did you realize that 10 is too many pennies for one pile?

HERE'S SOME MORE...INTERESTED?

1. Show the ways 16 pennies can be put in 5 piles so that each pile has a different number of pennies.

PROBLEM #7

<u>One</u> way to work the "15 pennies - 4 piles" problem is 1 + 2 + 3 + 9 = 15.

Other combinations are:

1, 2, 4, 8
1, 2, 5, 7
1, ~~3, 4, 7~~
1, 3, 5, 6
2, 3, 4, 6

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****

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(PROBLEM 8)

THE PROBLEM

8. Bill thinks there are eleven ways to put 15 pennies into 3 piles so that each pile has a different number of pennies. Can you find as many as Bill? Are there any more?

WILL THIS HELP?

1. How many ways did Bill find?
2. How many pennies did he use?
3. Do you think that there really are 11 ways?
4. Can you have less than one penny in a pile?
5. Is 13, 2, 1 an answer?

HERE'S SOME MORE...INTERESTED?

1. Show the ways 16 pennies can be put in 5 piles so that each pile has a different number of pennies.

PROBLEM #8

One way to answer "15 pennies - 3 piles" is:

1 + 2 + 12 = 15
1 + 3 + 11 = 15
1 + 4 + 10 = 15
1 + 5 + 9 = 15
1 + 6 + 8 = 15
2 + 3 + 10 = 15
2 + 4 + 9 = 15
2 + 5 + 8 = 15
2 + 6 + 7 = 15
3 + 4 + 8 = 15
3 + 5 + 7 = 15
4 + 5 + 6 = 15

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****

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****

THE PROBLEM

9. [illegible] $[illegible] week for allowance. This week his mother paid him 19 coins. He got nickels, dimes and quarters. Show how many of each coin he got.

WILL THIS HELP?

1. How many coins did John get?
2. What kind of coins did John get?
3. Could you solve this problem using 7 quarters?
4. Do you think this problem really happened?
5. Would it help to write number sentences like
   ____ Quarters + ____ Dimes + ____ Nickels = 19
6. Did you know that 16 dimes make $1.60? Or that 20 nickels make $1.00?
7. Is there more than one way that John could have gotten the 19 coins?

HERE'S SOME MORE...INTERESTED?

1. Show the ways John could get his $1.60 in 20 coins if the coins were quarters and nickels.
2. John's mom won some money in a contest and she decided to give him a bonus. She gave him $5.60 in dimes. How many dimes did John get?
3. In a pile of quarters and nickels, there are 2 more nickels than quarters. How many nickels are there if the pile is worth $3.40?

One way to answer the "$1.60 in 19 coins in quarters, dimes and nickels" is:

Q	D	N	$Tot	# of coins
3	1	15	$1.60	19
2	5	12	1.60	19
1	9	9	1.60	19
0	13	6	1.60	19

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****

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****

(PROBLEM 10)

THE PROBLEM

10. Jim works in an ice cream store. Ice cream cones cost 25¢. Show the ways that Jim can be paid exactly 25¢ for an ice cream cone.

WILL THIS HELP?

1. What are the different kinds of coins that can be used to solve this problem?
2. Can you guess how many ways there are to make change for a quarter?
3. Can you use 3 dimes to make change for 25¢?
4. Would it help to put the answers you've found in a table like this?

Quarter	Dime	Nickel	Penny	Total
0	1	2	5	25¢

5. Why are you interested in this problem?
6. If you had 3 nickels, what are the 2 ways you could make 25¢? (One way uses dimes. The other way uses pennies.)

HERE'S SOME MORE...INTERESTED?

1. If a sherbet cone costs 20¢, show the ways Jim can be paid.
2. If two dips cost 35¢, show the ways Jim can be paid.
3. A man came into Jim's store and spent 75¢. If a soft drink costs 10¢, show what the man could have bought for his 75¢.

Remember: Single dip 25¢
Double dip 35¢
Sherbet 20¢
Soft drink 10¢

4. Make up a problem like this one and give it to a friend to do. (You might want to try it at home, too!)

PROBLEM #10

One way to answer the "change for 25¢" problem is:

Quarter	Dime	Nickel	Penny	Total
1	0	0	0	25¢
	2	1	0	25¢
	2	0	5	25¢
	1	3	0	25¢
	1	2	5	25¢
	1	1	10	25¢
	1	0	15	25¢
		5	0	25¢
		4	5	25¢
		3	10	25¢
		2	15	25¢
		1	20	25¢
			25	25¢

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****

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****

THE PROBLEM

11. Rosie works in an ice cream store. Sherbet cones cost 20¢. Show the ways that Rosie can be paid exactly 20¢ for a sherbet cone.

WILL THIS HELP?

1. What are the different coins that can be used to answer this problem?
2. How many ways do you think there are to give someone 20¢?
3. What is the largest number of dimes you can use?
4. Could part of the money that you pay Rosie be 7 pennies?
5. What kind of sherbet cone do you like?

PROBLEM #11

<u>One</u> way to answer the "change for 20¢" problem is:

Dimes	Nickels	Pennies	Total
2	0	0	20¢
1	2	0	20¢
1	1	5	20¢
1	0	10	20¢
0	4	0	20¢
0	3	5	20¢
0	2	10	20¢
0	1	15	20¢
0	0	20	20¢

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(PROBLEM 12)

THE PROBLEM

12. Joe and Tim are playing a game. At the end of each game, the loser gives the winner a penny. After awhile, Joe has won 3 games, and Tim has 3 more pennies than when he began. How many games did they play?

WILL THIS HELP?

1. If Joe won the first game, how many more pennies would he have than when he started?
2. What happens when Tim wins a game?
3. If Tim wins the first game, and Joe wins the second, how many more pennies would Tim have than when he started?
4. Is this problem interesting?
5. Do you need to know how many pennies each boy had to start with?

PROBLEM #12

To solve the "Joe and Tim" problem, Tim must win 3 more games than he loses. Since Joe wins 3 games, Tim loses 3. So, Tim must win 6 games.

3 + 6 = 9, so 9 games are played.

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****

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****

(PROBLEM 13)

THE PROBLEM

13. Bob and Mary are playing a game. At the end of each game, the loser gives the winner a penny. Bob and Mary played 6 games. Show all the things that could happen.

WILL THIS HELP?

1. What happens when Bob wins a game?
2. What is the largest amount that Bob could have won?
3. Would you like to play this game?
4. If Mary won the first 2 games, how many more pennies would she have than when she started?
5. Would it help to have pennies to figure this problem out?

PROBLEM #13

One way to answer the "Bob and Mary" problem is:

Score	Penny Status
Mary 6 Bob 0	Mary + 6¢ Bob - 6¢
Mary 5 Bob 1	Mary + 4¢ Bob - 4¢
Mary 4 Bob 2	Mary + 2¢ Bob - 2¢
Mary 3 Bob 3	Mary even Bob even
Bob 4 Mary 2	Bob + 2¢ Mary - 2¢
Bob 5 Mary 1	Bob + 4¢ Mary - 4¢
Bob 6 Mary 0	Bob + 6¢ Mary - 6¢

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****

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****

(PROBLEM 14)

THE PROBLEM

14. If there were 10 handshakes at a party, and you knew everybody shook everybody else's hand once, how many people were at the party?

WILL THIS HELP?

1. How many handshakes were there?
2. About how many people do you think were at the party?
3. If there were 2 people at the party, how many handshakes would there be?
4. If there were 4 people at the party, how many handshakes would there be?
5. You can make up names for people at the party.
6. Is this problem difficult?
7. If Harold shook Joan's hand, then Joan would not have to shake Harold's hand.

PROBLEM #14

One way to answer the "10 handshakes, how many people" problem is:

Marilyn Frank	Frank	2 people/1 handshake
Marilyn Frank Art	Frank, Art Art	3 people/3 handshakes
Marilyn Frank Art Orville	Frank, Art, Orville Art, Orville Orville	4 people/6 handshakes
Marilyn Frank Art Orville Horatio	Frank, Art, Orville, Horatio Art, Orville, Horatio Orville, Horatio Horatio	5 people/10 handshakes

The children's work will probably not look like this. That's OK.

****

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****

(PROBLEM 15)

THE PROBLEM

15. Show the ways John could be paid his allowance of $1.60 if the coins were quarters and nickels.

WILL THIS HELP?

1. How many answers do you think there are to this problem?
2. How much is John's allowance?
3. What coins are used in this problem?
4. What is the largest number of nickels that John could be given?
5. How would you spend an allowance of $1.60 a week?
6. Could John get seven quarters?

PROBLEM #15

One way to answer the "$1.60 in quarters and nickels" is:

Q	N	Total
6	2	$1.60
5	7	1.60
4	12	1.60
3	17	1.60
2	22	1.60
1	27	1.60
0	32	1.60

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****

REMEMBER

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****

(PROBLEM 16)

THE PROBLEM

16. Some children are seated in a circle. They pass around a box of candy containing 20 pieces. Linda takes the first piece. Each child takes one piece of candy as the box is passed around. Linda gets a second piece of candy but not the last piece in the box. If Linda got two pieces of candy, how many children could be seated around the table?

WILL THIS HELP?

1. How many pieces of candy are there?
2. Who gets the first piece of candy?
3. How many pieces of candy did Linda get?
4. Did Linda get the last piece?
5. Could the answer be 19?
6. Is there more than one answer to this problem?

PROBLEM #16

There are several possible answers to the "Linda's candy" problem. They are: 10, 11, 12, 13, 14, 15, 16, 17, or 18 children.

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****

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****

(PROBLEM 17)

THE PROBLEM

17. Lemon drops come in packages of 3 for 10¢ and chocolate mints cost 1 for 5¢. Harold bought 20 pieces of candy. How many pieces of each kind of candy could he have bought?

WILL THIS HELP?

1. How many pieces of candy did Harold buy?
2. Could he buy 7 lemon drops? Why?
3. What is the largest number of lemon drops he could buy?
4. Do you like lemon drops?
5. Could Harold buy 20 chocolate mints and no lemon drops?
6. What would you buy?

PROBLEM #17

<u>One</u> way to answer this "lemon drop" problem is:

Lemon Drops	Choc. Mints	Total Pieces
0	20	20
3	17	20
6	14	20
9	11	20
12	8	20
15	5	20
18	2	20

The children's work will probably not look like this. That's OK.

****

REMEMBER

1. *Make sure everyone understands the problem.*
2. *Working on the problem is more important than getting a solution. Let the children "mess" with the problem.*
3. *Encourage children to talk with each other and work together if they want.*
4. *Allow and encourage as much use of the bulletin board as possible.*

****

(PROBLEM 18)

THE PROBLEM

18. Mike and David both work part-time at a grocery store which is closed on Sunday. Mike works one day and then has 3 working days off before he works again. David works one day and then has 4 working days off. Mike works this Monday and David works this Tuesday. Show the days in 3 weeks that Mike and David will work on the same day.

WILL THIS HELP?

1. How many days a week is the grocery store open?
2. Have you ever wanted to work in a grocery store?
3. Is Sunday a working day at the grocery store?
4. Have you thought of making a calendar for the 3 weeks?
5. If Mike works the first Monday, he next works on ___________. After that, the next time he works is ___________.
6. David first works on ___________. He next works on ___________.

PROBLEM #18

<u>One</u> way to work the "Mike and David" problem is:

Mon	Tues	Wed	Thur	Fri	Sat
M	D			M	
D		M			D
M				(MD)	

(MD) ← When they work on the same day.

The children's work will probably not look like this. That's OK.

****

REMEMBER

1. Make sure everyone understands the problem.

2. Working on the problem is more important than getting a solution. Let the children "mess" with the problem.

3. Encourage children to talk with each other and work together if they want.

4. Allow and encourage as much use of the bulletin board as possible.

****

TECHNICAL REPORT II: INSTRUCTIONAL MATERIALS

PART D: LEARNING TO SOLVE PROBLEMS BY SOLVING PROBLEMS

APPENDIX B: Observation and Interview Forms

OBSERVATION SHEET

Date	Teacher's Name (Class) (which classroom for teachers who work with 2 classes)	Start	Finish
		Time	

Observer

Problem #

Day on this problem: 1 2 ______ (other)

Nature of classroom organization:

Arrangement of furniture -

Location of bulletin board -

Ease of access of bulletin board -

Other observations -

Nature of problem session:

Introduction -

Degree of Teacher involvement (very much - none at all)

Degree of Teacher directiveness (very directive - no direction given)

"Messing" Time

Degree of Teacher involvement (very much - none at all)

Degree of Teacher directiveness (very directive - no direction given)

"Wrap-Up"

Degree of Teacher involvement (very much - none at all)

Degree of Teacher directiveness (very directive - no direction given)

Number of students involved: (elaborate if needed)

Only activity underway: Y N (elaborate if needed)

Mode in which students worked: individually small groups large groups (entire class)

Use of Bulletin Board

Use of "Will This Help"

Use of "Things Others Tried"

Observer's Comments & Summary

Conduct of the Session in General (did it go smoothly, etc.):

Additional Information Regarding the Teacher's Role:

Manner in Which Children Worked:

Type and Nature of Discussion (if any!):

Observed Difficulties (e.g., working of problem statement, use of B-B, ...):

Other Comments:

TO: Problem Solving Teachers DATE: May 12, 1976

FROM: Marilyn Jacobson RE: Post Pilot Test Interviews
Frank Lester
Art Stengel

During the week of May 17, 1976 we will be conducting the post-pilot test interviews. As we have discussed, these will consist of a one-hour interview with you and 10-20 minute interviews with some of your children. Your comments will help us gain further insights into the materials and how your students worked with them.

In order to help you organize your thinking about this problem solving experience, we have included an instructional process organizational sheet and an outline of the types of questions that we will ask during the interview. Below are specific instructions for each page:

Page 2 Instructional Process Organizational Sheet

The instructional process that was outlined during the in-service meeting included the following steps:

1. Problem presentation--The time during which the problem was given to the students and was clarified if necessary.

2. Problem solving--The time during which the students worked on the problem.

3. Problem discussion--The time during which the students discussed their solutions with their classmates and teacher.

In the interview we will want to know what happened in your classroom during each step of the process. You may use page 2 to make some notes, or to organize your thinking for the interview.

Page 3 Types of questions

The questions concern the materials, the students' perceptions and your perceptions. These questions should help you to organize your thoughts concerning what happened during the problem solving experience.

We hope that this information will be helpful in organizing your thoughts and we are looking forward to discussing with you your experiences with and thoughts about the materials.

INSTRUCTIONAL PROCESS

PHASE I: Problem Presentation

Teacher	Students

PHASE II: Problem Solving

Teacher	Students

PHASE III: Problem Discussion

Teacher	Students

TYPES OF QUESTIONS

I. Materials

A. Has the bulletin board been an effective way of delivering instructional material to the children?

B. Were the different sections of the board successful? What changes should we make?

C. Was the notebook a convenient and functional means for presenting the teacher materials? What additional information would be helpful?

D. What additional materials have aided the students in solving the problems? What additional materials might we include?

II. Perceptions of Students

A. How do you think your children view mathematical problem solving?

B. Do you think these materials changed their view in any way? How?

C. Do you think your students liked these problems more or less than those in your textbook?

D. Did any students react to these materials in an unexpected way?

III. Personal Perceptions

A. How did these materials fit in with your mathematics curriculum and were they relevant to any other subjects?

B. What, if any, is the value of using these materials or materials like these with your students?

C. In what ways are these problems different from textbook story problems? Which do you feel has been more valuable for your students?

D. In what ways, if any, did your children grow as a result of these materials?