PUZZLE TANKS:

A Game of Numbers and Logic

Apple
TRS-80 Model III, 4
TRS-80 Color

Teacher's Guide

SUNBURST
COMMUNICATIONS

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Thomas C. O'Brien is a professor and director of the Teachers' Center Project at Southern Illinois University, Edwardsville, Illinois. His work in education is three-fold: teacher education, curriculum development, and research on children's thinking. As a researcher, he has studied the growth of mathematical ideas in subjects from pre-school to medical school and law school. As a teacher, he has worked with students from grade 7 through graduate school. As a curriculum developer, he has authored twelve problem books for children, as well as authored and edited some eighty papers on children's thinking and education published through the Teachers' Center Project.

In addition, Dr. O'Brien has published and delivered some 100 papers in children's thinking, mathematics education, intellectual development and educational change. His papers and presentations have taken place in the USA, Canada, Great Britain, Holland, France, Switzerland, Hungary and Brazil. Dr. O'Brien was named a North Atlantic Treaty Organization (NATO) Senior Research Fellow-in-Science in 1978. Dr. O'Brien received his bachelor's degree from Iona College, New Rochelle, NY, and his Ph.D. from New York University.

Other programs designed by Thomas O'Brien include: Teasers by Tobbs, Tobbs Learns Algebra, Counters, Targets and King's Rule.

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PUZZLE TANKS

Table of Contents

INTRODUCTION TO PUZZLE TANKS

Suppose you have the following problem: You have two tanks, one of which holds 5 quarts and the other 6. You have an infinite supply of Wonder Juice and a holding container into which you could pour the contents of the tanks. You must use the original tanks -- the 5 and 6 -- to make 11 quarts of Wonder Juice.

Easy. Fill the 5 and the 6 and empty them into the holding tank.

Why do a problem like this? Such a problem calls for children to develop and/or apply addition skills and to view addition in its very essence. Addition is not reciting responses from memory. Addition involves combining things.

Here's another problem: Suppose you have the same 5 and 6 tanks and this time you need 2 quarts of Wonder Juice. Not so easy, is it? You could fill the 6 and pour it into the 5, thus leaving 1. Save the 1 in the holding container. Then empty the 5. Can you finish the problem?

This isn't addition facts. What is it?

It's problem solving, one of the most important abilities one can have.

Problem solving takes place when one reassembles (or creates) actions and ideas to achieve a goal in a new situation. We are all problem solvers every day, and we are all more or less successful at problem solving. But problem solving abilities are too important to leave to chance and the random experiences of everyday life. Problem solving needs special attention.

Much of the school curriculum purports to promote problem solving. The National Council of Teachers of Mathematics chose problem solving as <u>THE</u> issue for teachers to pursue in the 1980's. Present-day school children will live most of their lives in the Twenty First Century. What new issues will they face? No doubt some will be important to them, but no doubt they'll need to meet novelty and challenge and opportunity presently unknown to us. (Are you old enough to remember when Dick Tracy's wrist radio was unspeakably futuristic? Do you remember -- it's only twenty-five years ago -- when a man on the Moon was unthinkable? Can you think back to the time when a computer in a private home was a dream?)

A major aspect of life is novelty -- dealing with new situations for which you've not been programmed. What do you do? You create your own solutions. You become a problem solver. Problem solving is, and should be, a major objective in schools and home.

But problem solving in most textbooks is often falsely named. "Problems" in most math textbooks aren't really problems. They are computational exercises disguised in words -- "Two boys each ate 4 hamburgers..." Such activities are trivial so far as problem solving is concerned and they are trivial from the point of view of utility. I haven't had to solve a "word problem" in the last thirty years of my adult life but during the same time I have met and solved

dozens of problems every day.

What does problem solving involve? Hofstadter says it nicely in Godel, Escher, Bach:

> to respond to situations flexibly;
> to take advantage of fortuitous circumstances;
> to make sense of ambiguous or contradictory messages;
> to recognize the importance of different elements of a situation;
> to find similarities between situations despite differences that may separate them;
> to synthesize new concepts by taking old concepts and putting them together in new ways; and to come up with novel ideas.

PUZZLE TANKS, then, is concerned with problem solving in the Hofstadter sense. It is concerned with children's ability -- and willingness and confidence -- to make sense out of a situation and devise alternatives to reach a goal. The construction of alternatives, not the repeating of pat formulas, is what thinking and problem solving is all about.

About PUZZLE TANKS

One of the aspects of a good educational situation is that it deals with issues that are important. Problem solving is important.

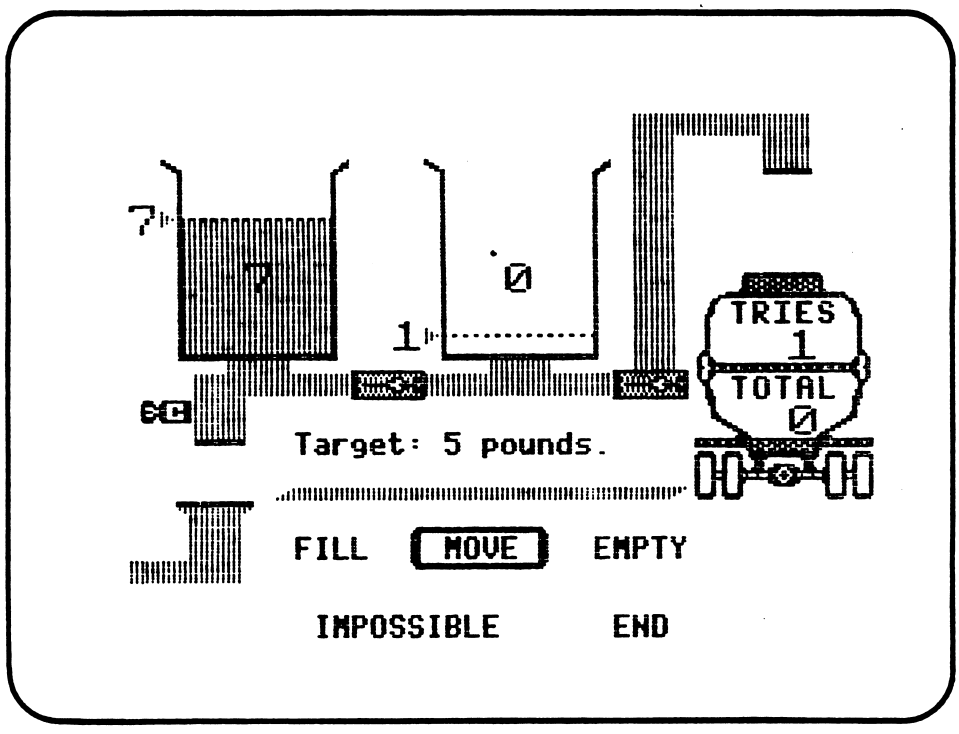
A second aspect of a good educational situation is that it enables the student to be active -- to invent ideas, to try them out and, if necessary, to revise them. The very nature of PUZZLE TANKS is that players invent solutions and revise them. Mistakes, by the way, are okay. (Can you conceive of an infant learning to walk without lots of falls at the beginning?)

A third aspect of a good educational situation is diversity. At each level of PUZZLE TANKS, what worked for the last problem is unlikely to work for the next. Further, every individual problem has many different solutions. There is no such thing as "the one right way."

A fourth major aspect of a good learning situation is that it has a wide variety of entry points and a high ceiling. PUZZLE TANKS starts with very simple problems, such as the 5 + 6 = 11 task described, but the higher level problems have stumped some very bright, well-educated people.

Thus, PUZZLE TANKS puts kids in real problem-solving situations.

PUZZLE TANKS



Skills: Addition, subtraction, multiplication and division

Grade Level: 3-8

Reading Level: 2nd grade

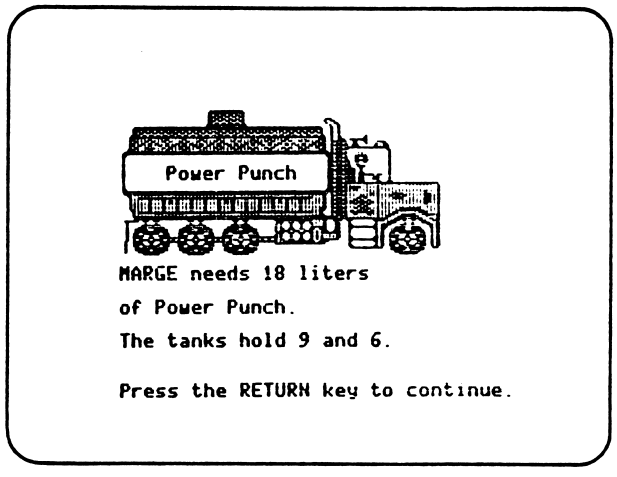
Objectives:

1. to develop skills in critical thinking and problem solving
2. to put students in a situation where they must invent ideas and try them out.
3. to reinforce concepts of addition, subtraction, multiplication and division in a problem situation.

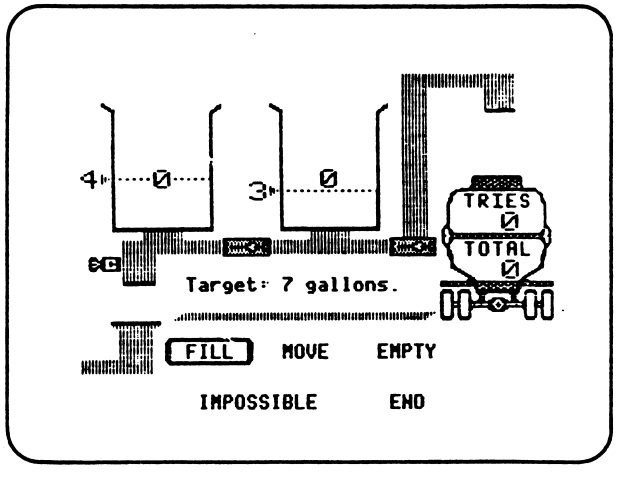
Program Description

In PUZZLE TANKS students are given the option of four levels of play: Beginner, Expert, Grand Master and Champion. Each level is increasingly more difficult. In the Champion level, the best scores are saved in a championship record.

After they select a level, the students are given a problem such as:



A graphic illustration of the elements in the problem is then shown. Students can attempt to solve the problem by filling tanks, moving liquids and emptying tanks.



Students select FILL, MOVE, EMPTY, IMPOSSIBLE or END by pushing the arrow keys (← , →) until the box surrounds their choice. They then press RETURN.

- FILL enables players to fill one of the two tanks. After selecting FILL, the players are asked which tank they want to fill or given a

BACK-UP option. Players select a tank or if they decide not to fill a tank, BACK-UP can be selected.

- MOVE allows the players to pour liquid from one tank to another. In the Beginner and Expert levels, a truck is available to use as a holding tank in addition to the two tanks. Having selected MOVE, players are shown pictures of the moves they can make. Again, the BACK-UP option is provided. Students select the move using the arrow keys and pressing RETURN. The liquid is then moved.

- EMPTY enables players to empty one of the tanks. The truck (in the Beginner and Expert levels) cannot be emptied. A BACK-UP option is also available. EMPTY removes the liquid from a tank so the student has a fresh tank.

- IMPOSSIBLE indicates that the problem is impossible. Some problems cannot be done with the numbers provided. Students must determine if the problem is impossible. If the problem is possible, the player will be charged with one try. If the problem in fact is impossible, the player is a winner.

- END enables players to start the problem over, to go to a new problem at the same level, or to return to the levels of play to select a different level.

Scoring

The program keeps track of the number of moves needed to solve each problem. In the Champion level, the number of moves is recorded on the diskette and the player that solved the problem in the least number of moves is listed as the Champion.

The Levels of Play

In the Beginner level, the problems involve simple addition, subtraction, and multiplication.

For example, given a 5 and a 6, make 11. Addition.

Given a 5 and a 6, make 1. Subtraction.

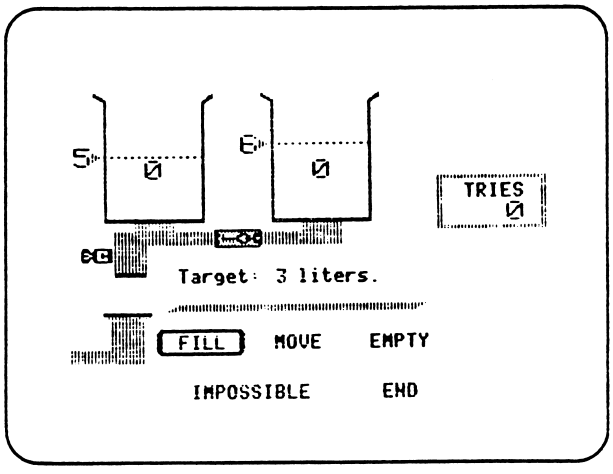
Given a 5 and a 6, make 25. Multiplication. That is, five fives.

Given a 5 and a 6, make 26. Multiplication and addition. Four fives plus a six does the trick.

In summary, if one tank holds "a" and the second holds "b," Beginners' problems use the following formulas: a + b, a - b, k*a (for example 6*a), k*a + c*b (for example, 4*a plus 3*b; i.e. four of one tank and three of the other will fill the truck), and k*a - c*b.

In the Expert level, the problems are not so easy. Here the tanks are chosen at random from 1 to 9 units and the goal is chosen at random. Suppose you had tanks holding 5 and 6 and the goal is 8. You could do eight 6-5's, emptying each 6-5 into the truck. Or you could do 6 + 1 + 1. (That is, fill the 6 and save it. Then fill the 6, pour it into the 5, empty the 5 and save the 1. Save another 1 in the same way.) Any other solutions?

As a Grand Master, the situation is completely different... there's no truck for storage! One must obtain the target with only the two tanks provided. (The computer is set to recognize a solution, whether it's in one tank or shared between the two tanks.)



Here's an example of a Grand Master problem: Suppose you had tanks of 5 and 6 and you want 3 units left in the two tanks! Here's a solution:

	Holds 5	Holds 6
Original situation:	0	0
Fill the 5:	5	0
Move the 5 to the 6:	0	5
Fill the 5:	5	5
Move the 5 to the 6:	4	6
Empty the 6:	4	0
Move the 5 to the 6:	0	4
Fill the 5:	5	4

Move the 5 to the 6:	3	6
Empty the 6:	3	0

The goal was 3, so the problem is solved. (Is there a solution with fewer steps?) (One major complaint of teachers, supported by research, is that many children can only solve "one-step" problems. Watch them here!)

Champion is the last level. Here, players' championship scores are recorded on the PUZZLE TANKS diskette and players try to solve various problems in fewer steps than the current champion. The diskette originally has no one holding the championship records. If a player beats or ties the current champ, his or her score is recorded. At all times, a player at this level can elect to replay a game to improve his or her record.

Impossible Problems

To spice things up a bit, some of the problems throughout PUZZLE TANKS are impossible. With or without a holding container, try to use a 2 and a 6 cup to make 1. It can't be done. With a 2 and a 6, only 2, 4, 6, 8, 10, etc. are reachable goals. In general, if the two tanks share a common divisor (for example, tanks of 3 and 9, 6 and 8, 2 and 10), only multiples of that divisor are possible. If the tanks share no common divisor other than 1, the sky's the limit! (For example, tanks of 3 and 5 can be used to obtain 1, 2, 3, 4, etc.)

Change Option

A Change Option is available for teachers to reset the scores in the championship level. This feature is only accessible when the levels of play are presented. To access the Change Option, hold the Control key and press the T key on the Apple computers; on the TRS-80 computers, hold the SHIFT key and the down arrow key while pressing the T key.

This option allows the teacher to reset the championship records on the diskette. The option can also be applied to a specific record. You might want to change a specific record when a player has typed in an inappropriate name or when a player or team has recorded an unbeatable score.) In resetting individual records, the teacher can enter a name and a score of his/her own choosing.

The Change Option can also be used to reset all championships when many Championship Level players are obtaining ties and when classes change at year's end.

On the Apple and TRS-80 Color computers, the Change Option can also be used to make the program play silently. By selecting Sound-Off, no sound occurs. If sound is desired at a later time, the Sound option can be changed to Sound-On.

Some Observations from Pre-Publication Tryouts

In field testing the program with children, the following observations were made:

1. Children were more able to "get off the ground" (i.e. get into the activities) than were many adults on whom PUZZLE TANKS was field tested.

2. Kids were immensely impressive in their growth from their first small steps to extremely complex thinking -- all without teacher intervention.

3. Even children who had rarely achieved school success -- the most disorganized, turned off, "failing" students -- achieved great success with PUZZLE TANKS. (Is this because it's not a paper-and-pencil activity? Because they were not being force-fed pre-cooked recipes?)

4. Many children preferred to work collaboratively, in groups of 3-4, rather than alone.

5. Some children spontaneously began to keep notes of their championship strategies so that they could attempt to beat their own score the next time around. Record-keeping, an important intellectual ability in itself, seems to be a worthwhile by-product of PUZZLE TANKS.

6. But perhaps most important are the problem-solving gains themselves. The National Assessment of Educational Progress (NAEP) and other sources report that children have great difficulty mastering even two-step word "problems" in traditional textbook format. With PUZZLE TANKS, it was routine that children became able to solve twelve- and fifteen-step problems with ease. Perhaps more important was their sense of condfidence, an issue rarely addressed in educational assessment. At all levels of play, many children looked at an extremely complex problem, said "I can do that," and proceeded to bang out an impeccable solution. Their complex analysis, planning and execution (their own constructions, not regurgitation of force-fed recipes) was ample evidence that knowledge is not a spectator sport.

APPLE II: WORKING WITH THE COMPUTER

1. Turn on the television monitor.

2. Insert the diskette into the disk drive with the label facing up and on the right.

3. Close the door to the disk drive.

4. Turn on the Apple II. (The on-off switch is on the back left side of the computer.)

5. You will see a red light on the disk drive turn on. If the disk drive light does not turn off in about 10 seconds, turn the Apple off and make sure your diskette is placed in correctly in the disk drive.

6. SUNBURST will appear on the screen.

7. Follow directions given in the program.

8. If at any time during the program you want to stop, hold the Control (CTRL) key down and press the E key.

9. To quit, choose the END Option on the menu.

TURNING OFF THE COMPUTER:

1. Remove the diskette from the disk drive and return it to its place of storage.

2. Turn off the Apple.

3. Turn off the television or monitor.

TRS-80 MODELS III and 4: WORKING WITH THE COMPUTER

1. Insert the diskette into the disk drive with the label facing up and on the right.

2. Close the door to the drive.

3. Turn on the computer.

4. You will see a red light on the disk drive light up. If the disk drive does not turn off in about 25 seconds, turn off the TRS-80 and make sure the diskette is placed correctly in the disk drive.

5. SUNBURST will appear on the screen, followed by a menu of levels.

6. Select the level you want.

TURNING OFF THE COMPUTER:

1. Remove the diskette from the disk drive and return it to its place of storage.

2. Turn off the computer.

TRS-80 COLOR: WORKING WITH THE COMPUTER

1. Turn on the disk drive. The switch is located in the back.

2. Turn on the television or monitor.

3. Turn on the TRS-80 Color Computer. The switch is located in the rear. On the television screen you will see:

```
Disk Extended Color Basic 1.0
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OK
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4. Insert the diskette in the disk drive with the label facing upward and to the right.

5. Close the drive door.

6. Type LOADM "PUZZLE"
   Press ENTER

7. SUNBURST will appear on the screen.

8. Follow the directions given in the program.

9. If at any time you want to stop the program, hold the Shift key and the down arrow and press the E key.

TURNING OFF THE COMPUTER

1. Remove the diskette from the disk drive and return it to its place of storage.

2. Turn off the computer.

3. Turn off the television or monitor.

4. Turn off the drive.

"WHAT HAPPENS IF...?" -- SUNBURST COURSEWARE AND WARRANTY

1. What happens if a program will not load or run?

   Call us on our toll-free number and we will send you a new diskette.

2. What if I find an error in the program?

   We have thoroughly tested the programs that SUNBURST carries so we hope this does not happen. But if you find an error, please note what you did before the error occurred. Also, if a message appears on the screen, please write the message down. Then fill out the evaluation form and call us with the information. We will correct the error and send you a new diskette.

3. What happens if the courseware is accidently destroyed?

   SUNBURST has a lifetime guarantee on its courseware. Send us the product that was damaged and we will send you a new one.

4. How do I stop the program in the middle to go on to something new?

   A program can be ended at any time by holding the Control (CTRL) key down and pressing the E key.

5. Can I copy this diskette?

   The material on the diskette is copyrighted. You <u>should not</u> copy the courseware.

6. Can I remove the diskette and use it in a different machine?

   No, it is not recommended.

Sunburst Lifetime Warranty Registration Form

Congratulations on your purchase of quality SUNBURST courseware! To register ownership and protect your lifetime warranty, please complete and return this card. The SUNBURST warranty—unlike any other—guarantees replacement of any program component that becomes lost or damaged during normal use. This warranty applies as long as the program is offered for sale.

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PRODUCT NO. DATE PURCHASED

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- ☐ magazine article.
  Name of magazine: _____

The education or computer magazine I read most is: _____

The three most important factors influencing my purchase decision are:

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- ☐ reputation of publisher
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- ☐ instructional quality
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- ☐ options to edit
- ☐ guide and support material
- ☐ ease of use
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