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Math Fluency Games

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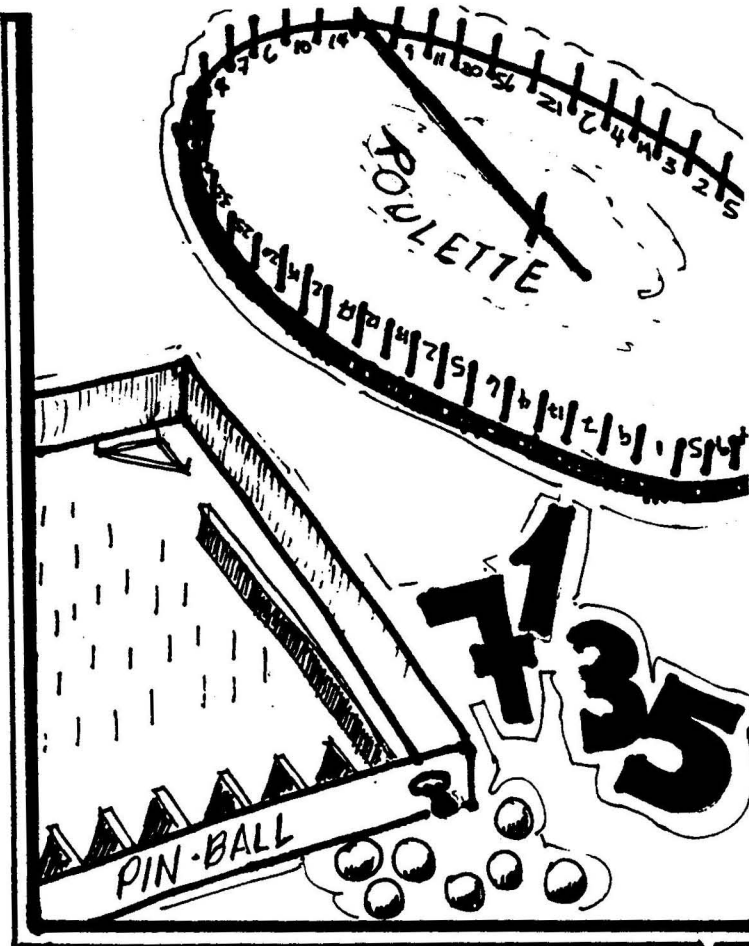
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TECHNICAL NOTE NO.

8



MATH FLUENCY GAMES

NOTE WRITTEN BY:

JOCK GUNTER

SUMMARY:

Math Fluency games are simple inexpensive devices designed to offer practice in the component skills necessary for performing arithmetic operations. In this note a variety of fluency techniques are discussed.

TECHNICAL NOTE SERIES/CENTER FOR INTERNATIONAL EDUCATION

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6. LETTER DICE: describes simple, participatory letter fluency games which involve illiterates in a non-threatening approach to literacy.
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21. Q-SORT AS A NEEDS ASSESSMENT TECHNIQUE: describes how a research technique can be adapted for needs assessment in nonformal education.
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26. RECORD KEEPING FOR SMALL RURAL BUSINESSES: describes how facilitators can help farmers, market sellers and women's groups keep track of income and expenses.

MATH FLUENCY GAMES

INTRODUCTION

Previous notes in this series have described market rummy and number bingo, two fluency games developed to offer practice in skills related to numeracy. In an effort to generalize about numeracy materials, and their role in the non-formal education project in Ecuador, this note will review the other eight number fluency exercises and games.

The word numeracy is closely associated with the word literacy. The Ecuador project has worked extensively with literacy and literacy fluency materials, and their role in our project has been discussed in note number nine. Many issues are common to both types of fluency materials and need not be reviewed here. However, there are significant ways in which literacy and numeracy are not alike. This note will concentrate on those areas.

Educators frequently calculate and comment upon their nation's literacy rates. But it is less common to hear one deplore low numeracy rates. Literacy, rather than numeracy, seems to have been chosen as the symbol of inclusion into the modern world. Reading and writing are seen as the measure of the "civilized" man. There are many reasons for this. Traditionally, formal education in Latin America has placed high priority on written expression, and has downgraded the importance of science and mathematics. Whereas literacy has a ready referent in daily life in the form of the spoken word, numbers are seen as tools of science, outside of the realm of daily experience of normal men.

In fact, though, one could argue that basic numeracy is far more useful to the Ecuadorean peasant than is basic literacy. Whereas there are virtually no reading materials available for peasant audiences, there are many situations calling for basic arithmetic skills. Any situation involving money requires such skills.

Nonetheless, the call for numeracy materials from the communities and institutions we serve has not been as great as that for literacy materials. Eleven number fluency materials have been developed, and four have seen substantial field use. As a result, the project has not delved deeply into the field of mathematics teaching. Rather, we have used a common sense approach to breaking down and presenting structured situations for practicing arithmetic skills. As with literacy materials, we have paid more attention to developing numeracy materials that would attract learners, than in maximizing instructional efficiency.

Teaching numeracy requires more extensive fluency materials than does teaching literacy. While literacy involves learning a limited code for a known form of expression (the spoken language), numeracy entails learning a new form of expression (numbers, numerical operations), as well as a symbolic written code.

The following list shows the main learner activity of each of the numeracy materials which have been developed. Each game focuses on one arithmetic skill, consequently ignoring others.

Some games present problems as obstructions; others (such as market rummy), couch them in terms of real life situations.

TABLE 1

| <u>Game:</u> | <u>The learner ability:</u> |
|--------------|--|
| bingo | marks the square on the game boards which contains the answer to the problem card (addition or multiplication) held up by the facilitator. |
| burro | assembles matching points from the problem (multiplication) and answer cards in his hand. |
| parchisi | divides a store of seeds as directed; distributes and receives seeds from other players. |
| roulette | spins the pointer; adds or multiplies the two numbers indicated by the two ends of the pointer. |
| ring toss | throws a ring around a peg near one of two problems; rings the corresponding solution. |
| pinball | shoots a numbered ball into a numbered slot; adds or multiplies the two numbers. |
| math soccer | answers a series of numerical problems (addition, subtraction, multiplication, and division). |
| dominoes | states which operation can create a valid equation between a number already played, and a number on the domino he wants to play. |
| number dice | tosses the dice; composes and solves as many problems as possible (operation may be addition, subtraction, or multiplication, depending upon the roll of the dice). |
| market rummy | multiplies commodity units by commodity unit prices; totals the value of his commodity cards and money cards; draws and discards cards; attempts to balance total value of commodities with total amount of money. |

Underlying the solution to any arithmetic problem, is a chain of more basic skills which must have been mastered. After listing these skills, and analyzing the game elements needed to teach each, the note will suggest the degree to which these skills are reinforced by existing materials, and to what degree they may call for new materials.

The most basic skill is to grasp the concept of quantity, the notion that more-than-zero is divided into discrete quantities.¹ Second, the learner must know which discrete quantities are represented by which number symbols. Then, he must understand the mechanics of the base ten number system, and the concepts of addition, subtraction, multiplication, and division.

Only after mastering the above skills, is the learner ready to deal with concrete arithmetic problems. At this point, numeracy materials can help him memorize the arithmetic tables covering single digit problems, and develop speed and fluency in computing problems involving larger numbers.

But these skills are not enough for practical purposes. The learner must be able to analyze situations to decide which arithmetic operations apply. And he must be able to synthesize the chains of arithmetic operations required to arrive at a real world solution to a real world problem.

Each numeracy game must include certain elements in order for the learner to acquire each of the skills described above. The following table delineates the elements necessary for each skill.

¹The question of fractions and decimals has not been a main concern of the project. The one fraction game which has been invented is included in the appendix.

TABLE 2

| <u>In order for the student to learn:</u> | <u>the materials must:</u> |
|---|---|
| 1. the concept of quantity ----- | represent various quantities |
| 2. the numbers representing specific quantities ----- | represent various quantities and their corresponding numbers |
| 3. the concepts behind the numerical operations (+, -, x, \div) ----- | demonstrate the process of performing the operations upon given quantities |
| 4. the arithmetic tables ----- | represent the number tables |
| 5. the mechanics for per- forming operations with numbers larger than those in the table ----- | represent the processes of manipulating large numbers in a base ten number system |
| 6. fluency in various arith- metic operations ----- | present problems for the stu- dent to perform |
| 7. selection of appropriate operation ----- | present various situations in which the student must choose the correct operation |
| 8. synthesis of operations ----- | present life-like situations where chains of operations are required |

The next table indicates which skills are taught (and which are neglected) in each game.

TABLE 3

| GAME/SKILL | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|--------------|---|---|---|---|---|---|---|---|
| Bingo | | | | | X | X | | |
| Burro | | | | | X | X | | |
| Parchisi | | | | X | X | X | | |
| Roulette | | | | | X | X | | |
| Ring toss | | | | | | X | | |
| Pinball | | | | | | X | | |
| Math soccer | | | | | | X | | |
| Dominoes | | | | | | X | X | |
| Number dice | | | | | | X | | |
| Market rummy | | | | | | X | X | X |

With a few exceptions, the materials' prime focus is on arithmetic operations. The bingo and burro games deal mostly with the solution to single digit problem cards. As a result, they focus more than other games on the process of rote memorization of arithmetic tables. The parchisi game extends down to the next lower skill level by having the learner divide quantities (piles of seeds). The dominoe game deals with a higher level by making the learner choose the problem which will yield a particular solution. It requires that learners analyze which operation fits a given situation. The market rummy game is the most complex of the fluency games. It demands that the learner synthesize a chain of arithmetic operations to compute values of his cards, and that he define and execute strategy for adjusting the values of his cards.

None of the games deal with the first two skill levels. Table Two indicates the instructional elements of these levels. Flexible sets of materials could be produced easily by adapting the rubber stamp literacy method (described in note number nine). By communicating visually and symbolically in parallel statements, facilitators could teach basic number skills. For example, a piece of paper with a group of three oranges stamped on the left side and four oranges stamped on the right side can be used to reinforce the concept of quantity. By stamping the corresponding number symbols below each group of oranges, learners could practice using number symbols and reinforce their understanding of their values.

It is not known whether materials are needed more for the three most basic skill levels, or whether learners would profit more from continued refine-

ment of materials dealing with the higher skill levels. The answer to this question would require extensive research into how campesinos learn arithmetic. Some groups could be provided with fluency materials covering the range of skills, others with existing fluency materials, and still others with new materials developed for higher skill levels.

There are serious questions, however, about the wisdom of allocating large amounts of project time and resources to such large-scale evaluations of cognitive outcomes. Such research would reduce project activities in other areas than numeracy. (The entire field of cognitive skill development represents only a minor focus for the project.) Also, there are serious value questions involved in developing professional materials for non-formal education, which aims to leave curriculum decisions in the hands of learners. (These issues are explored in greater depth in note number 9, which discusses literacy fluency materials.) Project participants now creating literacy and numeracy materials see value in developing and proving a broader, more flexible "menu" of materials, from which individual learners can choose. They do not want to undertake extensive evaluations to demonstrate one specific sequence of materials as more efficient, and then to distribute that set of materials alone.

In addition to skill level, there is a second important respect in which number fluency materials vary: the extent to which the learner participates actively or passively. Some exercises dealing primarily with middle levels of skill tell the learner which problem he will attempt to solve. Others allow the learner to participate, in varying degrees, in forming the problem he will confront. Some materials specify only the operation to be practiced, and leave problem formulation to chance or to strategy.

Games vary in the degree to which they involve learner initiative in the dynamics or flow of play. Some materials require one correct response per stimulus. After confirmation or correction of the learner's response, the game gives another stimulus. Materials on the other end of the continuum are designed so that each stimulus from the game engages the learner in a series of decisions and actions. The chart below examines the range of materials as they relate to variables dealing with activity-passivity of the learner.

TABLE 4

| | Problem is predetermined | Operation is predetermined | There is only one response per stimulus | Responses are either correct or false |
|--------------|--------------------------|----------------------------|---|---------------------------------------|
| Bingo | X | X | X | X |
| Burro | X | X | X | X |
| Parchisi | | X | X | X |
| Roulette | | | X | X |
| Ring toss | | | X | X |
| Pinball | | | X | X |
| Math soccer | | | X | X |
| Dominoes | | | | X |
| Number dice | | | | X |
| Market rummy | | | | |

The games in which the learner is most passive are those in which he does not participate even in selecting problems. In the Bingo game, for example, the sequence of stimuli is determined by the facilitator who chooses randomly from a shuffled deck of problem cards. Likewise, in Roulette, Pinball, and Ring Toss, problems are presented to, not chosen by, the learner. In these three games though, accuracy is judged by the group of players, not by the game itself or the facilitator, on operations ranging from 2×2 to 9×9 .

This game places the learners in a slightly more active role, because although the problems are pre-structured by the game cards, and a correct response (answer card) is available for each stimulus (problem card), the group of learners controls the flow of the game. There is no facilitator determining the sequence of stimuli.

This game forces the learner to demonstrate the process of division. Operations are performed physically, and number symbols are not involved. This is the only game that functions without written numbers.

The math soccer game places the learner in an even more active role. In this game, the successful player will run through a sequence of stimuli and responses culminating in a goal. The length of his turn depends upon his ability to provide correct answers.

The domino game differs considerably from the others in that there is more than one correct response (domino which can be played) to each stimulus (domino which has been played previously), and that the operation to be used is not specified in advance.

The number dice game places the players in a very active role. All of the dice contain a single digit number except one, which contains symbols

for arithmetic operations (+, -, x appear twice). The player generates the game stimulus himself when he throws the dice. In the most common version of the game, the player tries to compose problems by arranging some or all of the dice, and to recite aloud the solutions to the problems.

Players assume their most active role in the market rummy game. The stimuli (commodity and money cards) are generated by the learners, not by a facilitator. Each stimulus elicits a chain of calculations from the player and a decision as to which card to discard. Learners are not told which operations to use or in what sequence. They must decide upon a strategy for balancing total values of commodity and money cards on their own.

CONCLUSION

With further development of numeracy fluency materials, it should be possible to offer learners both active and passive roles on all skill levels. Additionally, it may prove more effective to begin learning a new skill in a passive role and later to move on to an active role in order to reinforce and consolidate that skill. Although evaluation could attempt to answer these questions definitively for certain populations, the project staff would prefer to let each community answer them in their own environment. Future project efforts in numeracy materials development should probably be in developing a more extensive "menu" of materials for communities involved.

APPENDIX

Name: number bingo

Developed by: Patricio Barriga, James Hoxeng

Description: a math fluency game in which players seek answers on their game boards to problems shown and read from problem cards by the facilitator.

No. of participants: from two to ten

Subject matter: addition and multiplication tables

User level: mastering the number symbols and the concepts of addition and multiplication

materials: game boards which include answers to problems
problem cards covering arithmetic tables (in the case of addition from $1+1$ to $12+12$, in the case of multiplication from 1×1 to 9×9
a bag of seeds with which players can mark squares on their boards

process: the facilitator distributes the game boards, along with an ample supply of beans for each player. He then shuffles the deck and begins to present problem cards to the group, first holding up the problem card, then reading it aloud once the students have had a chance to try to decipher the problem for themselves.

Students who have that number on their game board cover that square with a seed. The first player to complete a horizontal, vertical, or diagonal line across the board wins. Alternately, play may continue until one player has covered his entire board.

When play has ended, the winner reads aloud the numbers he has covered with seeds. The group must agree that these numbers were valid answers.

(For further information on this game, see technical note number seven.)

Name: Burro

Developed by: (based on an indigenous game)

Description: a drill for multiplication tables

No. of participants: from two to eight


Subject matter: multiplication tables

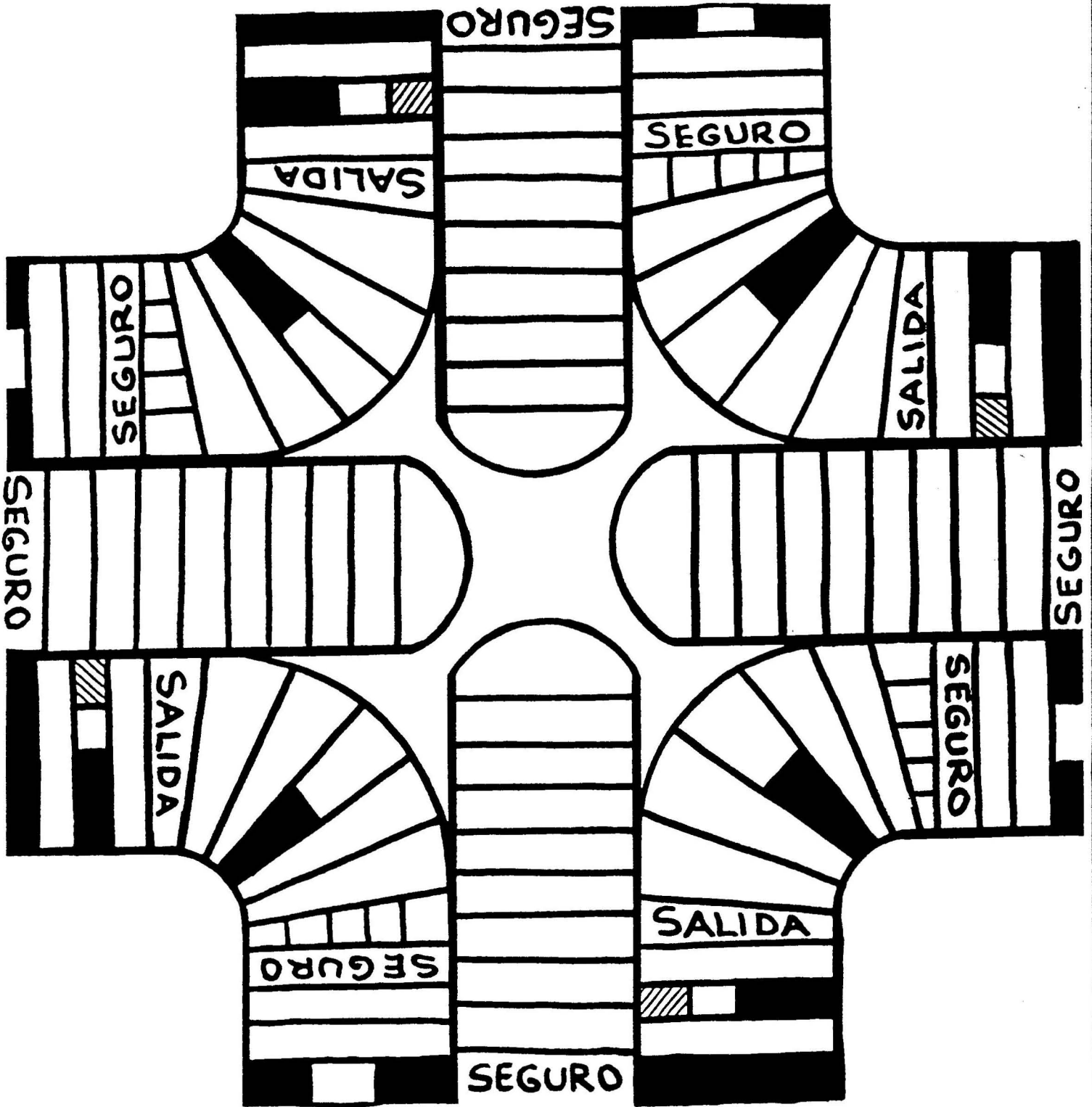
User level: mastering the number symbols, and the concept of multiplication

Materials: cards containing the multiplication problems 1x1 to 9x9; cards containing the solution to the problems; one card with "burro" written on it

process: All the cards are dealt to the players. The player to the left of the dealer looks in his hand for matching pairs of problems and answers. If he has any, he places them on the table in front of him. After the other players verify their correctness, he turns to the player to his left, with his cards held up, but with their faces out of the view of the other player.

The next player takes a card from his hand. Then he tries to match problems and answers in his hand. He then turns to the player to his left, who must choose a card from his hand. Play continues until one player has no more cards in his hand. The player with the "burro" card at this point is the loser.

- Name: Parchisi
- Developed by: Eugenia Caceres
- Description: Based on the popular game parchisi, the game has players rotate around a game board. At certain points, players are forced to divide their tokens, and pay them to other players. The player who first completes the circuit, without losing all his tokens, is winner.
- No. of participants: from two to four players
- Subject matter: fluency in division
- User level: mastery of the concept of division
- Materials: one game board, two dice, sixteen markers of four colors, sufficient tokens (upwards of 160) for four players. Tokens can be corn, beans, matches, or any small locally-available item.
- Process: The rules are basically those of the popular game of parchisi. Every player receives his own markers (from one to four, depending upon how long the game is to be). Each player receives ten tokens per marker.
- Players roll one dice. The player with the highest number begins play by rolling both dice, three times. He needs doubles in order to leave his corner. Double ones and double sixes permit him to move all his markers into the exit square. Other doubles permit him to remove only one. If he doesn't get doubles, he must wait for his next chance.
- Once a player has gotten one or more markers out of his corner, he begins to follow the path around the game board toward the center. (See attached game board.)
-  When a player lands on a square divided into two or more parts, he must divide his tokens into that number of parts and divide them among the players according to the colors represented. For example, if the red player arrives at the square divided into blue, he may keep half his tokens, but must give half to the blue player. Squares may be divided into two, three, four, or five parts.
- When two players arrive at the same square, the one who arrives second sends the other back to his starting point. Only on the square marked seguro, is a player safe.
- In order to win, a player must arrive at the center, and must have more tokens than the other players.



Name: Roulette

Developed by: Mauro Jacome

Description: A game in which the spin of the pointer poses arithmetic problems for the player to solve.

No. of participants: two people or two teams

Subject matter: Practice in addition and multiplication problems.

User level: Mastery of number symbols and the concepts of addition and multiplication.

Game materials: A flat wooden circle, with nails driven in vertically along the circumference of the circle. A pointer extends out in both directions from the center, where it is mounted so that it can rotate freely. The ends of the pointer are flexible, so that it can pass by the nails. After a spin, however, it will come to rest in one of the numbered spaces.

Process: One player spins the pointer. It comes to rest pointing at two numbered spaces, one in each of two opposing quadrants. The numbers are between one and twelve. According to the decision made at the start of the game, the player must either multiply or add the two numbers. His opponent or the opposing team then spins the pointer. Score is kept according to which contestant has the greater number of correct answers.

Name: Ring Toss

Developed by: Michael Haviland

Description: Ring Toss is a skill-practice game combining both physical dexterity and math knowledge to allow participants to practice basic math operations.

No. of participants: from four to twenty

Subject matter: Basic Math

User level: Low to medium levels of basic math proficiency.

Materials: Game board and eight colored rings - colors should be paired.

Process: The Ring Toss board is placed on the floor and a line approximately 7 feet away is drawn also on the floor. The rings are tossed from behind this line.

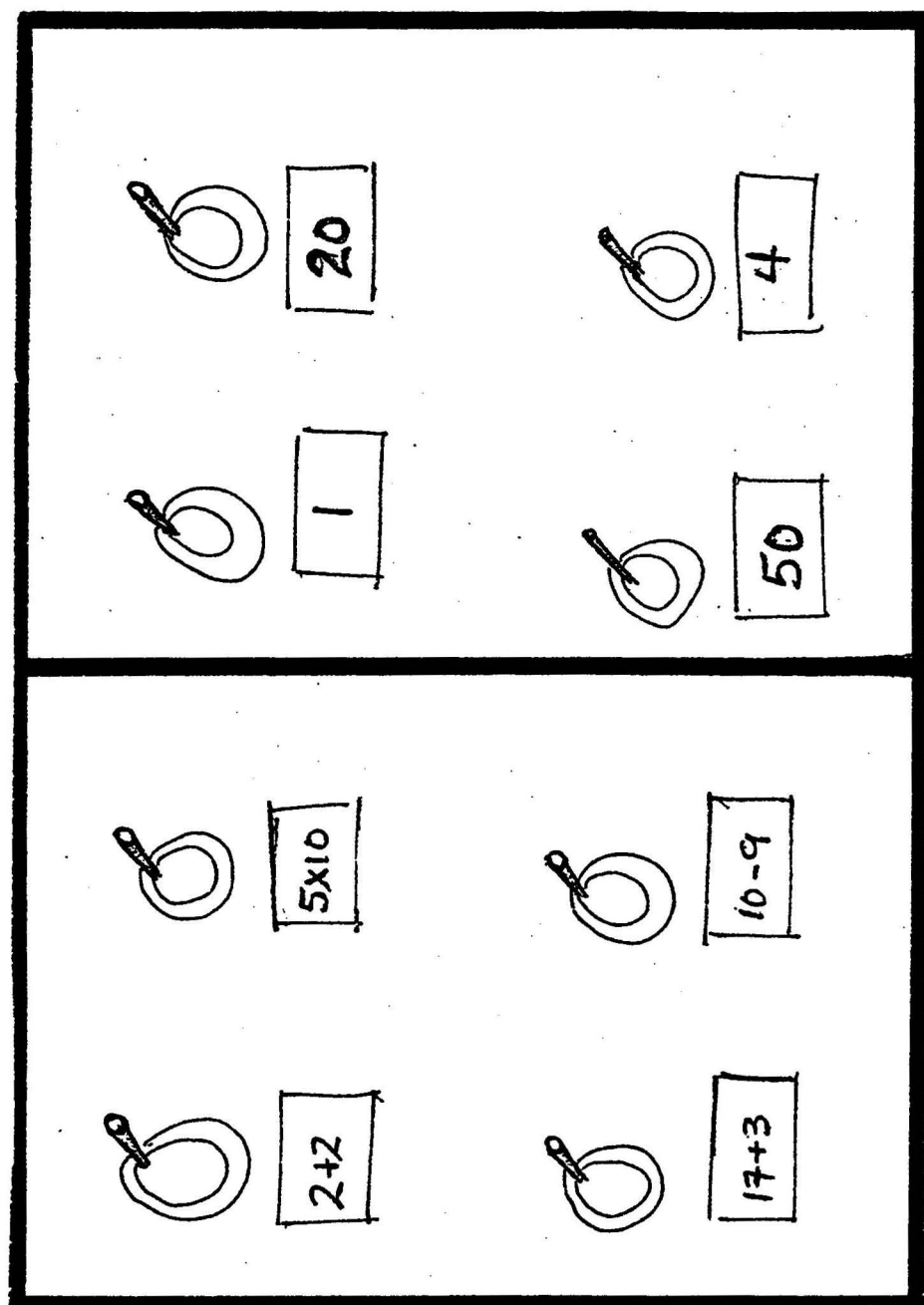
One player draws a "PROBLEMA" card from the deck and writes the four problems on the "Problema" side of the board. He also writes the answers of the problems on the "Respuesta" side of the board. The "problema" card is then hung on a hook on the front of the Ring Toss board.

The first player takes two rings. If he is able to ring both a problem and the correct answer, he scores the point and an answer. If the player rings a problem but does not ring an answer or rings an incorrect answer, his rings are removed from the board and the next player has the opportunity to ring both a problem and a correct answer.

When a "problema" and a correct "respuesta" have been ringed, those rings remain on the board until all four problems and correct answers have been ringed. At this point, a new "Problema" is drawn, the new "problemas" and "respuestas" are written on the board and the game continues. The game ends when one player has scored 15 points.

This game could be used to practice skills in any area where information is important; for example, history, geography, politics, health, nutrition, or agriculture, by matching vitamins with foods or classes of earth with kinds of fertilizers.

The pilot testing should specifically look for the appropriate mix of skill and knowledge. Does the physical difficulty of making a ringer interfere with the learning? The board should be constructed so that it can be replicated in a rural area and so that the physical and mental difficulty are mixed.



Ring Toss Game Board

Name: Pinball

Developed by: Mauro Jacome

Description: A fluency game for practice of addition and multiplication problems.

No. of participants: from two to eight

Subject matter: arithmetic operations

User level: mastery of number symbols and the concepts of addition and multiplication

Materials: A mechanical pinball machine made of wood; a rubber band for propelling marbles. The marbles and the slots at the bottom of the machine are numbered. The balls reach the slots after traveling through a forest of nails.

Process: Learners agree at the outset whether the game will be a multiplication or an addition game. The first player takes the pinballs, fires them one by one, and then adds or multiplies the numbers on the balls by the numbers on the slots they land in.

Name: Math Soccer

Developed by: Arlen Etling

Description: Math Soccer is a simple board game intended to provide skill practice in math. Using Soccer as the motivation and board format, facilitators can provide an alternative to number dice in the reinforcement of math skills.

No. of participants: Two

Subject matter: Math operations - addition, subtraction, multiplication, division, and compound problems.

User level: One who needs practice in math operations.

Materials: Game board, cards, a marker to represent the ball.

Procedure: Separate cards into five piles according to the number on the back of each card -

- 1 is for addition problems
- 2 is for subtraction problems
- 3 is for multiplication problems
- 4 is for division problems
- 5 is for compound problems (how much would you pay for 9 oranges at 4¢ each if you share the cost with 2 other friends?)

Place the piles beside the game board. Place the "ball" on the "x" at mid-field. Flip a coin to see who starts. That player passes the ball along one of the arrows to a new position. He must then draw a card whose number corresponds to the number at the end of the arrow along which he has just moved. He reads the problem and responds. If his answer is correct, he may move the ball again to a new position, following one of the arrows, and pick a new card. When an incorrect answer is given, the ball is returned to the previous position and the opposing player gains possession. He then moves toward his goal following the arrows and responding to the problems on the cards until he makes a mistake. A goal is scored when a player advances the ball into the net which his opponent is defending.

Variations:

1. If there are many who want to play, the learners can be divided into teams. A team captain can be named. He will assign players to fixed positions. If the ball comes to a certain position (closed circle) then that player must answer the question. In this case, two players will occupy each position; one is the offensive player for one team, the other is the defensive player for the other team.
2. As the players gain skill a "goalie rule" can be added which says that a team does not score a goal unless the opposing team's goalie fails to answer a question on a 5 card.
3. An optional rule would be that a

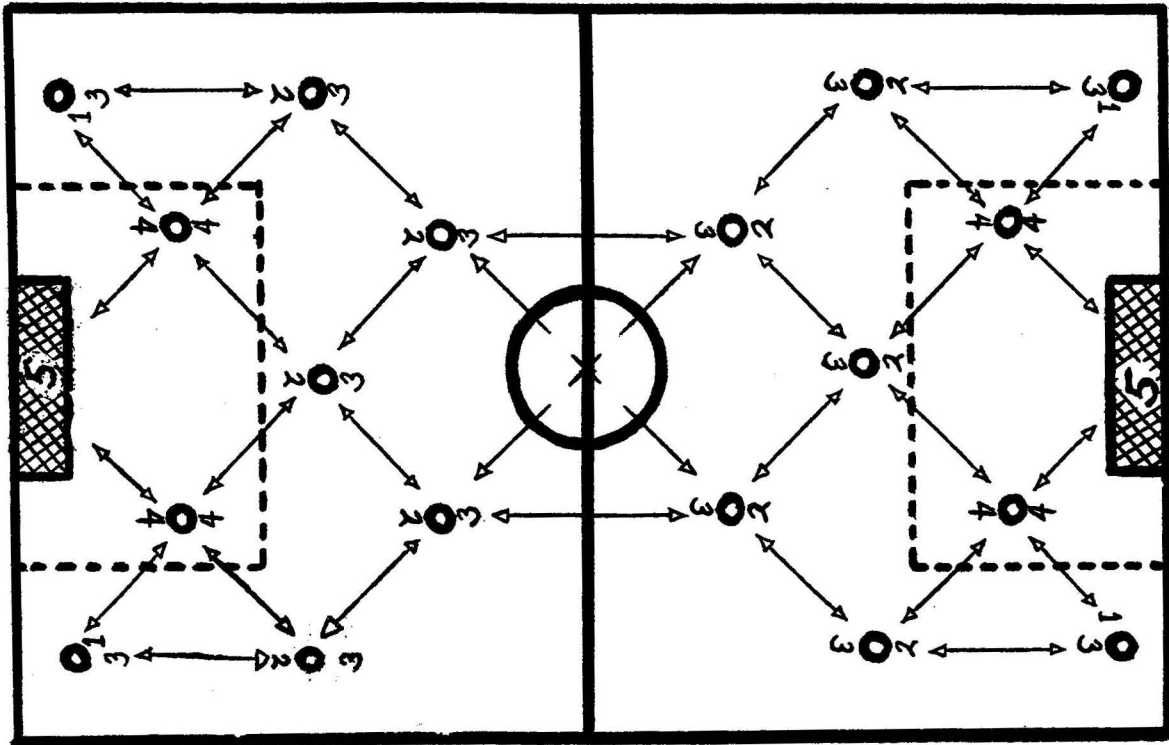
team can advance only one position each turn. Then the other team would have its turn. So if both teams successfully advanced the ball on a given turn the ball would end up where it began.

Comments:

This game may be a prototype for any information transfer. A reading literacy game could be constructed by merely substituting a new set of cards -
1 is for letter recognition (to read & pronounce)
2 is for syllable recog. (" " " ")
3 is for word recognition (" " " ")
4 is for phrases (read aloud)
5 is for sentences (read aloud)

Fewer cards should be used for beginners so they can practice and repeat familiar operations. As players gain facility the cards in each pile can be increased and made more difficult.

MATH SOCCER GAME BOARD



Name: Dominoes

Developed by: (traditional)

Description: An adaptation of a traditional game to teach arithmetic operations.

No. of participants: from two to four

Subject matter: the arithmetic operations.

User level: Mastery of number symbols, the concepts behind the arithmetic operations, a degree of fluency with the operations.

Game materials: Rectangular-shaped dominoes which contain a number symbol at each end.

Process: The dominoes are distributed to the players. One player begins by placing a domino in front of him. The next player may play a domino only if he can construct an arithmetic relationship between one of the numbers on the initial domino and one of the numbers of one of his dominoes. For example, a player may place a domino with the number 21 on it next to a domino with the number 3 by stating: "3x7 is 21." Dominoes may be played vertically or horizontally next to another domino. The goal is to get rid of all the dominoes in ones hand.

Name: Number Dice

Developed by: Pat Burke

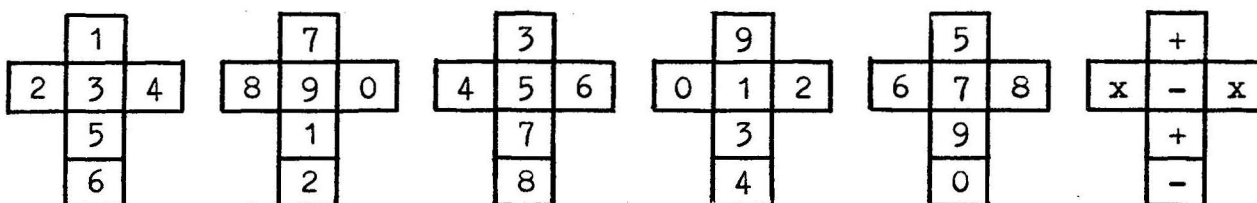
Description: Number dice provides practice in basic mathematics. It allows students to make a number of common operations on a continually changing base of numbers.

No. of participants: from two to ten

User level: Mastery of number symbols and basic operations

Subject matter: Basic Math

Materials: 1 set of 6 dice (with extras available) for use in the following format:



Process: There are three basic kinds of games possible with the number dice.

1. Getting to a Solution:

The basic idea of this type of game is that a number, or a series of numbers, determined beforehand to be the answer, is set up as the desired solution. A player must make arithmetic combinations (adding, subtracting, multiplying, or dividing) with the numbers showing on his dice to reach the desired solution.

A. Spending the Money

One player draws a card from a deck with amounts of money represented on a teach card (or a certain die is used to represent the money). The object of the game is to find ways to spend that amount. Each player throws from 3 to 6 dice and, using the numbers shown, tries to find an arithmetic combination which would give him the solution. He can tell a story such as: "I bought 3 lbs. of onions at 6¢ a lbs., and in this way I spent the 18¢ (solution)." Or "I spent 6¢ on onions, 3¢ on carrots and 9¢ on salt totaling 18¢."

The first player to find a correct solution could win, or a point system can be used where each player could get points for his correct solutions or where other players could be given a chance to "better" the first solution by using more dice.

B. Making an Equation

A single die is thrown as a desired answer. All players throw their dice, the number of dice used varying with skill, and try to make an equation

equalling the desired solution. Special dice with addition, subtraction and multiplication signs rather than numbers can be thrown with the other dice. Beginners may choose to use these dice any way they want. Winning strategy is the same as described above.

C. A Series of Solutions

A series of numbers is chosen as a set of desired solutions (1 to 10, or 10 to 15, etc.). The choice can depend on the skill to be practiced. Players throw dice to seek combinations of numbers which have any of the numbers in the series as their solution. This answer is then checked off. On the next roll of the dice, a player seeks to find another number in the series as a solution. The first player to "check off" all the numbers in the series is the winner.

2. Making a Correct Problem:

The basic idea in this type of dice game is to use the dice for arithmetic drill and practice. The players do the required tasks and are rewarded for a correct solution.

A. Drill Practice

Players roll dice and perform the mathematical operation specified. Rules should be set according to skill; a special die with addition, subtraction and multiplication signs may be used if practice in these skills is desired. Players may check each other's answers, or one player may have access to the answers.

B. Buying a Product

A card or single die represents the cost per unit of a product. Players throw their dice to find out how much they have to spend. They total the dice, or perhaps multiply if the same number turns up on more than one die, to get this amount. The object of the game is to figure out how many products you can buy with the amount you have thrown. The player to buy the most, provided he's worked out the correct solution, is the winner. Another possibility is that scores can be kept for several rounds, prolonging the game. Players could also save change left from play to play to use in a future round. This "change" could be represented by a card or a die.

3. Approaching a Solution:

Played like "21", the card game, a number is first decided on as the maximum number to try to attain. 21 may be used to begin with. Each player rolls out two dice. He adds the numbers that turn up, and decides whether he wants to add still another number. Players who choose another number then roll a third die. The player who reaches 21, or comes closest without going over, wins. Small bets can be made between rounds as they are in "21".

Advanced players could be allowed to use other mathematical operations than addition. Permitting all four basic operations would make the game very challenging.

An important aspect of this game is that there is not a single correct solution that a player is aiming for. The value of the game is in the process of figuring out a range of solutions.

TECHNICAL NOTES

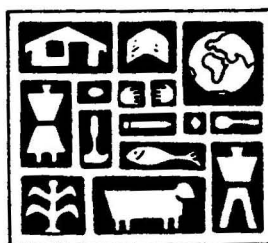
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The project was financed by USAID and was a joint undertaking of the Ministry of Education in Ecuador and the Center for International Education at the University of Massachusetts. Ideas and materials derived from the ideas were created jointly by staff in Massachusetts and staff in Ecuador. All materials have undergone considerable change in the field as usage in various situations indicated needed modifications. The notes attempt to accurately credit the creators of each technique. In some cases, though, ideas have been modified by a variety of people and precise assignment of credit is difficult. In all cases, various members of the staff have made substantial inputs into the final version of the materials.

After three years of effort the number of people in Ecuador and in the United States who have made substantial contributions to this project is considerable. Rather than trying to enumerate the particular contributions of each, we will only note that this has been a genuine bi-national effort.

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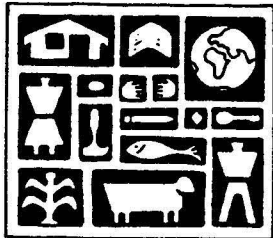
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