

**DEVELOPING VISUALIZATION THROUGH GAMES AND PUZZLES**

A special project report

by  
**SHAH G. A.**

Guide  
**U. A. Athavankar**

**INDUSTRIAL DESIGN CENTRE  
INDIAN INSTITUTE OF TECHNOLOGY  
BOMBAY  
APR. 1989**

# **DEVELOPING VISUALIZATION THROUGH GAMES AND PUZZLES**

A special project report

by  
**SHAH G. A.**

Guide  
**Prof. U. A. ATHAVANKAR**

**INDUSTRIAL DESIGN CENTER  
INDIAN INSTITUTE OF TECHNOLOGY  
BOMBAY  
APR. 1989**

APPROVAL SHEET

The special project titled ' DEVELOPING, VISUALIZATION THROUGH GAMES AND PUZZLES ' by SHAH G.A. is approved in partial fulfilment of the requirement for M.Des degree in Industrial Design

Signature



Date 13-7-89

Guide

## ACKNOWLEDGEMENT

I sincerely thank Prof. U. A. Athavankar for his valuable guidance and encouragement throughout this project.

I sincerely thank all concerned faculty, staff and my fellow class mates also for their kind help extended for this project.

SHAH G A.

CONTENTS

|                        |    |
|------------------------|----|
| 1. INTRODUCTION        | 1  |
| 2. OBJECTIVE AND SCOPE | 3  |
| 3. THE FORMAT          | 11 |
| 4. BIBLIOGRAPHY        | 14 |

## 1. INTRODUCTION

## INTRODUCTION

Thinking is central to human existence. It not only is habitual; it is compulsive. We gather information from the environment with our senses and process it. Thus thinking, in essence, is information processing. It requires words, abstract concepts and images. When we think using words - as we almost always do - we are indulging in verbal thinking. This is characterised by inner speech. Thinking with abstract concepts like those in algebra is termed as abstract thinking. When thinking involves visual images it is called visual thinking.

Visual and verbal (or abstract/mathematical) thinking are complementary by virtue of differences in structure. Verbal and mathematical symbols are strung together linearly in conventional patterns such as those afforded by grammar. Mentally tracking these linear structures automatically enforces certain thinking operations. Visual thinking by contrast is wholistic, spatial and instantly capable of all sorts of unconventional transformations and juxtapositions. This is because visual thinking involves images which are not an exact replica of reality. These images are a highly personal creation and are more flexible and encompassing than any reality. By virtue of its flexibility visual thinking is a very powerful thinking tool. It can be immensely helpful in creative thinking because of innumerable

possibilities of transformations.

Visual thinking pervades all human activity. Most memory systems rely heavily on visualization. Designers, engineers, architects use it most often. Athletes often visualize scenes during practice. Physicists exploring the world of atomic and sub-atomic phenomena use it. Surgeons think visually while performing operations. Carpenters and mechanics use it to translate plans into actions. Unlike verbal and mathematical thinking, visual thinking is laden with sensory content which lead to pleasurable experiences.

Most of our thinking is neither purely verbal, nor abstract and nor purely visual. Most of the time it is a dynamic combination of all three modes. Each mode has its limitations. But, of late, an increasing number of educationists and psychologists are condemning our current system of education, for it actively discriminates against visual thinkers and favours the verbalizers. We are relying more and more on verbal thinking. This can result in visual atrophy. This can be compensated for through games and puzzles that call for reliance on visualization. Whether these games and puzzles are evaluative or training oriented is immaterial so long as the emphasis is on visualization and its mental operations.

## **2. OBJECTIVE AND SCOPE**

## OBJECTIVE AND SCOPE OF THE PROJECT

The dictionary defines the term 'visualize' as follows:

1. To make perceptible to the mind or imagination
2. To form a mental image of
3. To call up images.

It is the second meaning that the project lays emphasis on and goes one step further in the sense that it emphasizes the basic mental operations of visualization as well. The objective of the project is to design puzzles that help one develop one's visualization. The puzzles are so designed as to discourage dependence upon surrogate modes of thinking such as verbal logic/reason and mathematical logic. They encourage dependence upon visualization.

Most of the work done in this area so far revolves around certain themes which are as follows :

### 1. TWO DIMENSIONAL MANIPULATION :

This involves visual-spatial operations in two dimension. The operations include pattern seeking, matching, folding and mirror-imaging.

a) Pattern seeking : This is one of the most common and active mental operation of visualization and contributes greatly to perception. It is closely allied to the act of visual thinking. An example of this is shown in Fig.1. The task here is to find out which of the figures a,b,c and d has the given figure hidden in it. (answer b and d)

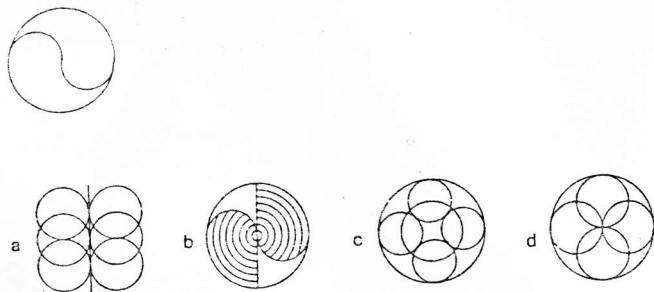


fig. 1

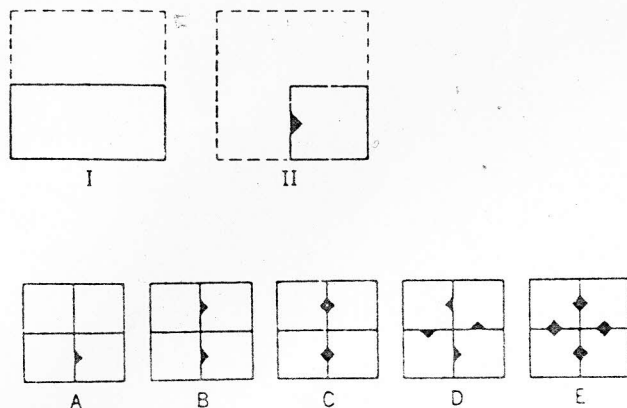


FIG.2

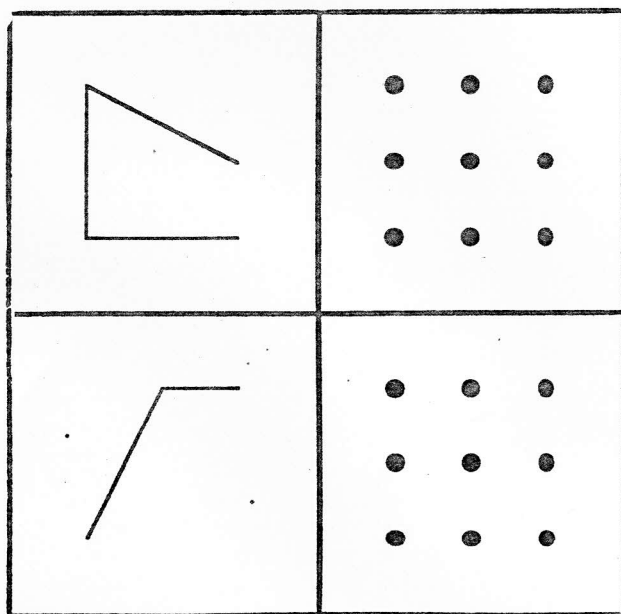


FIG.3

(Robert McKim, EXPERIENCES IN VISUAL THINKING,  
Brooks/Cole Publishing Co.,1972)

b) Matching : Another kind of visual operation involving pattern perception is matching.

This operation is extremely common and is fundamental to all thinking.

c) Folding : A sample example is given in fig.2. Diagrams I and II show two steps in folding a square piece of paper and cutting a notch in a certain location. Which alternative shows how the paper would look when unfolded ? (Answer C). This involves figural transformation and is good for visualizing two dimensional transformation.

d) Mirror-imaging : This is, to some extent, similar to figural transformation occurring in folding. A sample problem is given in fig.3. Here one has to draw the mirror image of the figure on left, mentally. (Robert McKim, EXPERIENCES IN VISUAL THINKING, Brooks/Cole Publishing Co.,1972)

## 2. ORTHOGRAPHIC IMAGINATION :

It involves building up three-dimensional objects from orthographic views or inversely, visualizing the object from different view points. In fig.4, which of the figures a,b,c and d shows the view of the object from a different view point ? (answer c) (Robert McKim, EXPERIENCES IN VISUAL THINKING, Brooks/Cole Pub.Co,1972)

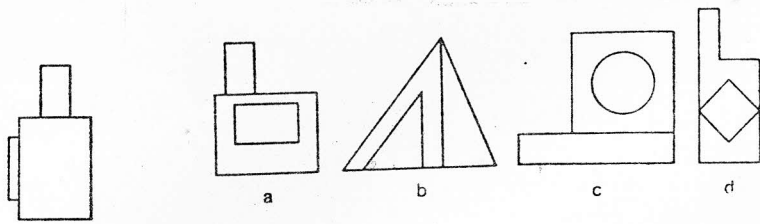


fig. 4

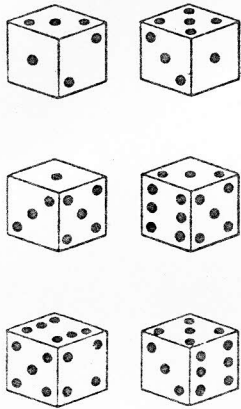


fig.5

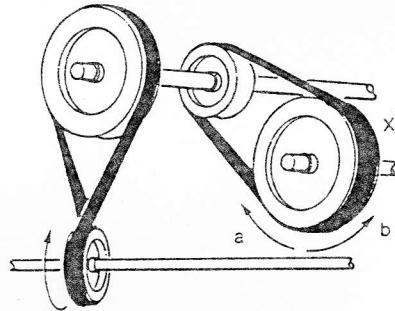


Fig. 6

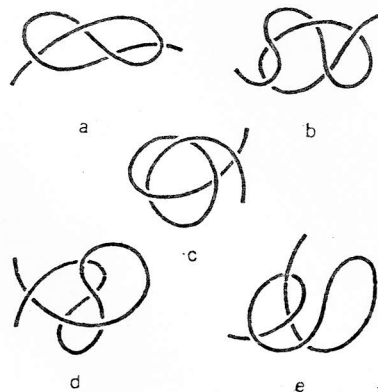


fig.7

### 3. THREE DIMENSIONAL MANIPULATION :

This includes 3D rotations and dynamic systems. Fig.5 shows three pairs of different views of a dice. The task is to visualize if the view on the right side in each pair can be arrived at from that on the left by performing rotation operation on it. Here one visualizes not only the rotation about a particular edge or axis but the number of dots on the hidden faces.

Another kind in this category is a system of rotating pulleys as shown in fig.6. The subjects are required to say which way pulley 'X' will rotate. This problem encourages the subjects to actually feel ( through visualization) the rotational motion of the pulleys and belts.

Yet another interesting problem which comes under this is that of knot as shown in figure 7. Of the five strings shown which ones when pulled at the ends form knots ? (Answer b,c) (Robert McKim, EXPERIENCES IN VISUAL THINKING, Brooks & Cole Pub. Co., 1972

This is a challenging problem and taxes the faculty of visualization. As one tried to solve these puzzles, one actually goes through a series of intermediate stages as the ends are pulled. These are called dynamic systems because they involve visualization of motion.

Psychologist Robert Sommer, in his book 'The Minds Eye' refers to the following work done in this area. An excellent workbook for visualization training has been prepared by Kristina Hooper for England's Open University. It uses radio, T.V. and part time instructors. The workbook accompanying the section on 'Imaging and Visual Thinking' contains many valuable exercises for developing imagery. They include, besides encouragements and practice in visualization, exercises to develop clear perception in all the senses through sketching, photographing objects from different angles, touching objects, being sensitive to what is heard, smelled and felt; practice in reconstructing the process of creating something, for example a bookcase one has built (Robert Sommer, THE MINDS EYE, Delta Publishing Co; INC, 1978, p.142.)

Grace PetitClerc gives an interesting teaching tool in his book 'The 3-D test for visualisation skill'. In this a child is asked to explore objects that she can't see, using touch and her powers of visualization. ( Robert Sommer, THE MIND'S EYE, Delta Publishing Co, INC, 1978, p.142.)

Richard DeMille in 'Children's Imagination Games' uses games involving guided fantasies. In one game, the child is asked to imagine ' a boy standing in a corner of this room\_\_\_\_\_ let us give him a hat. What colour would you like the hat to be ? Let us give him a jacket. What colour jacket shall we give him ? Now change the colour of his hat, What colour did you change it to? Change it again. What colour this time ?' (Robert Sommer, THE MIND'S EYE, Delta Publishing Co., INC, 1978, pp. 142-144)

By far the most comprehensive collection of visualization exercises is found in Robert McKim's excellent workbook titled 'Experiences in Visual Thinking'. Visualization training, as McKim teaches it involves three related processes - seeing, imaging and drawing. (Robert Sommer; THE MIND'S EYE, Delta Publishing Co; INC, 1978, pp.144-145).

This project explores newer vistas. Newer vistas in the sense that the experience of visualization is on a different plane. Some of the puzzles come from very common day-to-day experiences such as shadows and reflections, two dimensional figural transformation (a situation very common in chess), intersection of solids etc. Few sample examples in each category have been given. By no means its an exhaustive collection of puzzles. The complexity gradually increases as one goes along in each category. The following categories have been explored :

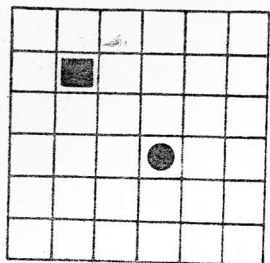


fig. 8

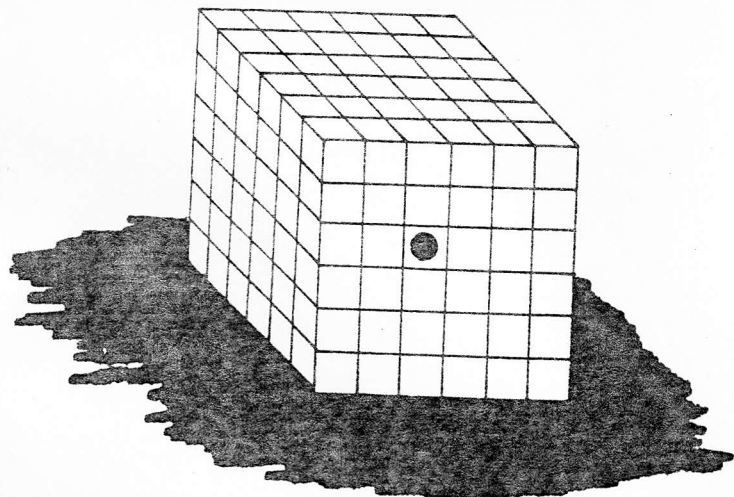


fig. 9

1. MOVEMENT : This involves movement in 2-D and 3D. The interesting case in this category is the visualization of two simultaneous movements occurring in opposite direction but having the same magnitude. This is depicted in fig.8. The task here is to visualize the movements of a square and a circle in accordance with a series of instructions and click at the answer figure showing the final positions at the end of these operations. Here care has been taken in designing the answer figures to discourage problem solving using elimination method or mathematical logic. Other more complex examples in this category include movement of an imaginary ball inside a cube(fig.9) and that in the space defined by three mutually perpendicular planes. The salient feature of these exercises is that the problem figure becomes unavailable after some time so that while solving the problem the subjects have to work from the mental image of the problem figure. In the problem of fig.9, an imaginary ball ( represented by black dot) is kept as shown. The ball moves inside the cube in accordance with certain rules. The task is to visualize this movement and the final position of the ball. This is extremely challenging

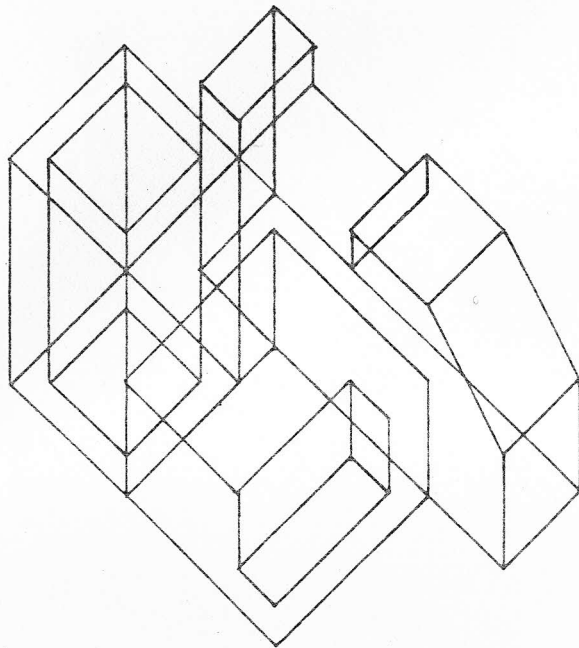


fig. 10a

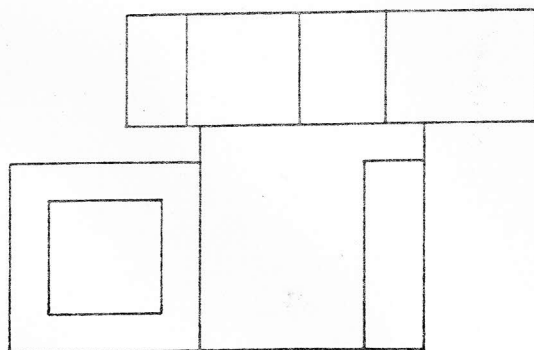


fig. 10b

problem on account of the fact that the space inside the cube. is visually accessible. The problems can be made still more complex and challenging by having more number of dots and balls and specifying different rules for the movement of each of them.

2. HIDDEN LINES: Removal of hidden lines had been one of the central problems in computer graphics and numerous algorithms have been developed to solve it. Given a system of transparent objects, it is reasonably taxing to one's visualization to eliminate the lines that ought to be hidden in order to make the objects opaque. A sample problem is shown in fig. 10(a). The plan view of the same is given in fig.10(b) to enforce viewing from the top. The subjects tick at the lines they think should be hidden and those lines are eliminated. Here as one goes on eliminating the lines, one visualizes the objects taking shape. But one has to have a mental image of the final shapes in order to decide which lines to remove.

3. REFLECTIONS AND SHADOWS : In this, one has to visualize how the reflections and shadows will be cast. Reflections and shadows have a lot of sensory content. Here one visualizes one's

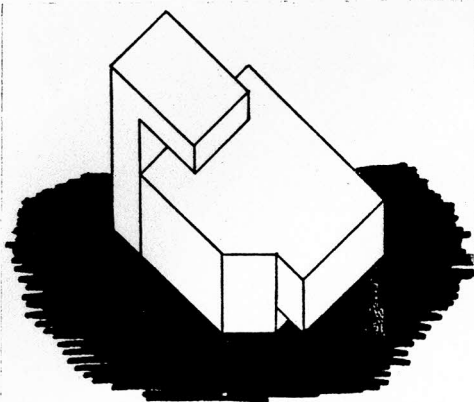


fig.11a

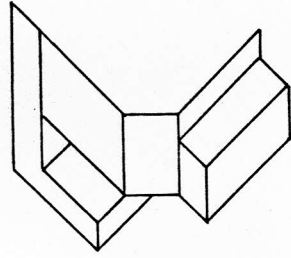


fig11 b

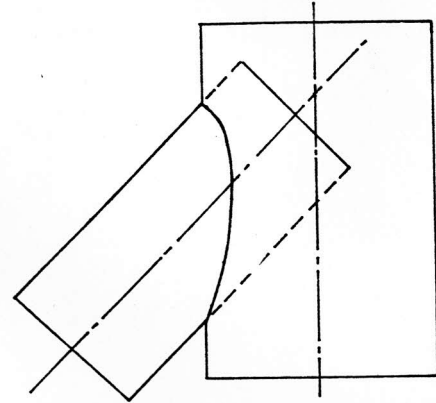


Fig.12a

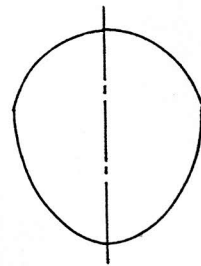


Fig.12b

position with respect to the object (or a collection of objects) and figures out what the shadow or the reflection will look like. Fig.11(a) shows one such problem. Fig.11(b) shows the reflection in a mirror on which the object is kept.

4. INTERSECTION OF SOLIDS : Visualizing the intersection of solids can be challenging for visualization on account of the fact that there exists a dynamic interplay of curved surfaces at the intersection. Two curves meet and continually undergo transformation causing a third curve which is the sum total of the two geometries at the intersection point. A sample problem in this category shown in fig. 12(a). Fig.12(b) shows the solution. As the angle of intersection changes, a variety of curves are obtained.

**3.THE FORMAT**

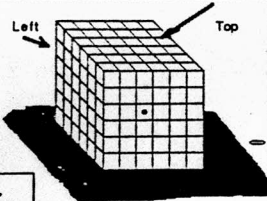
### THE FORMAT

In order to see what computer has to offer in this regard, the puzzles are designed for Hypercard application software. Hypercard uses cards which are grouped together with other cards into stacks. Information on the cards is in the form of text and pictures. Navigation between cards and stacks is possible. Hypercard has, built in it, a programming language called Hypertalk. The programming facility makes it possible to have a flexible, dynamic, and nonlinear format unlike the conventional linear book format. Book format has limitations of its own. It might not be as interactive as the computer. It enables one to refer back to the problem as often as one feels. Sometimes, this might encourage the subject to bypass visualization and solve it using verbal or mathematical logic. Hypercard offers animation possibilities also. Animation of movements and such things can greatly contribute to activating and encouraging visualization in addition to giving lively feedback. The third possibility is that of choosing complexity levels of the problems. Subjects can choose to solve the puzzles with complexity they relish. Yet another possibility is that of switching to evaluative mode or training mode. In evaluating mode the puzzles can have certain time limit in which to solve them and evaluation of the responses can be carried out. Computer offers many such possibilities. However, it is not to say that the computer

format is better than the workbook format. Computer is just a possibility; not solution.

The following pages show one exaple from each category of puzzles with all the cards and their relation to one another. The complete package is on Hypercard.

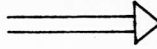
**QUESTION 2:**



Imagine a ball in an opaque, hollow cube as shown. It can't move diagonally. Note the position of the ball and remember it. You are soon going to do something to it.

Go ahead

GO AHEAD



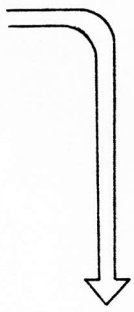
The ball moves in the following sequence. You have to find out its final position.

1. Away from you- 3 units.
2. Up- 1 unit.
3. Left- 2 units.

Visualize a compartmentalized transparent cube and the movement of the ball.


Go ahead

GO AHEAD




GO BACK

CORRECT ANSWER



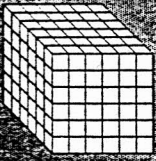
Sorry. You're wrong!  
Why don't you try again?



Go back

Correct answer

IF INCORRECT

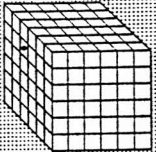



Tick at the place you think the ball will be at end of those operations.

IF CORRECT




The correct answer is this.



Next question

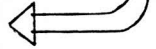
QUESTION 3:



YOU SOLVED IT CORRECTLY!!!  
GOOD VISUALIZATION.

Next question

IF CORRECT



## BIBLIOGRAPHY

1. Colin Blakemore; MECHANICS OF THE MIND; Cambridge University press; NEW YORK; 1977.
2. David A. Taylor; MIND; Century Publishing CO; Ltd., LONDON 1983.
3. Peter Eldin ; FUN AND GAMES WITH PAPER ; Pan Books Ltd., LONDON ; 1976
4. Robert H. McKim; EXPERIENCES IN VISUAL THINKING ; Brooks /Cole Publishing Co., CALIFORNIA; 1972.
5. Robert Sommer ; THE MIND'S EYE; Delta Publishing Co.; Inc., 1978.
6. Y.A. Pereman; FIGURES FOR FUN ; MIR Publishers, MOSCOW.

