Experiential learning kit for School Children

Product design
Project III

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APPROVAL SHEET

The Product Design Project-III titled “Experiential learning kit for School Children” by Girish S 05613804 is approved as a partial fulfillment of the requirements for Post Graduate Degree in Industrial Design.

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THANKS

God
Mom
Dad
Prof A G Rao
Savi
Sachin
Kasif
Sandeep
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Dr. K subramanian
A D Pradhan
Gangamma
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and most important of all…
Children of Kendriya Vidyalaya, IIT-Bombay
Children from Pomegranate workshop
Children from MOEMS, India

Abstract

This project looks at children and tries to understand the difficulties faced by children to understand the concept of area. Children find it rather difficult to appreciate the concept of area and its implications in real life even after two years of being introduced to the concept. Children who are exposed to all kinds of virtual stimulations through Television, Internet and computer games seem to be disconnected from the real world. Their knowledge base is a collection of facts dished out by these sources. These children find school and subjects like mathematics and science insipid and inconsequential due to the absence of a powerful stimuli.

The project aims to wean children away from their virtual world and introduce them to the real world and making it of immediate consequence to them by making it a hands-on activity with the elements of fun and playfulness.

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Introduction

Formal education inspite of all its advantages has merely been reduced to merely an exercise involving exchange of facts. The knowledge base of children going through this method of education is nothing but a collection of facts memorized from time to time. The element of observation and discovery has been lost in the mad competitive race. Children in school resort to rote learning because it is easier and show little interest in subjects like mathematics and science because of the inability of the system to make them realize the immediate consequences of the 'knowledge'. Moreover the formal education method has been made almost devoid of any fun whatsoever.

Urban middle class children live in fast times and are exposed to a mind numbing number of stimulation through Television, computer games and internet. Most of their cognitive knowledge is based on the virtual reality dished out by these sources. As a result they have more or less lost touch with simpler things and require an increasing stimulation to interest them. Being bombarded by thousands of images and sounds everyday it is easier to adapt to filter out anything that is not interesting as not being important than careful observation, analysis and independent thinking.

It becomes important for people involved in the field of education to come up with interesting and playful ways of introducing concepts to children and making them realize the immediate consequence on their real lives.

INITIAL STUDIES

Initial Studies

Visits

- Kohinoor Circus
- Homi Bhabha Centre for Science Education
- Nehru Science museum

Discussions

- Dr K Subramanian, Homi Bhabha Centre for Science education
- Priya Srinivasan, The Pomegranate Workshop
- Dr Vivek Monteiro, Navnirmiti
- Maths Teachers, Kendriya Vidyalaya.

Literature

- Mathematics Textbooks from 1st to 10th standard
- Syllabus review and selection of Topic
- Research Papers

Initial Studies – Visits

Visits were made to a circus, a science museum, and an educational research institution to observe children in different spaces and to understand their behaviour.

- Children prefer group activity to solitary activities
- Children are not interested in reading instructions and are more interested in actions and excitement
- Children are fearless to experiment and to discuss about their experiences
- Children are easily distracted and creating a atmosphere through music and lighting helps in maintaining their focus on the subject
- Children constantly discuss amongst themselves and bring to the attention of their friends about their '*discoveries*'.

Initial Studies – Discussions

Informal meetings with various people involves with children's education were held and the general issues regarding the difficulties faces by children were discussed

- "Parents have little time to 'participate' in the child's education"
- "Schools must be the key place for learning as there are fewer distractions"
- " Children tend to forget the earlier lessons in classrooms"
- "Children in classrooms have the fear of committing mistakes"
- "They tend to rote learn the concepts rather than understand it"
- "There is little time to cover the entire syllabus"

Initial Studies – Literature

Mathematics textbooks form classes 1 to 10 was reviewed and topics in geometry was studied for selecting a suitable topic.

Class 1

Measurement
Longer – shorter
Longest – shortest
Taller – shorter
Tallest – shortest
Thicker – Thinner
Thickest – thinnest
Heavier – lighter
Heaviest – lightest

Measuring with hands and feet

Introduction to simple shapes like square, triangle, circle etc

Class 2

Shapes – What is long? What is round ? Etc
Introduction to patterns
Introduction to the concept of volume
Guessing distances using palms, pencils, hands, matchsticks etc.

Class 3

Introduction to different views – plan, elevation etc
Join the dos to form simple shapes like square, triangle etc and other shapes like star, pot , leaf etc
Symmetry (Planar)
Measuring with scale
Shape recognition(How many triangles in a complex figure…)
Curved lines, edges and corners
Tangram/Tasselations
Complex patterns(Block Print etc)
Comparison of Volumes

Class 4

Patterns with bricks - Plan/elevation of common cuboids
Distance between objects (Perimeter basics)
Plan/elevation/Introduction to perspective
Volume comparison using liquids
Circle and radius
Perimeter - Farms and fences/Quadrilaterals/ Organic shapes
Introduction to Area

Class 5

Basic introduction to Euclidean geometry and the use of a geometry box
Plane, line, line segment, ray, angle, parallel lines, perpendicular lines etc
Acute and Obtuse angles (Classification and construction)
Triangles – vertex, side and angles
Circles – circumference, centre, diameter, radius
Perimeter, area, Volume. – Introduction to l x b .

Class 6

Points, Lines, line segments, curves
Parallel lines
Polygons
Angles
Quadrilateral – sides and angles
Parts of a circle – segment, arc and sector
Angles – acute, obtuse and reflex
Perpendicular lines
Classification of triangles
Faces, edges, vertices
Perimeter and area – slightly complex problems
Symmetry
Construction of perpendicular using a compass.
Marking the midpoint using compass
Construction of congruent angles
Construction of angular bisector
Construction of 30, 60 and 120 degrees using compass.

Class 7

Lines and angles
- Complementary and supplementary
- Adjacent
- Linear pair
- Vertically opposite angles

Pairs of lines
- Intersecting lines
- Transversal
- Angles made by a transversal
- Transversal of parallel lines

Triangles
- Median
- Altitude
- Exterior angle
- Angle sum property
- Equilateral and isosceles triangle
- Sum of lengths
- Right angled triangle and Pythagoras theorem

Congruence of triangles

Construction of parallel and perpendicular lines

Perimeter and area
- Area of a triangle
- Area of a parallelogram
- Circle – circumference and area
- Introduction to Symmetry – planar and rotational
- Visualizing solid shapes – isometric view and cross section

Classes 5, 6 and 7 become very important, because most of the basic concepts are being learnt in those classes. A transition in the syllabus can be observed from class five onwards where the learning in some ways ceases to be experiential in class rooms. Ironically it is here that the children learn most of the basic concepts of geometry. For the same reason these classes were further studied.

It is here that for the first time a child is introduced to the concept of a formula. The formula for area, *l x b*, and there for it becomes rather critical to address this. This is where the child is weaned away from the world of understanding and experience to the world of rote learning.

For this reason the concept of area was chosen to be addressed. All further investigations were carried out to understand the concept of area and to understand the difficulties faced by children to understand the concept of area.

Research papers and books were studied to understand the work done previously and to set the tone and tempo of the direction of my user study. Correspondence with scholars working on similar projects in other universities were also established for discussions of the results.

USER STUDY AND ANALYSIS

About 80 children predominantly belonging to urban middle class families with an average age group of 11 years were interviewed and quizzed to understand their concept of area and the difficulties they face to learn the concept. A series of three quizzes was conducted with these children and the results are reproduced here. The actual test and some of the answers are given in the annexure.

The series of quizzes was designed in a manner to understand the perception of children about the concept of area, the difficulties they face while encountering the problems from their textbooks and to confirm and validate the research done by various people in mathematics education.

About 80 children were interviewed at their schools, homes, and playgrounds and quizzes were distributed to be solved. The results were quite surprising which were concurring with the results of earlier research done by people and some were new.

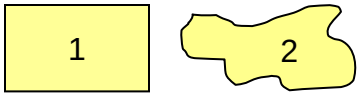
Fun with Area – 1
A lot of simple questions regarding the concept of area were given. The basic idea was to gain an understanding of the conceptual knowledge that the children posses. What things have area and what can you with an area were the basic themes of the questions and they gave very interesting results.

Fun with Area – 2
The questions in the second quiz were taken from the text books of sixth and seventh standard. One question each of the type of problems was copied and distributed among children to figure out their 'academic prowess'. The results were mixed, but it gave a general idea about the difficulties that they face when encountering word problems.

Fun with Area – 3
The questions in the third quiz were based on the results from previous research by different people around the world. These results were collected by reading research papers and books that discuss about the difficulties faced by children in education.

FUN WITH AREA – 1

Does this have an area? *(Results are given in percentages)*



	Yes	No	Don't Know
1	100	0	0
2	20	80	0
Leaf	50	50	0
Box	100	0	0
Mobile Phone	100	0	0
House	100	0	0
Pen	10	80	10
Computer	100	0	0
Ball	20	70	10
Hand	10	80	10
Feet	10	80	10
Newspaper	100	0	0
TV	100	0	0
Water	20	80	0
Sun	10	80	10

FUN WITH AREA – 1 *Contd..*

Can you…

	Yes	No	I don't know
Sit in an area	30	70	0
Run in an area	80	20	0
Sleep in an area	60	40	0
Play in an area	100	0	0
Eat an area	50	50	0
Drink an area	40	60	0
Go into an area	90	10	0
Jump onto an area	80	20	0

	Yes	No	I don't know
Add an area	80	20	0
Subtract an area	80	20	0
Divide an area	80	20	0
Multiply an area	50	50	0
Arrange an area	90	0	10
Fill an area	70	20	10
Increase an area	30	70	0
Decrease an area	30	70	0

FUN WITH AREA – 1 *Contd..*

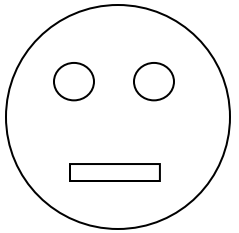
Can you…

	Yes	No	I don't know
Move an area	50	40	10
Paint an area	100	0	0
Pull an area	0	90	10
Push an area	30	60	10
Squeeze an area	0	90	10
Suck an area	0	90	10
Touch an area	100	0	0

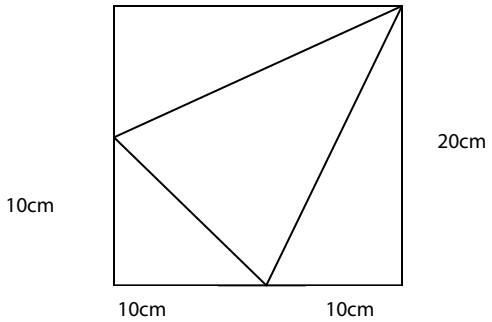
	Yes	No	I don't know
Pinch an area	20	80	0
Mix an area	20	80	0
Can area be long	100	0	0
Can area be small	100	0	0
Can area be tall	40	60	0
Can area be short	60	40	0
Can area be round	60	40	0

FUN WITH AREA – 2..

1. Raj wants to cover the floor of a room 3m wide and 4 m long by squared tiles. If each square tile is of side 0.5m, then find the number of tiles required to cover the floor of the room.
2. Five square flower beds each of sides 1m long are dug on a piece of land 5m long and 4m wide. What is the area of the remaining part of the land?
3. A wire is in the shape of a rectangle. Its length is 40cm and breadth is 22cm. If the same wire is re-bent in the shape of a square, what will be the measure of each side? Also find which shape encloses more area.
4. From a circular sheet of radius 14cm, two circles of radius 3.5 cm each and a rectangle of length 3cm and breadth 1cm are removed. Find the area of remaining sheet.



5. Find the area of the shaded portion *(Triangle in the middle)*

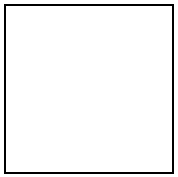


	Correct		Incorrect	
Question	G1	G2	G1	G2
1	27	55	73	45
2	71	84	29	16
3	39	51	61	49
4	-	23	-	77
5	-	52	-	49

Two groups were given this test. Group 1(38) had an average age of 11.3 years and Group 2(43), an average age of 11.7 years. The results are as follows…

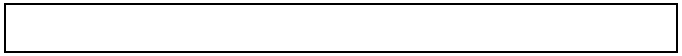
FUN WITH AREA – 3

1. Which among the following has the largest area? *(Dimensions were not given and a white sheet was used)*



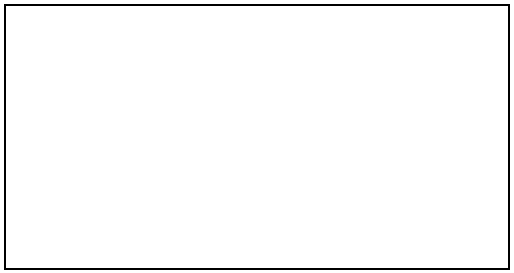
4 x 4 cm

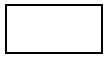
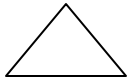
8 x 2 cm



16 x 1 cm

2. How many of these tiles would be required to cover the given area?

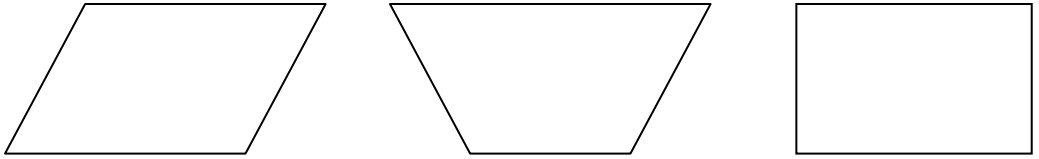


a  b  c 

FUN WITH AREA – 3 *Contd…*

3. What will happen to the area of square if its sides are doubled
   1.Area will remain the same
   2.Area will be doubled
   3.Area will become four times the original area
   4.Area will increase

4. Which among the following has the largest area?



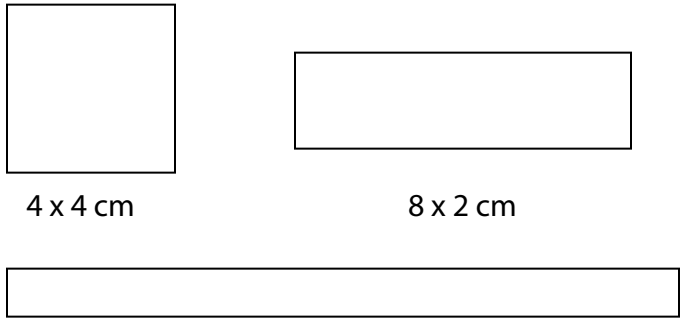
The results are as follows…

	Correct	Incorrect	Don't know
1	18	79	3
2a	81	16	3
2b	71	26	3
2c	55	42	3
3	71	29	0
4	5	95	0

Difficulties faced by children to understand the concept of area

1. Children use perceptual justifications, focus only on the dominant dimension of the shape, or compare the areas of shapes by their perimeters.*(Douady & Perrin, 1986)*

Quiz 3 – Question 1 : Which among the following has the largest area ?



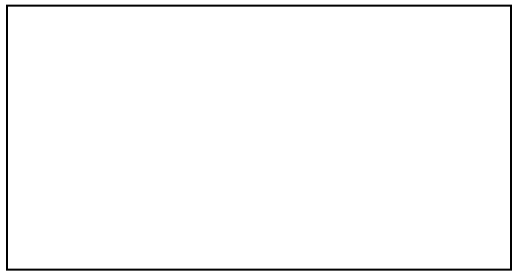
All the three figures are of the same area, but only 18% of the children interviewed could realize that. Most of them thought that the 8x2 rectangle was the biggest.

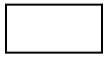
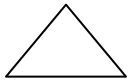
That the children use perceptual justification to compare area becomes clearer in following tasks.

Difficulties faced by children to understand the concept of area

2. They often have difficulty in conceiving the inverse relationships between the size of a unit and the number of units required to cover the same area. (Carpenter and Lewis, 1976)

Quiz 3 – Question 2 : How many of these tiles would be required to cover the given area?



a  b  c 

80% answered the first one correctly, 71% answered the second correctly and only 51% answered the third correctly. Though the inverse relationship was not established, the fact that the children are unable to visualize the problem was established. Also the difficulty in perceiving the area of different shapes especially triangle over a rectangle was proved.

This also strengthens the fact that children use perceptual justifications to compare areas

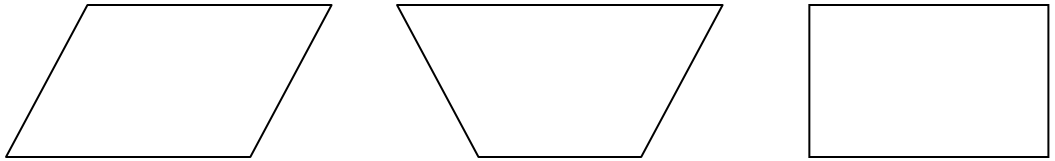
Difficulties faced by children to understand the concept of area

3. Children have problems in finding a strategy to measure irregular shapes.(Douady & Perrin, 1986)

   This has been a recurring observation throughout the study. Most children believed that irregular shapes did not have area. A few children tried to use the graph method to calculate the area.

4. Children are unable to conserve units from their parts (Hirstein et al., 1978)

   Quiz 3 Question 4 : Which among the following has the largest area ?



   Only 5% of the children interviewed realized that that all have the same area. Most of them thought that figure in the middle has the largest area. Some of them justified this perceptually yet some others compared the perimeters. This strengthens the earlier observations too.

5. Children are unable to connect standard area units with standard length units or could not appreciate the size of a rectangular area with known dimensions. (Kordaki & Potari, 1997)

   This became quite visible when the children could not understand the concept of units or when they could not draw figures close to the dimensions, for instance children drew squares in problems involving rectangles and vice versa even though they wrote the dimensions next to the sides of the figure.

Difficulties faced by children to understand the concept of area

6. Children believe that the ratio between areas is same as the ratio between the corresponding dimensions. (Kordaki & Potari, 1997)

Quiz 3- Question 3: What will happen to the are of the square if the sides are doubled?

About 71% could answer correctly that the area would become four times the original area.

Other Observations

1. Children do not realize that area is a surface phenomenon.
2. Children believe that only regular geometric shapes like rectangle, square and triangle have area.
3. Children believe that irregular shapes do not have area
4. Children believe that only three dimensional objects resembling cuboids have area.
5. Children believe that organic shapes do not have area.
6. Children are unable to visualize the problems and convert them into figures when encountering word problems.
7. Children have little visual sense of lengths.
8. Majority of children have difficulty in visualizing word problems.
9. A good number of children multiply the sides of a triangle or a quadrilateral to find its area which indicates the lack of understanding of the derivation of area of a rectangle/square.
10. A good number of children have a very vague idea about units or its significance.
11. A good number of children find it difficult to relate area numerically. *(Whether to divide or multiply)*
12. Children tend to get confused between area and perimeter in the absence of any direct hints/clues either verbal or visual.

How does an average child spend his/her day….

Children are exposed to multitude of sensory stimulations all day long. The change in their behavioral patterns are fairly visible and it becomes very important to understand how the spend each day. What do they play, what do they read, what do they watch on TV…

School	8
Play	1
TV	2
Other classes	1.5
Study/Tuition	1.5
Getting ready, commute, relaxation etc.	2
Sleep	8

In Hours

** All the children interviewed belonged to an urban middle class family*

What do they play…

Boys:

Football, Cricket, Basket ball
Kabaddi, Relay race
Hide and seek

Carrom, Chess, Monopoly

Counterstrike, Roadrash, NFS, GTA, Pokemon

Mobile Phone games

Girls:

Badminton, Dodgeball, Handball

Kho – Kho, Relay race
Gallery, Catch and Catch, *Lagori,* Hide andseek, , 1234, Lock and key, *Khamba – Khamba*.

Carrom , snakes and ladders, Monopoly

Mobile Phone games

What do they watch…

Pokemon, Doraemon, Kiteretsu, Dragonball Z, Inuyasha, M.A.D, Mickey mouse, Looney Tunes, Batman.

Most girls also liked watching popular soaps where as boys preferred watching sports. It is surprising that the stereotyping of preferences happens at such an early age.

What do they read…

Batman, Spiderman, Tintin, Amar Chitra Katha, Tinkle.
Harry Potter, Eragon, Narnia.

It is ironic and surprising that movies and animations of popular books have encouraged children to read more books

What do Teachers say…

Informal interviews and discussions were held with mathematics teachers and their opinions and views on this was probed. Since it is the teacher who is directly involved in a child's education it becomes very important to understand their take on this whole issue.

1. Children tend to forget the topics that they learn in previous classes.
2. The number of students in each class *(approx. 40)* is more than what they can handle
3. The syllabus constantly changes making it difficult for teachers to update themselves
4. There is a redundancy in syllabus.
5. Children have very small attention spans.
6. Children are exposed to mind numbing stimulus that there is no space left for independent thought.
7. Children resort to rote learning as it is much faster and easier for them to memorize just before he exams rather than to understand the concepts.
8. The time that a teacher gets to cover the syllabus is very little.
9. Craft/Work/Art education is not a part of main curriculum
10. Children no longer are attentive in classes as they know that they can learn these thing sin their tuition centers.
11. Parents need to involve actively in a child's education, which seems missing.
12. Children are highly influenced by TV/Internet and they are under a very high peer pressure.
13. Different children come from different family backgrounds and their learning curve largely depends on the family that they come from.

What do parents say…

Informal interviews and discussions were held with parents to understand about their children. All the parents interviews belonged to an urban middle class family. It was equally important to understand the parents concern and issues because they are the integral part of the child's education and development.

1. Children have very little time. They do so many things in so little time.
2. Some teachers in school are good but many are not.
3. Price is not a major factor when parents buy toys for children unless it is exorbitantly expensive.
4. Most of the parents interacted did not actively take part in child's academic or extra-curricular activities. They attributed it to the lack of time.
5. Parents tend to confront children when addressing issues.
6. Some parents who involve directly in their child's education read the topic first themselves.
7. Parents always act as a bridge between siblings.
8. Most parents believe that a tuition centre can be depended for their academic development of the child and that it is more effective than the child studying at home.
9. Parents do not approve of the programs that the children watch on TV are often unable to do anything about it.
10. Most parents realize that their children are under intense pressure to perform, but have accepted that and are afraid that the child may lose to other children.

Workshop environment

A couple of workshops conducted for children were attended to observe and understand a child's behaviour in that space. Since workshops are informal and do not have more than about twenty participants, it was interesting to observe the interaction of children in that environment.

Theatre workshop by Mr. Divya Bhatia, Pomegranate workshop

1. Children prefer to work/play in groups
2. Four to five is a good size for a group
3. Children tend to perform better when a specific task is given rather than open ended tasks.
4. Children do not mind gentle persuasion and positive criticisms
5. There is always one dominant member in each group who directs the play/work of the group.
6. Children freely express themselves once hey realize that they are not being admonished or judged.
7. Figures of authority in a workshop environment are often ignored.






Discussions with tradesmen who use area extensively.

Most of the tradesmen like the carpenter, mason, tailor etc use the master-apprentice method of imparting knowledge, the master usually being the father or a father figure. The pupil is introduced to the trade at an early age who initially does a lot of unskilled work while observing the master and then gradually is taught the 'secrets' of the trade. The time bracket for learning is not fixed and depends on the progress the pupil makes unlike the school format. The master-apprentice relationship becomes a more effective mode of communication than the teacher-student relationship as there is a personal relationship and an emotional bond.

Mason

Informal interviews and discussions were held with a few masons at their work site to understand the manner in which they learn their trade from their master and the manner in which the master imparts knowledge to his apprentice. The technique that they use to understand the concept of are was also probed and the conceptual model of area in their mind was explored.

1. There are different *mistris* for different tasks. For example, there are *mistris* for plastering, scaffolding, carpentry, tiling etc.
2. The learning is through master-apprentice method but is not as intensive as other trades as there are many people under one *mistri.*
3. On an average it takes one to three years to learn the job and become a *mistri* from a helper.
4. For the *mistri* involved in laying down tiles the main skill involved is to arrange the tiles in such a manner that the wastage is minimal.
5. It is difficult to arrange marble pieces as they are available in random sizes and a decision has to be taken depending upon he floor size, the available marble size and sometimes the grain structure while keeping the wastage minimal.
6. This is done by discussion with architect/site in-charge and the marble vendor.
7. The calculation is usually done after inspecting the site. Smaller ones are done mentally whereas complex ones are done on a piece of paper.
8. The skill develops through observation and practice. Mistakes are usually expensive so extreme care is taken before cutting the marble.

Tailor

Informal interviews and discussions were held with a couple of tailors and their apprentices at their shop to understand the manner in which they learn their trade from their master and the way a mst. The technique that they use to understand the concept of are was also probed and the conceptual model of area in their mind was explored.

1. Introduced to the trade at an early age.
2. The learning is through the master-apprentice method
3. They are first introduced to simple tasks like sewing salwars after the pieces have been cut by the master. It usually takes 1- 1.5 years before an apprentice can start cutting complex pieces like the blouse under the supervision of the master.
4. It is very important to develop a strong sense of symmetry because tailoring involves a lot of symmetry.
5. Though the templates for different dresses are standard it is important to have a strong sense of surface development as the measurement changes according to the desired fitting. A small mistake while visualizing or measuring can drastically change the fitting.
6. Lot of importance is give to practice and observation.
7. Pupils are sometimes made to practice on newspapers.
8. Since this is a ‘zero error’ trade, mistakes are not tolerated
9. It is very important to keep experimenting and keep up to the changing fashion.

Carpenter

Informal interviews and discussions were held with carpenters at their workshop to understand the manner in which they learn their trade from their master. The technique that they use to understand the concept of are was also probed and the conceptual model of area in their mind was explored.

1. Introduced to the trade at an early age.
2. The learning is through the master-apprentice method which is effective because the ratio never exceeds 1:5 unlike schools which has a ratio of 1:45
3. They are first introduced to simple tasks like planing and then asked to cut the wood measures and marked by the master before letting them to measure and cut themselves.
4. A lot of importance is given to strengthen the pupil's observational skills.
5. Experimentation is strongly encouraged though it is usually not permitted in the working hours.
6. They have a very strong visual sense of lengths and shapes.
7. They have little knowledge of the formula, but use visual judgment for all tasks.
8. They are conceptually very strong when it comes to manipulation of area. .

Tradesmen – What is their concept of area ?

Masons

1. Masons hardly work with any other shape other than rectangles and squares. They have an ability to break a given rectangle/ square into smaller pieces to fit in the tiles.
2. When dealing with marbles, they have to optimize the size of the marble pieces according to the size of the floor and the size of available marble while trying to minimize wastage.
3. They tend to think in a **Grid pattern** i.e overlaying a grid over the given floor and dividing it into squares/rectangles.

Tailors

1. Tailors have a very distinctive pattern of thinking since the basic shapes they deal with are much more complex than a carpenter or a tailor. They deal with irregular shapes *(Templates for different dresses)*
2. Tailors tend to think in a **Jigsaw puzzle pattern** as they have to fit the different templates in a given rectangular area while minimizing wastage and also have to join various different parts to produce a complex object.

Carpenters

1. Carpenters think in terms of length and breadth and their idea of area is predominantly rectangles. Even if they are asked to imagine a circle or an organic shape they instinctively tend to enclose it in a rectangular space.
2. Carpenters are adept in conservation of area. They have the ability to visualize and breakdown a larger piece of an area usually a rectangle into smaller pieces of squares/rectangles and occasionally other shapes and are good at optimizing that
3. Carpenters employ both grid pattern and the jigsaw puzzle pattern of thinking.

MARKET SURVEY

Market Survey

Existing products available in the market were studies by visiting toy shops, by talking to children and educationists and by searching on the internet They can be classified as follows

1. Based upon their dominant characteristics
   - Problem Solving - Visualizing, creative thinking, strategy based
   - Simulation

2. Based on child development
   - Fine motor development
   - Large motor development
   - Toys which develop imagination skills
   - Toys to develop creative skills

3. Role playing games

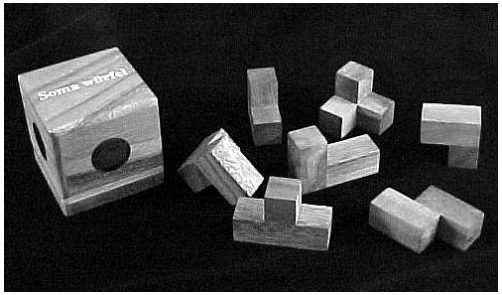
4. Educational aids

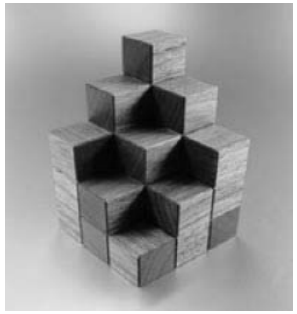
5. Construction Kits

Classification of toys

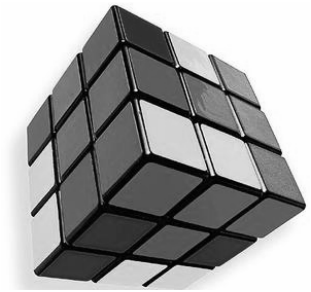
1. Based upon their dominant characteristics

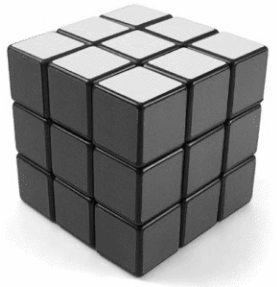
Problem Solving - Visualizing, creative thinking, strategy based
Examples: SOMA cube, Rubik's Cube, Towers of Hanoi etc





Soma Cube: Seven basic pieces are arranged in various forms





Rubik's Cube: One of the most popular toy ever made. The task is to manipulate the individual cubes so that all faces are of the same colour

Classification of toys

2. Based on child development

Fine motor development

These toys require a child to manipulate it with their fingers and hands. .Manipulative toys involve coordinating the eye to what the hands are needed to do. They stimulate fine motor development because they require controlled use of hand and finger muscles. Some manipulative toys such as puzzles are self- correcting, fitting together in only one specific way. These types of toys allow children to work until they achieve success since they only fit together one way, and they know that when they are done that they have accomplished something great

Example- Various stacking toys, Shape sorters, popup toys with dials, Jack in the boxes, Blocks and Large wooden puzzles with handles are the toys that develop fine motor skills.

Classification of toys

2. Based on child development

Large motor development
Eg: Pull/Push toys, ride on toys etc.

Toys which develop imagination skills

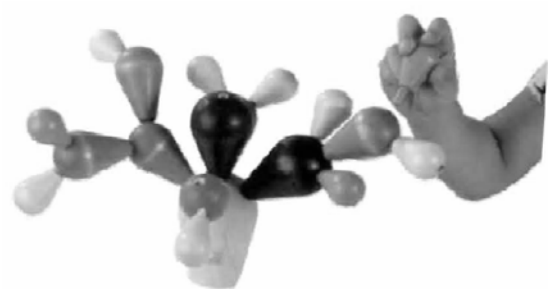
When playing with these toys, children see themselves in the roles of various persons and try to copy the activities of the person, thus these toys provide wide scope to develop their imaginative skills. Role playing kits like Doctors kit, Kitchen Set, dolls, Stuffed animals, Vehicles are some of the popular toys of this type.

Classification of toys

2. Based on child development

Toys to develop creative skills

Puzzles, Building blocks, Lego, Crayons, Paper, Coloring books etc. A toy in which children enjoys the process rather than clearly defined result oriented toy is needed for creative development The creative mind needed for this kind of toy or puzzle allows varying experience each time it is played. It perfects eye hand coordination



Classification of toys

3. Role playing games

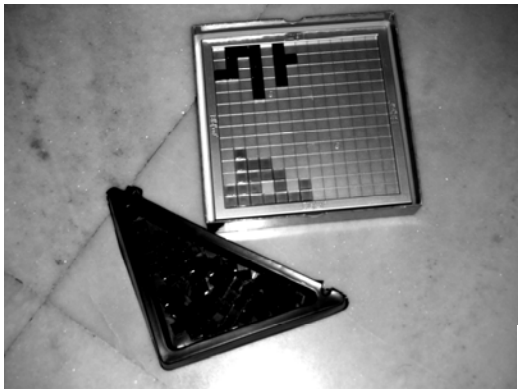
RPG is a game in which the participants assume the roles of fictional characters and collaboratively create or follow stories. Participants determine the actions of their characters based on their characterization, and the actions succeed or fail according to a formal system of rules and guidelines. Within the rules, players can improvise freely; their choices shape the direction and outcome of the games. While simple forms of role-playing exist in traditional children's games such as "cops and robbers", "cowboys and Indians" and "playing house", role-playing games add a level of sophistication and persistence to this basic idea. Instead, participants in a role playing game will generate specific characters and an ongoing plot. A role-playing game rarely has winners or losers. That makes role-playing games fundamentally different from board games, card games, sports and most other types of games. Role-playing games are typically more collaborative and social than competitive.

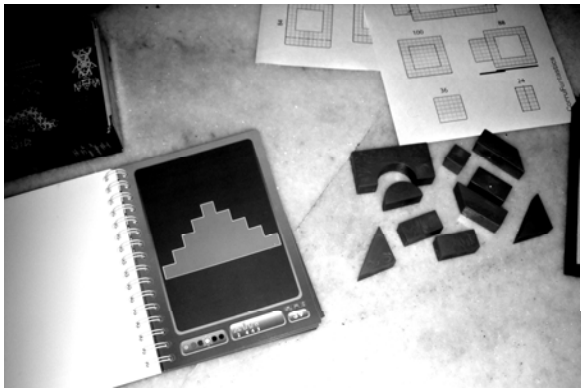
Classification of toys

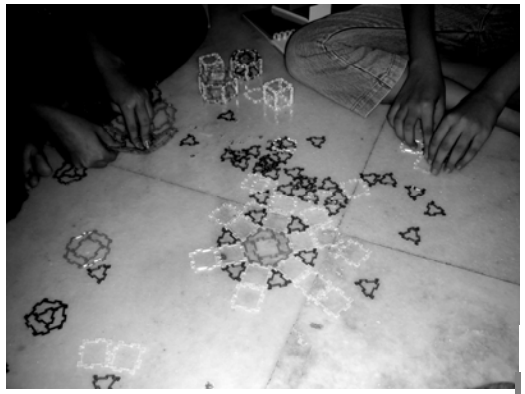
4. Educational aids

Lots of educational aids are available to teach mathematics. Some of them are listed here…

1.Abacus
2. Pyramid of spheres
3.Jodo Kit
4. Jodo Blocks
5. Pentominoes
6. Pythogoras triangle
7. Hundreds, Tens and units pieces
7. Cuisenaire rods



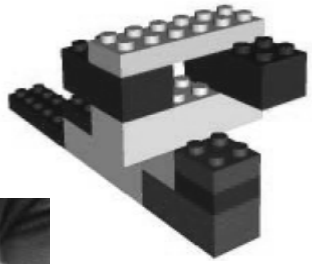


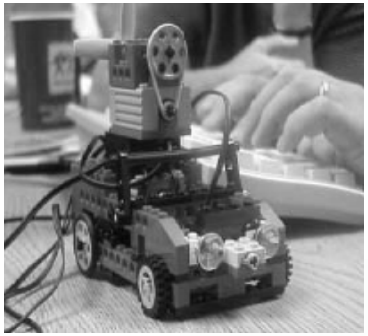


Classification of toys

5. Construction Kits

Construction kits like Meccano, Lego, Erector have been popular for many years now.





PRODUCT BRIEF

Product Brief

To design a tacit intuitive model using a suitable exemplar that will convey the concept of area and its manipulation without distorting, misleading or blocking the correct interpretation of the concept.

Essential objectives of the design will be to convey the following…

1. All surfaces have area and that area *'covers'* or defines a space within a boundary.
2. Concept of units and unit iteration.
3. Manipulation and conservation of area.
4. Irregular shapes/ 3D/ organic shapes have area.
5. To introduce both the methods of understanding area – Grid Pattern and Jigsaw Puzzle pattern

Approach

To create a paradigmatic model that is an autonomous entity but at the same time a trusty mediator between the original solution and the solvers intellectual activity.

To help understand how lots of surfaces can be arranged in various ways to create a new shape or form and vice versa with the help of suitable props based on the grid method and jigsaw method.

The essential idea is to **extend the knowledge to usable experience thereby deriving the principle from the experience.**

Conditions for efficacy of Models *

1. The model has to be faithful to the original on the basis of a structural isomorphism between them.
2. The heuristic capacity of the model depends on its autonomy in respect to the original. And such autonomy, as already said, implies that the model must be able to function coherently on the basis of its own laws.
3. The model must correspond to human information-processing characteristics

What are Paradigmatic Models ?

A paradigm is not a mere example: it is defined by its function rather than by its intrinsic qualities. It is particular instance or a sub-class of a class of objects, used as a model. Through the paradigm, a concept gets, subjectively structured meaning: the various properties defining a concept do not appear to be arbitrarily related. They describe a certain object and it is this object which, being kept in mind, confers unity, structure and productiveness to the concept. Paradigms play a fundamental role in every intellectual activity: in defining, in understanding, in learning and in every solving attempt.

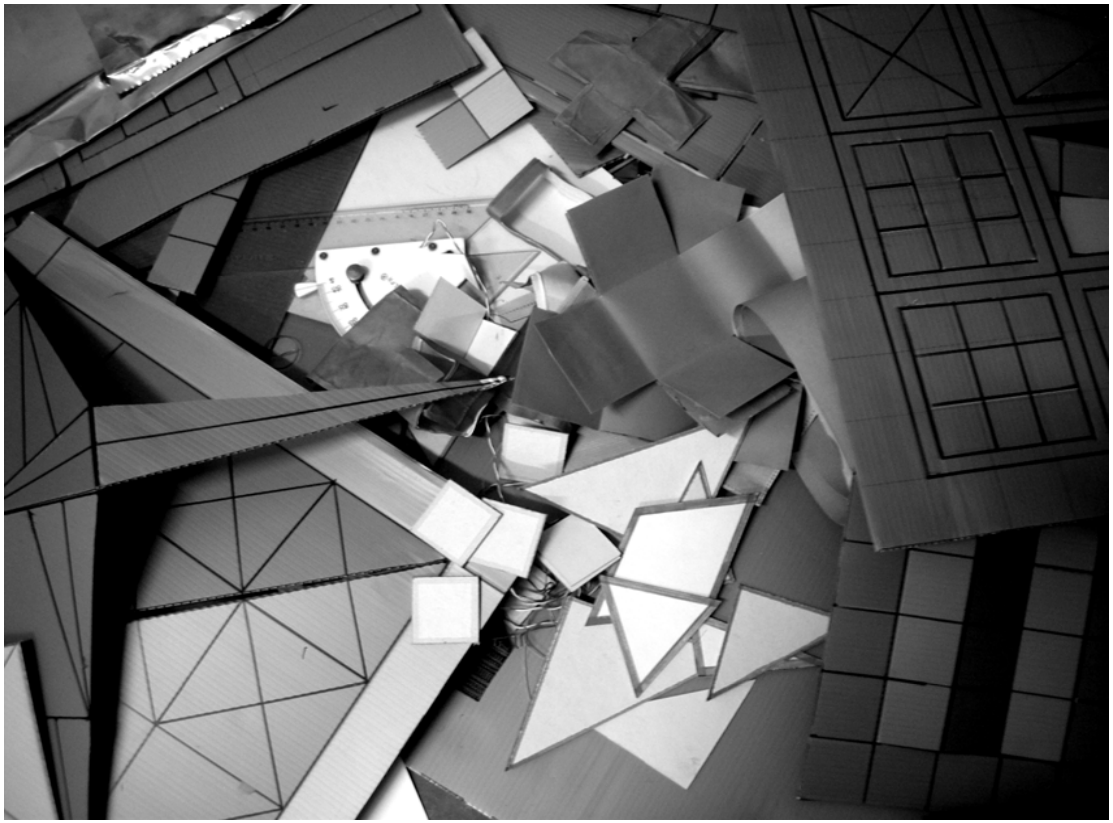
Paradigmatic tacit models are an essential factor in shaping our intuitive approaches, interpretations and solutions. The process of reasoning, at least its genuinely productive forms is to a very great extent stimulated, shaped and controlled by paradigmatic instances.

**Efraim Fischbein, Intuition in Science and Mathematics, D Reidel.*

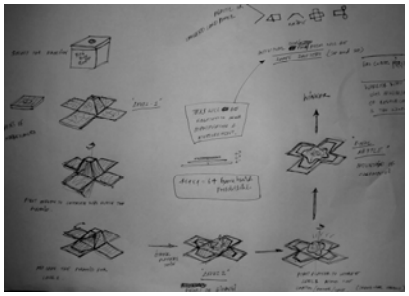
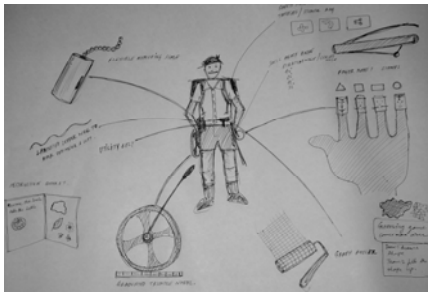
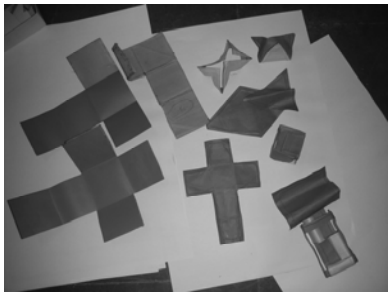
INITIAL IDEATION AND EXPLORATION

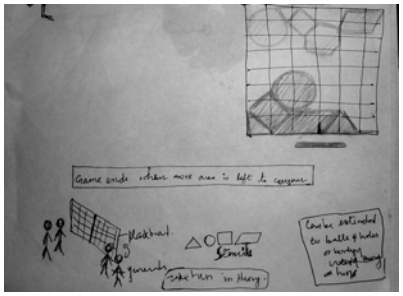
Initial Ideation and explorations

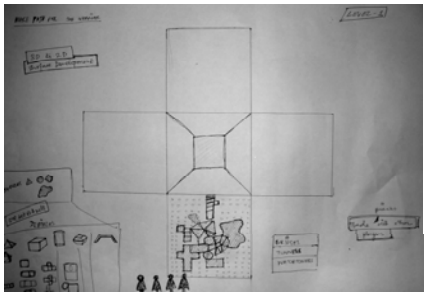
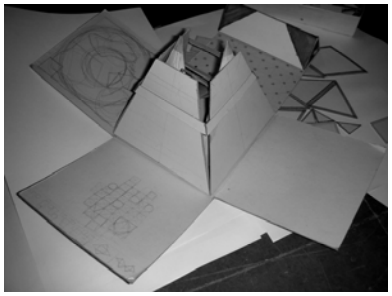
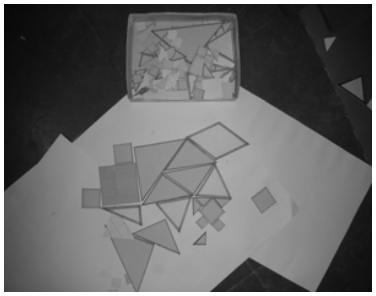
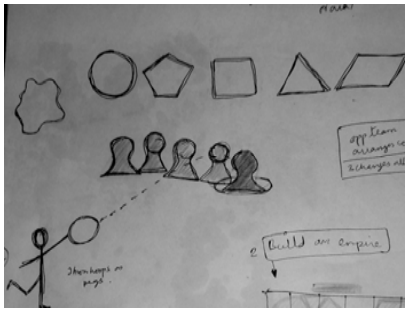
Initial ideation and exploration was done with various materials like cardboard, acrylic, copper wires and brass shims of different thickness, PP sheets, PP corrugated sheets, bamboo sticks etc to understand the materials and the various possibilities.

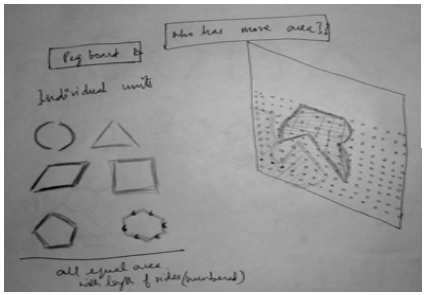


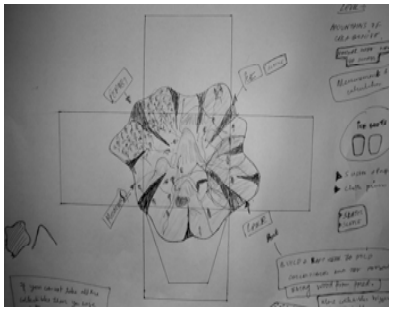
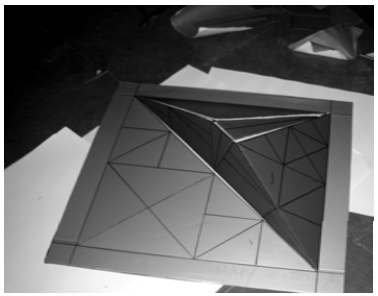
Initial Ideation and explorations

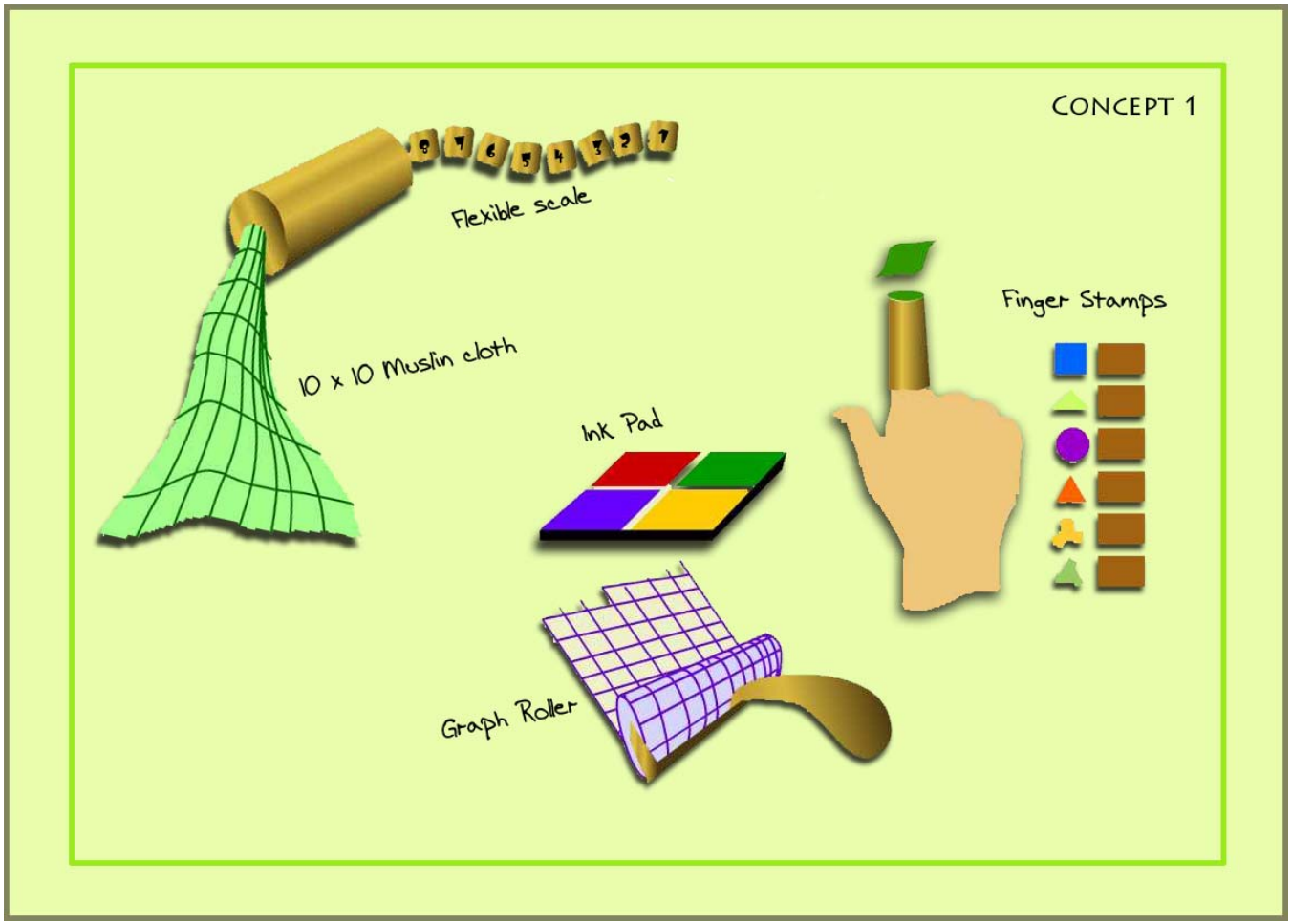


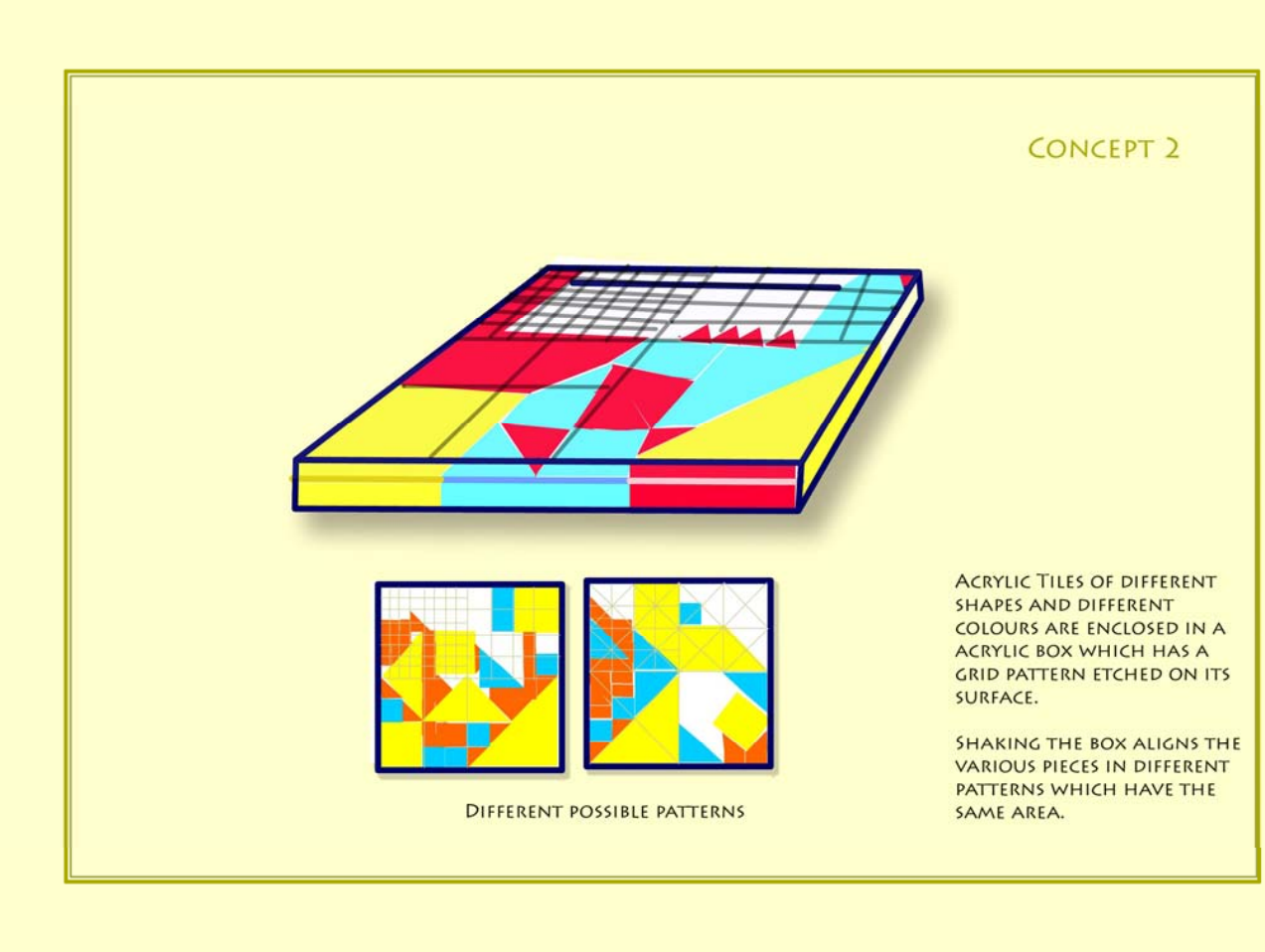


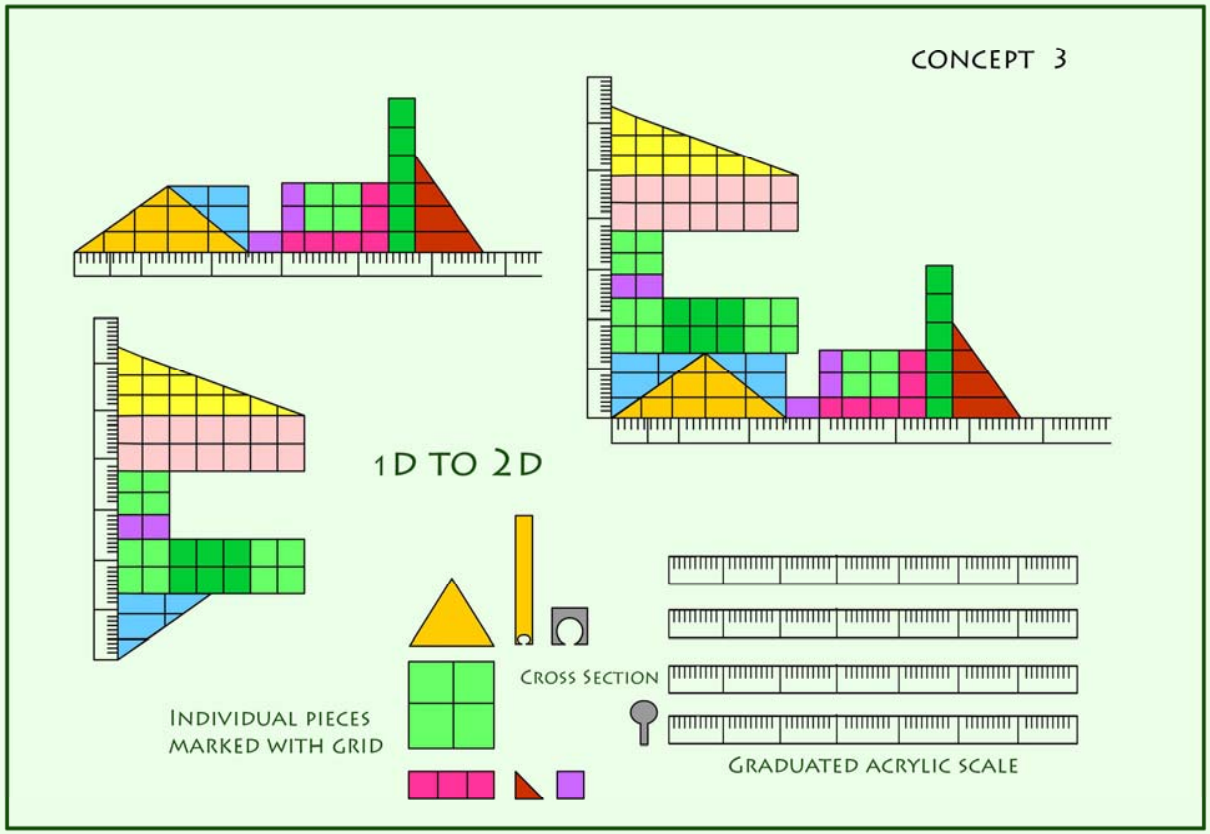
INITIAL CONCEPTS



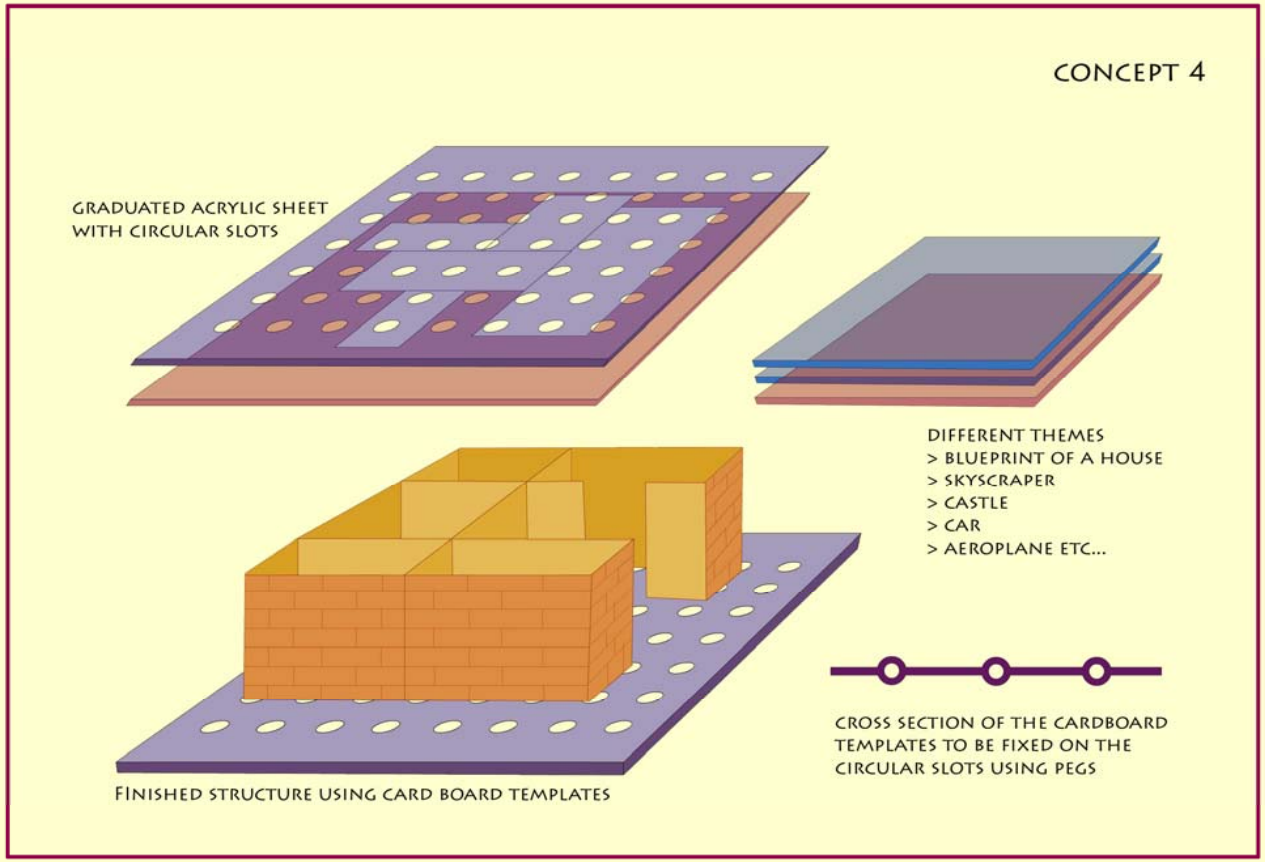
The child uses the finger stamps to create various space filling designs and discovers tessellations in the process. The graph roller enables to draw graph sheet of 1cm x1cm easily. The flexible scale has 100 units and the printed muslin cloth has the same number. This makes the child realize unit, unit iterations. The child would use the flexible scale to measure objects around her/him and also use the muslin cloth to overlay it over objects and count the squares to figure out the area.



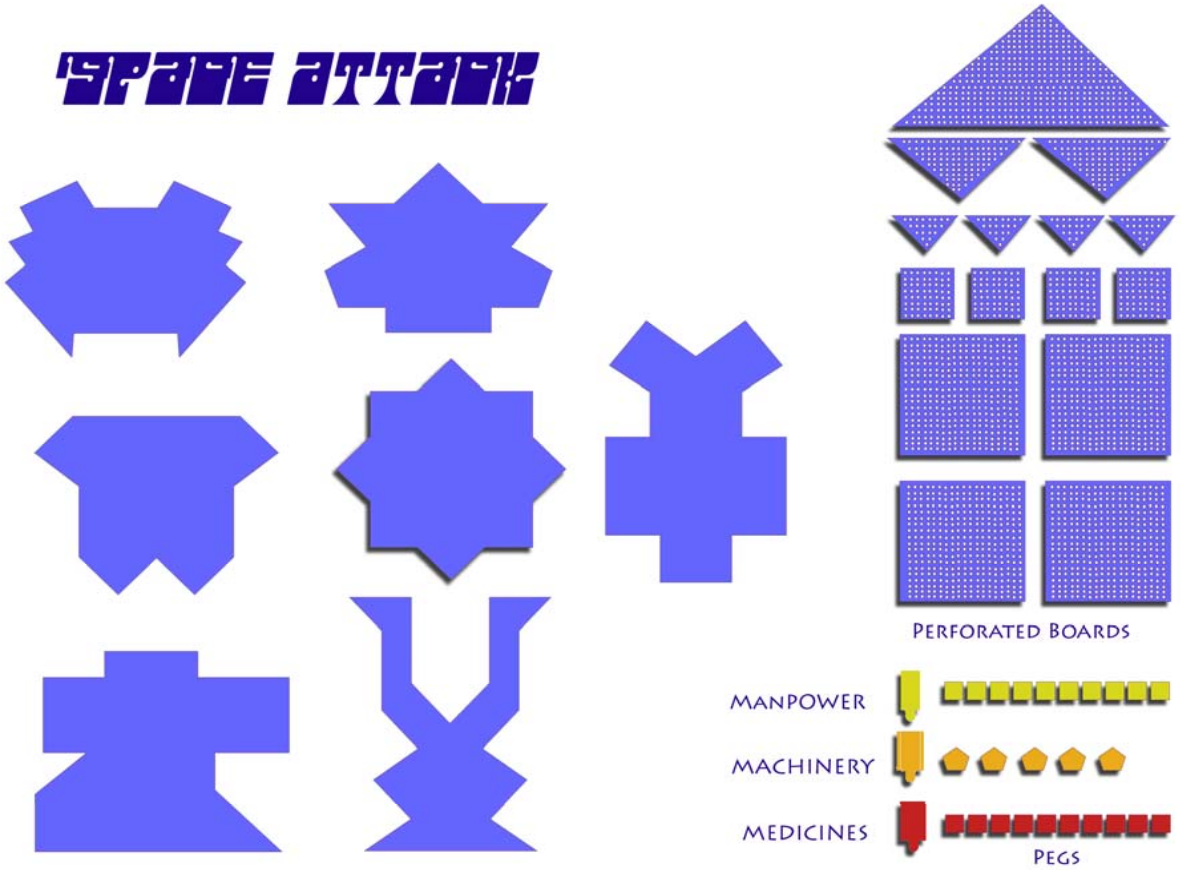
Acrylic tiles of different shapes and areas are enclosed in a graduated acrylic box. Shaking the box gives different patterns of the same area. This conveys the idea of manipulation and conservation of area and the concept of unit and iteration.



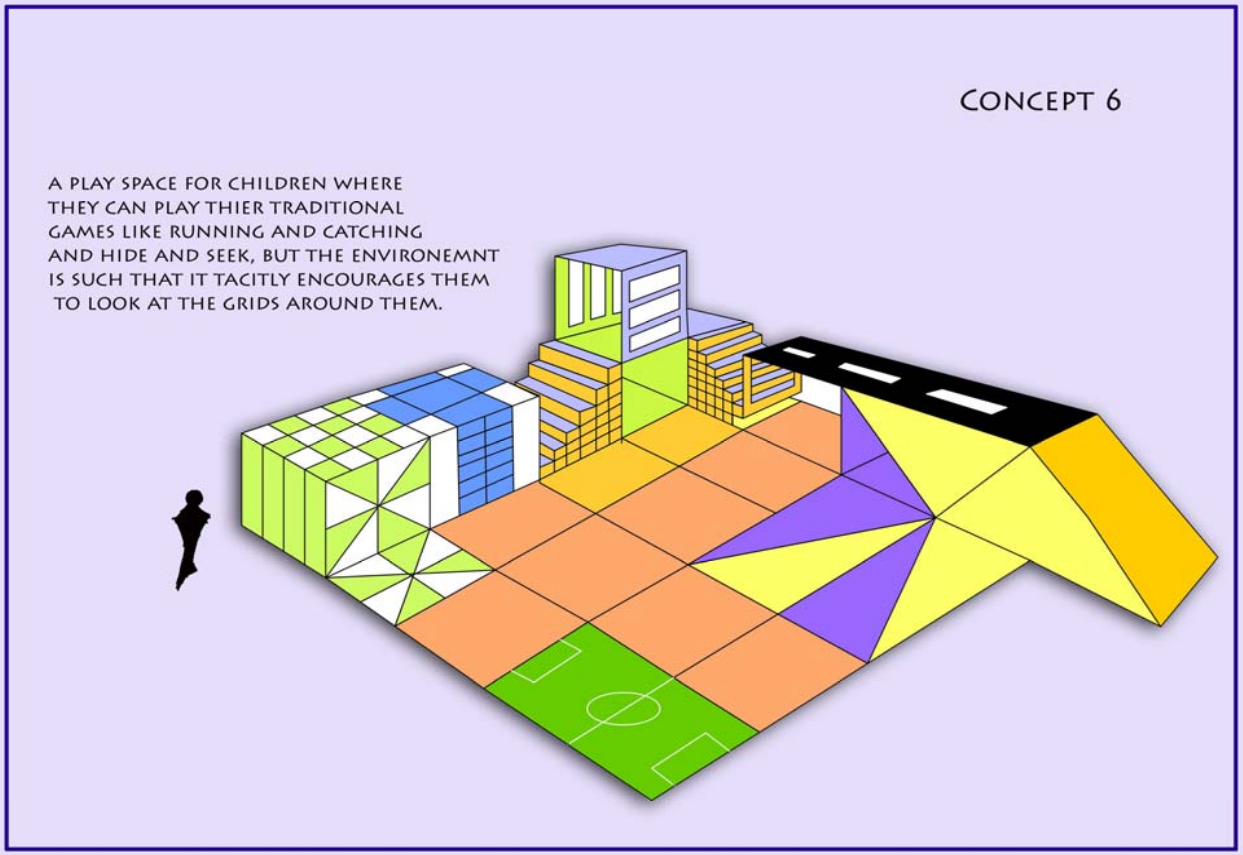
Different coloured pieces marked with grid each with a groove is inserted into a graduated acrylic scale. This explains the concept of transformation of length into are and the concept of unit.



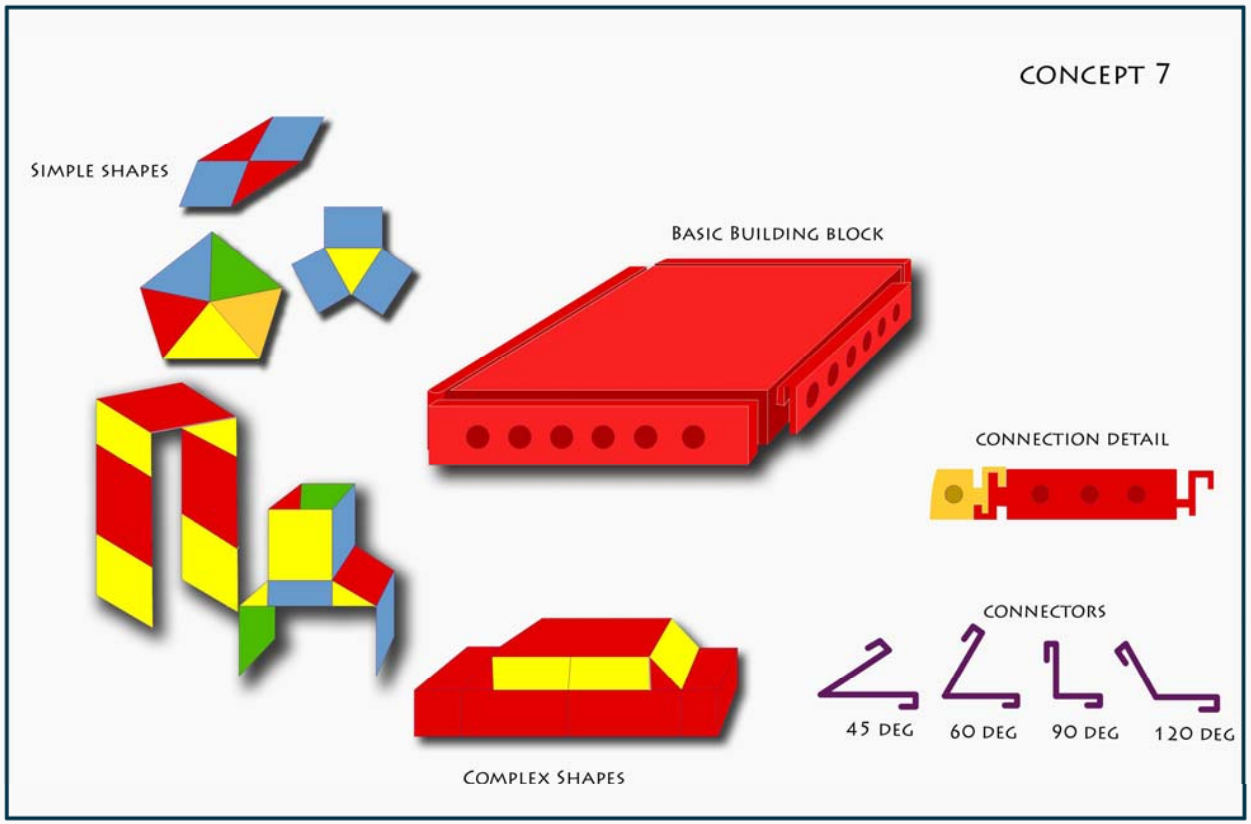
Different themes like blue print of house, skyscraper, castle, car, aero plane etc are kept under a graduated acrylic sheet with circular slots. These themes are then constructed with the help of sticks and printed cardboard



The idea is to form different space ships using the given 15 basic perforated pieces and to transport men, material and medicines as much as possible and to arrive at a solution that can transport maximum possible. The men machinery and medicines are of different unit sizes and this conveys the idea of area manipulation and the concept of unit and iteration



A play space with structures that explain the concept of unit and unit iteration and manipulation of area with the help of examples from real life like the road, football field, ,skyscraper etc…



The idea is to connect the pieces to give different forms. This conveys the idea that all surfaces have area as they can be broken down into squares, rectangles and triangles.

FINAL CONCEPT

The final solution is a kit made up of two units. The first solution is based on the 'Grid and Jigsaw Puzzle' pattern used by tradesmen to understand area. It consists of a 4ft x4 ft grid printed on a plastic sheet. The grid is divided into four equal squares which in turn are divided into 64, 16 and 4 square units. 32 Inter connectable bamboo sticks of a fixed unit which make up the total perimeter are supplied. Children can make various shapes like a tree. Monster, dog etc inside the grid using these sticks. This tacitly conveys the idea that the same perimeter can have different area and this would discourage children to compare areas by comparing their perimeters. Apart from these sticks thin coloured squares of 1, 4 and 9 square units are given and children are asked to make various objects like house, ship, monster etc on the grids. This helps children to estimate the area in the absence of a grid and also help them to break down a surface in known units. Later in the school when they are introduced to basic measurement units and area, children would be able to connect to the game they would have played thereby bringing in a consequence in their daily lives.

BENDAROOS is a what one could call as 2D clay. In this concept children have flexibly surfaces which can be bent into different organic shapes. The surface units are basic shapes like squares rectangles, triangles and different combinations like the surface development of a cube. Children make complex shapes like samurai warrior, airplanes road roller, wearable objects like crown, spectacles etc out of these basic units there by tacitly learning that even complex organic shapes are made out of simpler basic units like squares and triangles and since these basic shapes have area the complex shapes made out of these units too have area.

POSITIONING

The kit, initially, aims to cater to a small niche in the huge market which has a enormous potential for growth. The kit would be used by educators who are engaged in alternate methods like workshops etc. After a certain period of time, it is intended that teachers in regular schools would be trained to use the kit as a teaching aid for their daily lessons.

Bendaroos would be sold as an off-the-shelf toy into the main market. It would also be used by teachers and educators along with the kit to help children learn the concept of area.

HOW TO USE

Activity 1

1. Spread the printed mat on the floor
2. Let the children join all the 32 sticks to form a closed chain
3. Map this chain on the perimeter of the grid and ask the children to observe how the stick forms the basic unit of measurement.
4. Now ask the children to form various shapes like tree, house dog etc using the sticks but the constrains being that the sticks must follow the grid and the two sticks can meet at only 90 degrees or 180 degrees.
5. Encourage the children to observe the change in area by counting the squares inside the *perimeter.*

Activity 2

1. Spread the printed mat on the floor
2. Encourage the children to use the square and triangular elements to form various shapes like house, monster, rocket, Ship etc, the constraint being that they must follow the grid even in places where it is not printed.
3. Encourage the children to estimate the number of squares and triangles needed to fill a given grid.
4. Encourage the children to use the smallest square and triangle as the basic unit and that iteration of those units makes bigger squares, triangles, rectangles, and other polygons.

Experiential learning Kit for school children

The kit helps children learn the concept of area and its relationship with perimeter. It also helps them learn unit, unit iteration and manipulation of area,

HOW TO USE

Bendaroos is a more like a 2D clay and the child can let his/her imagination run wild in making objects that they wish. However the constraint that all the pieces are essentially flat will challenge and encourage them to use the material in innovative ways. Children can make simple objects like cubes, cuboids, cones etc or complex shapes like airplanes, samurai warriors, road-rollers, and wearable objects like masks and assorted fantasy objects.

The most important learning however does not lie while building the objects, but when breaking them down. The child observes and tacitly learns that all complex organic shapes can be broken down into flat surfaces. This becomes the child's first lesson in surface development of three dimensional objects.

Bendaroos is a fun toy to play with, that helps children learn the basic concepts of surface area of an object. Children play with bendable colourful strips to create variety of 3D objects.

They can make wearable objects and other objects like aeroplane, roadroller, samurai etc.

Bibliography

1. Robert N carson, Montana State University, A Taxonomy of Knowledge for Use in Curriculum Design, Interchange, Vol35/1,59-79,2004,Kluver academic publishers, Netherlands
2. Thomas William Nielsen, Rudolf steiners pedagogy of Imagination, A phenomenological case study.A paper to complement a presentation given at the first International Conference on Imagination in Education, 16-19 July, 2004, Vancouver, Canada, BC
3. Lawrence W. Barsalou ,Grounded Cognition ,*Annual Review of Psychology*, volume, 59, 2008
4. Donald A Schon, Intuitive Thinking? A metaphor Underlying some Ideas of educational Reform, March 1981
5. Maria Kordaki and Despina Potari , A learning environment for the conservation of area and its measurement: a computer microworld , January 1999.
6. Maria Kordaki and Despina Potari, Children's Approaches to Area Measurement through Different Contexts
7. Seymour Papert , Constructionism vs. Instructionism, Speech delivered in 1980's in Japan

1. Jiddu Krishnamurti, On Learning and Knowledge, Penguin India, 2004
2. Tetsuko Kuroyanagi, Totto Chan - The little girl by the window, Kodansha International, 1984
3. Catherine Fishel, Designing for Children Rockport, 2001
4. Seymour Papert and Idit Harel,Constructionism, Ablex Publishing Corporation, 1991
5. Stewart Mosberg, The Best of Children's Product Design, PBC International, 1988
6. Marta Sved, Journey into Geometrics, The Mathematical Association of America, 1991
7. Louis Lyons, All You wanted to Know about Mathematics but were aftraid to ask, Cambridge University Press, 1995

Bibliography

8. Roger B Nelson, Proofs withous words, The Mathematical Association od America, 2000
9. Robert S Siegler, Children's Thinking, Prentice Hall, 1986
10. Hans G Furth & Harry Wachs, Thinking Goes to School, Oxford University Press, 1974
11. Herbert P Ginsberg, The Develeopment of Mathematical Thinking, Academic Press, 1983
12. Richard Lesh & Marsha Landau, Acquisition of Mathematics Concepts and Processes, Academic Press, 1983
13. Efraim Fischbein, Intuition in Science and Mathematics, D Reidel.
14. Seymour Papert and Idit Harel , *Constructionism,* Ablex Publishing Corporation, 1991.

1. Raja Mohanty, Designing books for Children, IDC, IIT- Bombay, 1989
2. Anchal Kumar, Interactive device for colloborative learning among Kids, IDC, IIT-Bombay, 2005
3. RupeshNath U, Play kit in Bamboo, based on Optics, IDC, IIT-Bombay, 2007
4. Mayura Deshpande, Interactive Toy, IDC, IIT-Bombay,2004
5. VIdys Joshi, Design of Play Objects for children, IDC, IIT-Bombay,2004
6. Muralidhar K, Creative aid for school children, IDC, IIT-Bombay,2003
7. Sri Hari Tulsi, Aid for children to learn sound, IDC, IIT-Bombay,1999

1. John Taylor Gatto, How public education cripples our kids and why?
2. Mark Allerton and Dr. Terezinha Nunes, A new way to measure area : Another brick in the wall

ANNEXURE

Theories in learning

Psychologists for learning have generated various theories. Five such theories are briefly described whose researches are mainly concerned with children's learning.

° Piaget's theory of learning
° Vygotsky's theory of the zone of proximal development (ZPD)
° Skemp's 'theory of learning'
° Jerome Bruner's 'Theory of Instruction' and 'Constructivist theory'
° Dienes 'theory of learning'

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Piaget's theory of Learning

From the Piagetian standpoint, children learn from actions rather than from passive observations; for example, telling a child about the properties of materials is less effective than creating an environment in which the child is free to explore, touch manipulate and experiment with materials.

Piagets Cognitive Learning Stages

1. **Sensori motor:** *(birth to about age 2)*
During this stage, the child learns about himself and his environment through motor and reflex actions. Thought derives from sensation and movement. The child learns that he is separate from his environment and that aspects of his environment -- his parents or favorite toy -- continue to exist even though they may be outside the reach of his senses. Teaching for a child in this stage should be geared to the sensorimotor system. You can modify behavior by using the senses: a frown, a stern or soothing voice -- all serve as appropriate techniques.
2. Preoperational: *(begins about the time the child starts to talk (2) to about age 7)*
Applying his new knowledge of language, the child begins to use symbols to represent objects. Early in this stage he also personifies objects. He is now better able to think about things and events that aren't immediately present. Oriented to the present, the child has difficulty conceptualizing time. His thinking is influenced by fantasy -- the way he'd like things to be -- and he assumes that others see situations from his viewpoint. He takes in information and then changes it in his mind to fit his ideas. Teaching must take into account the child's vivid fantasies and undeveloped sense of time. Using neutral words, body outlines and equipment a child can touch gives him an active role in learning.

Piaget's theory of Learning

Piagets Cognitive Learning Stages

3. Concrete *(about first grade (7) to early adolescence (11))*
During this stage, accommodation increases. The child develops an ability to think abstractly and to make rational judgments about concrete or observable phenomena, which in the past he needed to manipulate physically to understand. In teaching this child, giving him the opportunity to ask questions and to explain things back to you allows him to mentally manipulate information.

4. Formal Operations (*adolescence (about 12 through adulthood)*
This stage brings cognition to its final form. This person no longer requires concrete objects to make rational judgments. At his point, he is capable of hypothetical and deductive reasoning. Teaching for the adolescent may be wide ranging because he'll be able to consider many possibilities from several perspectives.

Vyagotsky's Zone of Proximal Development

According to Vygotsky, ZPD is the distance between the child's actual developmental level and his or her own potential level of development under the guidance of more expert adults or in collaboration with more competent peers.

The intervention is in its most effective when it is contingent upon the child's existing repertoire of skills and knowledge. This makes it clear that a new intervention when made has to be within the child's existing knowledge which includes his academics, exposure to books, TV and other media.

As far as the project is concerned Vygotskys theories gives some important clues for design. They are

° Children learn from other people who are more knowledgeable than themselves. This point is very important for the teenager (12 + years) because this is the age he mingles more with friends and forms gangs where a lot of interactions happen.
° When a child's level of understanding is deliberately challenged (but not challenged too much) then he or she is more likely to learn new things effectively without experiencing failure.

Skemp's Theory of Learning

British psychologist Richard Skemp introduced the idea that concepts constructed by humans form a hierarchy viz. Primary, secondary, tertiary and so on. For example car,bus, lorry are primary concepts. Automobile is a secondary concept.

Bruner's Theory of Instruction

Central to Bruner's thinking is the conviction that the process of learning is the same whether we are talking about the pioneer at the frontier of knowledge or the child engaged in making a construction of wooden blocks. Bruner's theories can be explained well with his concept of spiral curriculum. (refer annexure)

This concept can be seen in the school curriculum where a single concept for example in geometry thought in one grade is again repeated as a more complex chapter in another grade. In any learning method the type of increment mentioned above has a very important place.

With a proper structured knowledge within a proper sequence if the children discover for themselves what is beyond it and how to do it- nothing more is reward able and motivating than this intrinsic satisfaction. Here proper means the principles and concepts of a particular subject to be taught or to be understood, must be relative and related to the needs of the learners. The idea of motivation and reward is very important because when the teenager sees the positive results of his actions his is motivated to go to next level. The use of current / past knowledge means that the teenager recalls and applies to an activity, the previous skills and knowledge he has learnt or come across.

Diene's Theory of Leaning

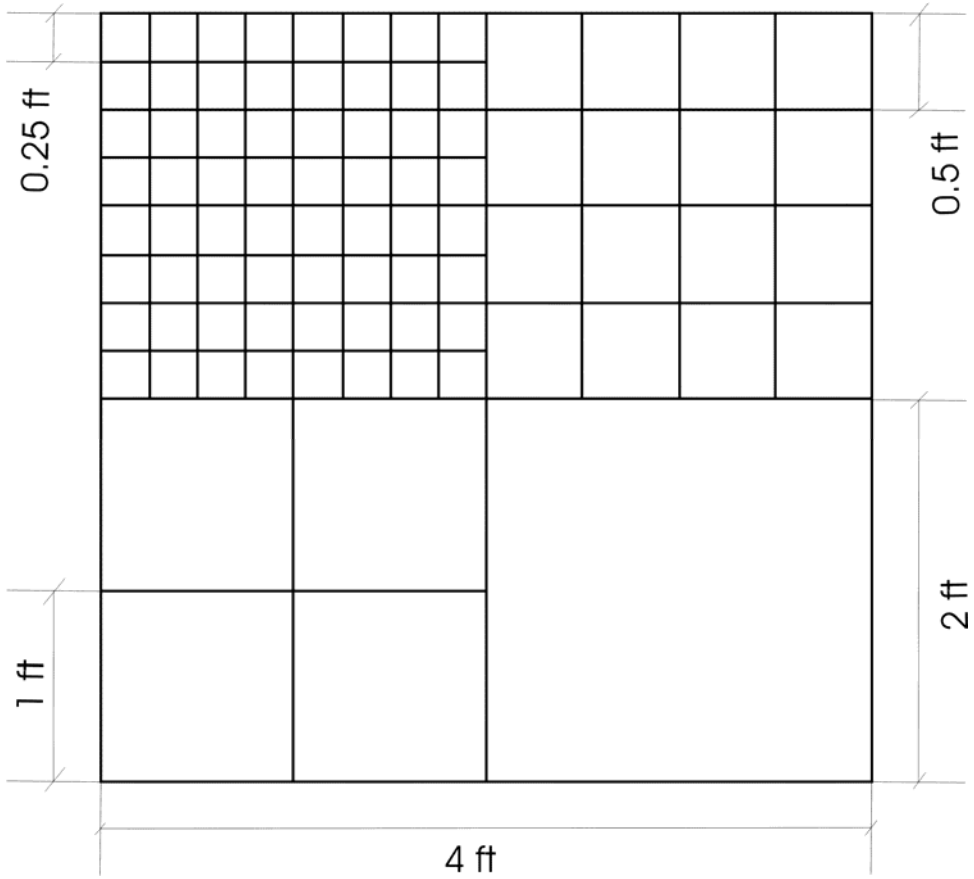
Zolta Dienes theory of learning is a process of an increasingly intricate play. He says that these plays are of two types- primary play and secondary play.

Primary play is the activity with materials aimed at gratifying immediate desires or instincts. It involves the manipulation and investigation of materials for its own sake.

Secondary play is the activity performed with awareness, aimed at an end, which is beyond the immediate gratification of desires. This involves trying to build with the materials, discovering patterns or regularities and forming abstract conjectures or rules concerning the patterns found.

DIY DRAWINGS

Grid Dimensions



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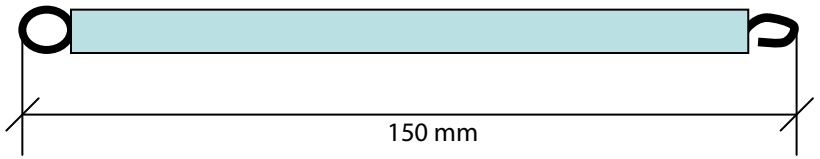
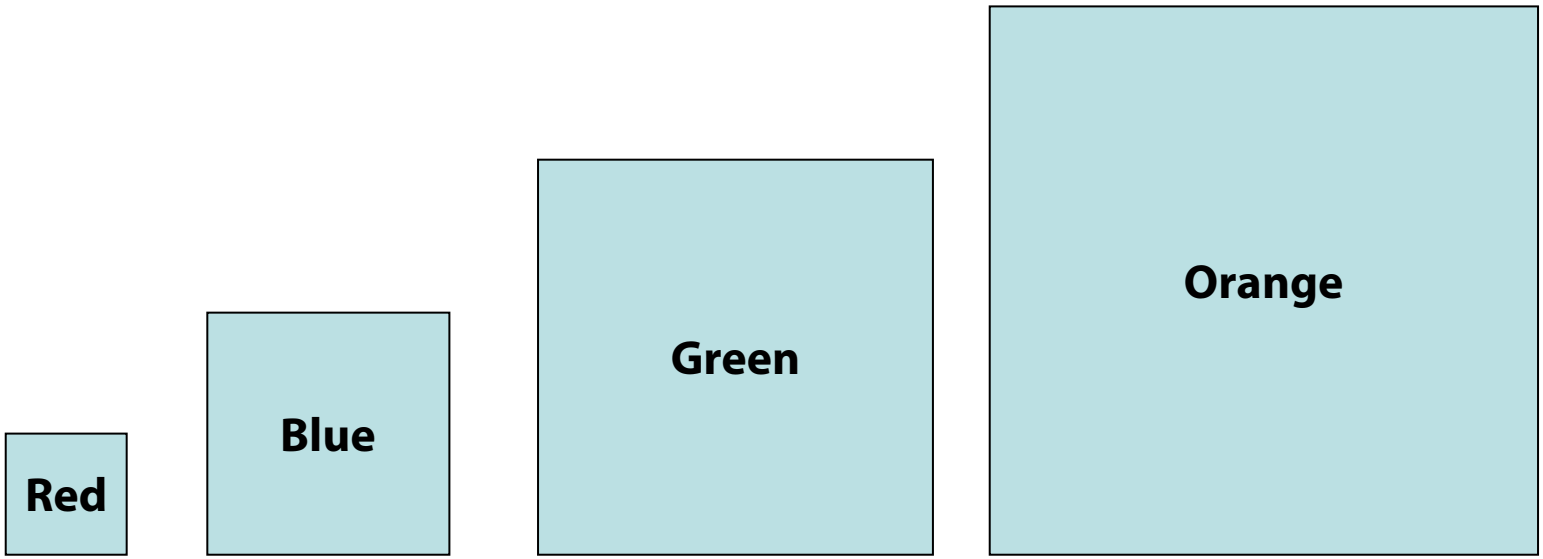


32 nos.



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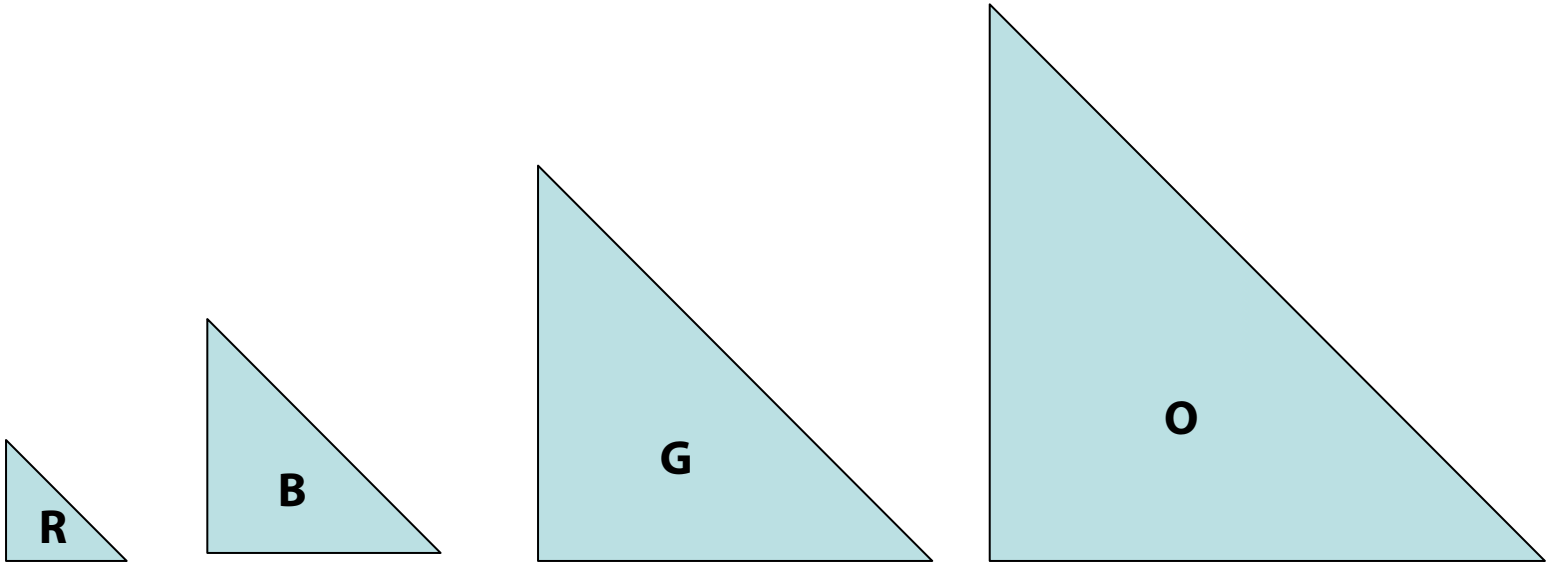
8 nos	**5 nos**	**3 nos**	**1 nos.**

Stick and tile dimensions



75 mm	150 mm	225 mm	375 mm
16 nos	**10 nos**	**6 nos**	**2 nos.**