



**IDC** School of Design  
अभिकल्प विद्यालय

**P3**

# Optics based Play Design for Secondary School Children

Project Guide : Prof. Avinash Shende

*Submitted by*

Vaibhav Watile  
216130004, Industrial Design  
IDC School of Design, IIT Bombay

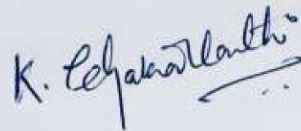
# Approval

This is to certify that the Industrial design project 3 entitled "Optics based Play design for Secondary School Students" by Vaibhav Watile, 216130004 (M.des, 2nd year, Industrial Design 2021-23) is approved for the partial fulfilment of the Post graduate degree, Master of Design in Industrial design.



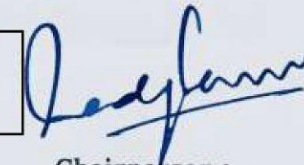
**Project Guide :**  
Prof. Avinash  
Shende

**External examiner :**



Digital Signature  
Purba Joshi Joshi (i09042)  
27-Jul-23 07:41:06 AM

**Internal examiner :**



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# Declaration

I declare that this written submission is the representation of my ideas in my own words and wherever other ideas and words are cited, I have adequately cited and referenced the original sources.

I also declare that I have adhered to all the principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea, data, fact or source in my submission.

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Name of student : Vaibhav Watile

Roll no : 216130004

M.Des, Industrial design 2021-23

Date : 27/ 7/ 2023

# Acknowledgement

I would like to sincerely thank my guide [Prof. Avinash Shende](#) for his invaluable guidance at every stage of the project and for supporting the project in every way possible. I am also grateful to [Prof. Vinayak Nabar](#) for his guidance and connecting me with Govardhan Skill Centre, Wada.

My special thanks to [Mr. Anand Gosavi](#), Principle in charge at GSC, Wada for permitting the school visit and interact with teachers and observe kids.

I also extend my gratitude to all the [Faculty, Workshop Staff of IDC](#) (Industrial Design Centre) for all the help throughout the project, without whom it would have been a difficult task. My special thanks to my [Batchmates](#) from Industrial Design, for brainstorming sessions and their feedback at various stages during the duration of project.

# Abstract

In child's life play has an important role to improve their linguistic, psychological, motor, and psycho emotional skills. The project aims towards creating a play based on Science principles, which is fun, engaging and involves learning. Amongst various topics Optics was selected, based on the need and scope to create play out of it.

The play had to incorporate hands-on activities that would allow children to strategies and explore, with different elements that actively engages children. This would involve puzzles, challenges and games that require them to apply optics principles to solve problems and complete tasks. The game is focused towards engaging children to think with an understanding of basic optics principles, learn different strategies that they would employ to win the game, and also to make them think in two and three dimensional spaces.

The play is aimed towards learning at school, it also can be used by the parents while homeschooling their children. The targeted users are the students of class 6th,7th and 8th which is the age group of 11-13 years.

The idea was to explore and look for various ways in which the play can be enhanced, in a way that the play accommodates different concepts of optics. Due attention was given to make the play more intuitive, which would make it easy to start and navigate as they play.



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# 1. Introduction

This project aims towards designing a toy/ game/ play for school children, to learn, experiment and explore the concepts of Physics. When different chapters were studied, it was found that Optics as a subject had opportunity to explore.

Toys are tools used by children when playing, an activity that involves learning and fun that they voluntarily participate in. The importance of play in children's lives cannot be underestimated. It aids in the growth of linguistic, psychological, motor, and psycho emotional skills. It is essential for developing joyful, imaginative, and self-assured youngsters. Children have the same need for their playmates as adults do for their coworkers. The abilities a youngster develops while playing will be crucial to them throughout their entire lives.

Children need practical education, and when it comes to science, they need space and tools to explore the various applications of the concepts they have learned in school.

Although audio visual learning on screens is a tool that aids kids in visualising and grasping complex scientific ideas, it cannot be all that kids need to understand it; they also need to apply, experiment, and play with it. Only then can one fully comprehend a subject.

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## 1.1 Why STEM toys?

**STEM** toys, which focus on **science, technology, engineering, and mathematics**, are important for children for several reasons:

**Developing Critical Thinking and Problem-Solving Skills:** STEM toys often involve challenges that require children to think critically, analyze situations, and develop problem-solving strategies. These toys promote logical reasoning, creativity, and innovation as children work through obstacles and find solutions.

**Enhancing Spatial and Mathematical Skills :** Many STEM toys involve building, construction, and spatial awareness. They help children develop an understanding of shapes, measurements, and spatial relationships. These skills are crucial for later learning in subjects like mathematics and engineering.

**Promoting Collaboration and Communication :** Some STEM toys are designed for cooperative play, encouraging children to work together, share ideas, and communicate effectively. This promotes teamwork, social skills, and the ability to collaborate on projects—a valuable skill set for future endeavors.

**Fostering Creativity and Imagination :** STEM toys provide a platform for children to explore and express their creativity. They can design and build structures, experiment with different materials, and come up with innovative solutions to challenges. This encourages imaginative thinking and nurtures their ability to think outside the box.

**Building Confidence and Resilience :** When children engage with STEM toys, they experience a sense of accomplishment when they successfully complete a project or solve a problem. This boosts their confidence and resilience, teaching them that perseverance and effort lead to success.

Overall, STEM toys play a vital role in fostering love for learning, developing essential skills, and preparing children for the demands of an increasingly technology-driven world, setting a strong foundation for lifelong learning and future success.

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## 1.2 Why Physics?

Physics deals with **understanding the fundamental principles** that govern the universe. Many of these **concepts are abstract** and require a strong mathematical foundation to grasp fully. Topics such as quantum mechanics, general relativity, and particle physics can be particularly challenging due to their complexity.

Many of the **concepts** in physics **are not directly observable or intuitive in everyday life**. Concepts like wave-particle duality or the theory of relativity often defy our common sense and require a lot of mental effort to comprehend.

Physics involves a significant amount of **problem-solving**. Students must be able to apply theoretical concepts to **real-world situations**, which can be challenging, especially when the problems become more intricate and involve multiple variables.

As mentioned earlier, many physics concepts **challenge our intuition**. The behavior of particles at the quantum level, for instance, does not align with our daily experiences, making it difficult to internalize such phenomena.

Physics **intersects with other scientific disciplines** like chemistry and astronomy. Understanding physics often requires a broad understanding of other fields and the ability to connect concepts from different domains.

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## 2. Secondary Research

### 2.1 Bloom's Taxonomy

In 1956, Benjamin Bloom with collaborators Max Englehart, Edward Furst, Walter Hill, and David Krathwohl published a **framework for categorizing educational goals: *Taxonomy of Educational Objectives***. Familiarly known as **Bloom's Taxonomy**, this framework has been applied by generations of K-12 teachers and college instructors in their teaching.

**Remembering:** Retrieving, recognizing, and recalling relevant knowledge from long-term memory.

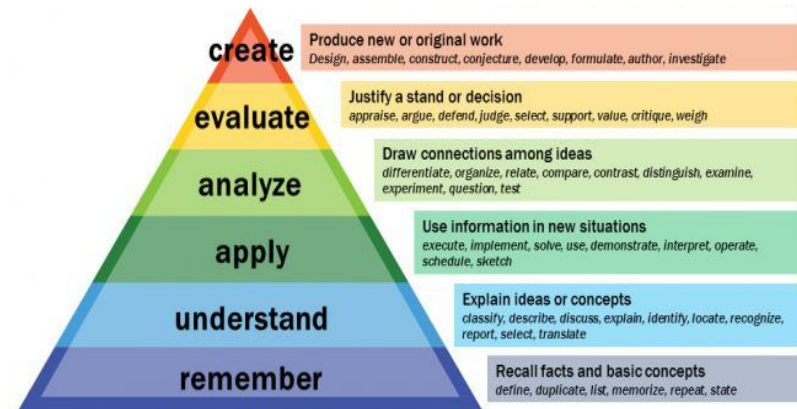
**Understanding:** Constructing meaning from oral, written, and graphic messages through interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining.

**Applying:** Carrying out or using a procedure for executing, or implementing.

**Analyzing:** Breaking material into constituent parts, determining how the parts relate to one another and to an overall structure or purpose through differentiating, organizing, and attributing.

**Evaluating:** Making judgments based on criteria and standards through checking and critiquing.

**Creating:** Putting elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure through generating, planning, or producing.



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## 2.2 BaLA - Building as Learning Aid

BaLA is a way to **holistically plan and use the school infrastructure**. It incorporates the ideas of activity based learning, child friendliness and inclusive education for children with special needs (CWSN). At the core, **it assumes that the architecture of school can be a resource for the teaching-learning processes**.

Since buildings are the most expensive physical assets of a school, efforts should be made to derive maximum educational value from them. Thus, BaLA is about exploring uniqueness of three dimensional space as a child friendly learning resource for all children.

The building elements of normal concrete shapes are modified innovatively to involve children creatively. The different elements of BaLA may be located in interior and exterior spaces like classroom. Corridors and backyard so that a variety of learning situation are generated across the school space. The built structure of the school can also provide shelter during educational activities.



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## 2.3 HomeSchooling - John Holt

**John Caldwell Holt** (April 14, 1923 – September 14, 1985) was an American author and educator, a proponent of **homeschooling** (specifically the **unschooling** approach), and a pioneer in **youth rights** theory.

Homeschooling is a progressive movement around the country (and the world) in which parents educate their children at home instead of sending them to a traditional public or private school. Families choose to Homeschool for a variety of reasons, including dissatisfaction with the educational options available, different religious or educational philosophies, and the belief that children are not progressing within the traditional school structure.

In Maharashtra, the government has decided the following age wise bifurcations to appear for the exams:

- 10 Years – Class 5
- 13 Years – Class 8
- 15 Years – Class 10



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## 2.4 Learning Styles

While researching about what would be the most effective way of learning, following video at Veritasium was very informative. Some of the learning points were -

- VARK theory - Different students have different learning styles
  - V - Visual
  - A - Auditory
  - R - Reading/ Writing
  - K - Kinesthetics
- Everybody learns the best with multimodal approaches, like learning through videos (audio-video)
- Most important in learning is not what's presented but what is happening in learners head - *People learn the best when they are actively thinking about the materials, solving problems or imagining what happens when different variable change*
- Interventions on improving learning



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## 2.5 Physics Syllabus

### 6th Class

#### Motion and Measurement of Distance

- Transport
- Methods of Measurement
- Standard measurements
- Types of Motion

#### Light Shadow and Reflection

- Transparent, Translucent and Opaque objects
- Shadows
- PinHole Camera
- Mirrors and Reflection

#### Electricity and Circuit

- Electric cell
- Bulb
- Electric circuit
- Switch
- Conductors & Insulators

#### Fun with Magnets

- Magnetic and Non Magnetic material
- Compass
- Making magnet
- Attraction and Repulsion

### 7th Class

#### Motion and Time

- Speed
- Measurement of Time
- Measuring Speed
- Distance and Time Graph

#### Electric Current and Its Effects

- Symbols of Electric components
- Heating effect of electric current and its applications
- Magnetic effect of electric current
- ElectroMagnet

#### Light

- Reflection of Light
- Image in Plane Mirror
- Spherical Mirrors (Sp.)
- Image formed by Sp. Mirrors
- Lenses and Their Image formation
- White light and Prism

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## 2.5 Physics Syllabus

### 8th Class

#### Force and Pressure

- Type of Force
- Force and its affects
- Non contact forces
- Pressure
- Pressure exerted by Fluids

#### Friction

- Friction force
- Increasing and Reducing friction
- Wheels
- Fluid Friction

#### Sound

- Vibrations
- Voicebox
- Medium of propagation
- Ears
- Amplitude, Time Period and Frequency of Vibration
- Audible and Inaudible sounds

#### Light

- Laws of Reflection
- Regular and Diffused Reflection
- Multiple Images
- Kaleidoscope
- Dispersion of light
- Eyes
- Braille

#### Stars and Solar system

- Moon
- Stars
- Constellations
- Solar system
- Satellite

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## 2.6 Possible areas of intervention

After reading through the NCERT school syllabus, following topics were thought, which can be considered. Understanding the need to make the concepts easy to understand and be able to make a fun game out of it.

Following topics were considered, which could be woven together with fun, learning and exploration

- Optics
- Magnets
- Electric Current and Its Effects
- Force and Pressure

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## 2.7 Why Optics?

Optics **introduces students to core scientific concepts such as reflection, refraction, diffraction, and interference**. It helps them understand how light interacts with various materials and how these interactions shape our perception of the world.

Optics has numerous **real-world applications** that impact our daily lives. Learning about optics allows students to make connections between scientific principles and their practical applications, such as cameras, lenses, eyeglasses, microscopes, and telescopes.

Optics often involves **mathematical calculations**, such as the application of geometric optics equations or the use of trigonometry to analyze light's behavior. Some students may find the mathematical aspects challenging and may require additional support and practice

**Conducting hands-on experiments and observations in optics can be challenging** due to the need for specialized equipment and controlled environments. Limited access to resources or equipment in schools can hinder students' ability to directly engage with and explore optical phenomena.

It **involves lot of visual representations**, such as ray diagram and light paths, which may be difficult to understand for some students, hindering their ability to understand and solve problems related to optics.

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## 2.8 Optic Concepts

### List of Concepts

- Transparent, opaque, translucent objects and Shadows
- Pinhole Camera
- Plane Mirror - Reflection and Its Applications
- Spherical Mirrors - Reflection and Its Applications
- White light and splitting of colors
- Laws of Reflection
- Multiple Images in Plane mirror
- Regular and Diffused Reflections
- Dispersion
- Human Eye - Demonstration of blind spot, Bird and cage

## 2.8 Optic Concepts

### 2.8.1 Opaque, Transparent, Translucent Objects and Shadows

#### Learning Objective :

- Luminous objects
- Effect of light on Opaque, Transparent and Translucent objects
- Nature of shadow
- Shadow and different shapes

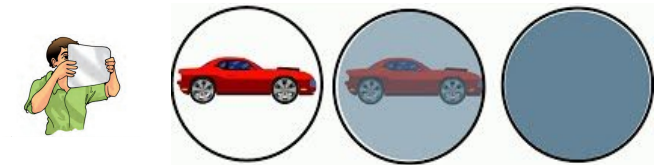
**Luminous objects :** are objects that emit their own light. They produce light through a process called luminescence, which can be either natural, like the Sun or a fire, or artificial, like a light bulb or a glowing LED.

**Opaque Objects:** Opaque objects do not allow light to pass through them. When light falls on an opaque object, it gets reflected or absorbed by the object's surface.

**Transparent Objects:** Transparent objects allow light to pass through them freely. When light passes through a transparent object, it travels without significant scattering or absorption, resulting in a clear view of objects on the other side.

**Translucent Objects:** Translucent objects partially transmit light but scatter it in different directions. When light passes through a translucent object, it gets scattered and diffused, resulting in a blurred or diffused view of objects on the other side.

#### Experiments :



Transparent Translucent and Opaque objects



Luminous Objects

## 2.8 Optic Concepts

### 2.8.2 Light & Shadow

#### Learning Objective :

- To understand the nature of light
- Understanding the Working and Principle of Pinhole camera.
- To get the Image of brightly lit objects

Light travels in straight lines, exhibits reflection, refraction, and diffraction, and can be absorbed or transmitted by various materials. Light carries energy and allows us to see objects by interacting with our eyes or other optical devices.

#### Working and Principle of a Pinhole

**Camera:** A pinhole camera is a simple optical device that uses a small aperture (a tiny hole) to capture an image.

It consists of a light-proof box or container with a small hole on one side and a photosensitive surface (such as film or digital sensor) on the opposite side.

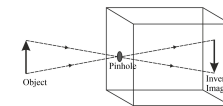
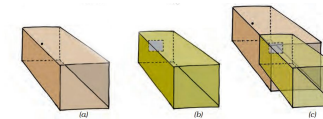
When light enters through the small hole (aperture), it forms an inverted image on the surface. This happens because light rays from different points on the object pass through the hole and form an image by intersecting and spreading out on the opposite surface. The smaller the hole, the sharper the image, but it also reduces the amount of light reaching the surface.

To obtain a clear image, the pinhole camera needs a brightly lit object to ensure sufficient light is available.

#### Experiments and Applications :



Light travels in straight line



Pinhole Camera



Natural Pinhole Camera

## 2.8 Optic Concepts

### 2.8.3 Plane mirror, Reflections and its Application

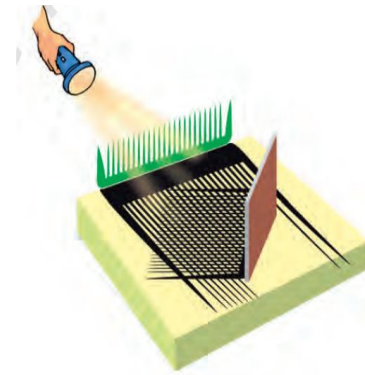
#### Learning Objective :

- Reflective surfaces
- Lateral Inversion
- Reflection

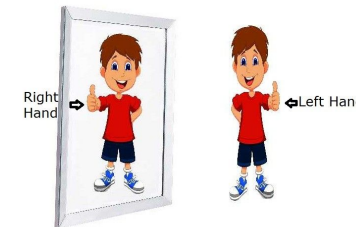
**Reflection:** Reflection is the process by which light bounces off a surface and changes its direction. It occurs when light encounters a smooth and polished surface, such as a mirror, and follows the law of reflection. The law of reflection states that the angle of incidence (the angle between the incident ray and the normal to the surface) is equal to the angle of reflection

**Lateral Inversion:** Lateral inversion refers to the phenomenon where the left-right orientation of an object or image appears reversed in a reflection. In other words, the image appears flipped horizontally. This occurs because the incident light rays and the reflected light rays change their direction during reflection, causing the image to appear laterally inverted. Mirrors are the most common examples of surfaces that cause lateral inversion.

#### Experiments and Applications :



Reflection



Lateral Inversion

## 2.8 Optic Concepts

### 2.8.4 Spherical mirrors and its applications

#### Learning Objective :

- Reflection through Curved Mirrors
- Image formation
- Nature of Image formed

**Concave Mirrors:** Concave mirrors have a curved inward surface. If the object is located beyond the focal point, a real and inverted image is formed. If the object is located between the focal point and the mirror, a virtual, upright, and magnified image is formed.

**Convex Mirrors:** Convex mirrors have a curved outward surface. When an object is placed in front of a convex mirror, the image formed is virtual, upright, and smaller in size than the object. The image appears to be located behind the mirror.

#### Experiments :



Image formed by Concave Mirror



Convex and concave mirror



Dentist examining a patient -  
Concave Mirror



Side view mirror -  
Convex Mirror

## 2.8 Optic Concepts

### 2.8.5 Spherical lenses and its applications

#### Learning Objective :

- Reflection through lenses
- Image formation
- Nature of Image formed

**Convex (Converging) Lens:** A convex lens is thicker in the middle and thinner at the edges. When parallel rays of light pass through a convex lens, they converge, meaning they come together and meet at a point called the focal point.

**Concave (Diverging) Lens:** A concave lens is thinner in the middle and thicker at the edges. When parallel rays of light pass through a concave lens, they diverge, meaning they spread apart.

**Nature of Image Formed :** The nature of the image formed by a lens depends on the type of lens used (convex or concave) and the position of the object relative to the lens.

**Convex Lens :** Object Beyond Focal Point: A real, inverted, and diminished image is formed on the opposite side of the lens.

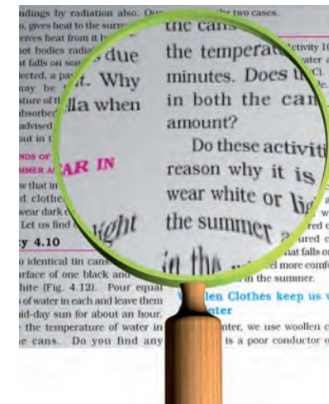
**Object Within Focal Point :** A virtual, upright, and magnified image is formed on the same side as the object.

**Concave Lens :** Regardless of the object's position, a concave lens always forms a virtual, upright, and diminished image on the same side as the object.

#### Experiment and Applications :



Image formed by Convex lens



Magnifying glass - Convex lens

## 2.8 Optic Concepts

### 2.8.6 Refraction

#### Learning Objective :

- Light traveling through different materials
- Refractive Index
- Lateral shift
- Total internal refraction

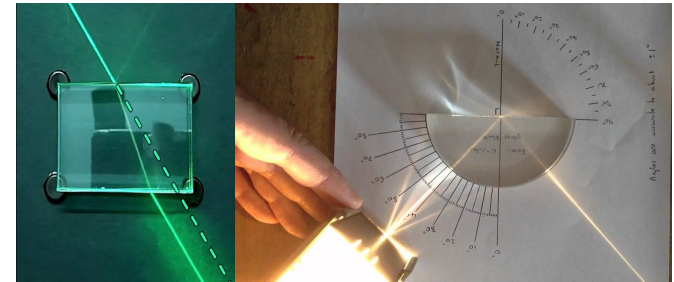
Light travels at different speeds when it passes through different materials. The speed of light in a vacuum is approximately  $3 \times 10^8$  m/s. However, when light enters a medium such as air, water, or glass, its speed changes. The change in speed causes the light to bend or change direction, a phenomenon known as refraction.

**Refractive Index:** The refractive index is a measure of how much a material can bend or refract light. Each material has its own refractive index, which determines the extent to which light bends when it enters or exits that material.

**Lateral Shift:** When light passes from one medium to another at an angle, it not only changes direction but also experiences a lateral shift or displacement. This lateral shift is the change in the path of light as it crosses the boundary between two materials with different refractive indices. The amount of lateral shift depends on the angle of incidence, the refractive indices of the materials involved, and the thickness of the materials.

**Total Internal Reflection:** Total internal reflection occurs when light traveling from a denser medium to a less dense medium reaches a critical angle of incidence. The critical angle is the angle of incidence at which the refracted ray lies along the boundary between the two media, and no light is transmitted into the less dense medium. Instead, all the light is reflected back into the denser medium.

#### Experiments :



## 2.8 Optic Concepts

### 2.8.7 Splitting of white light

#### Learning Objective :

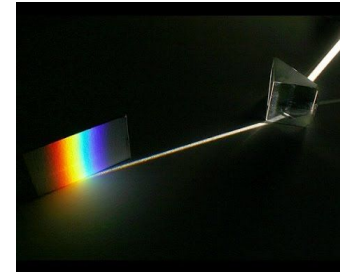
- Splitting of White light
- Rainbow formation

**Splitting of White Light:** White light is composed of a mixture of different colors, commonly referred to as the visible spectrum. When white light passes through a transparent material with different refractive indices for different wavelengths (colors) of light, such as a prism or a droplet of water, it undergoes dispersion.

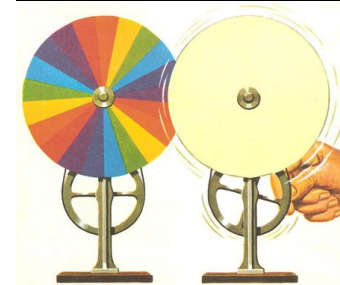
Dispersion is the phenomenon where light of different wavelengths bends or refracts at different angles as it passes through a medium. The shorter wavelengths, such as violet and blue, bend more than the longer wavelengths, such as red and orange.

**Rainbow Formation:** Rainbows are natural optical phenomena that occur when sunlight interacts with water droplets in the air. The formation of a rainbow involves reflection, refraction, and dispersion of sunlight within the water droplets.

#### Experiments



Prism



Newton's Color Disc



Rainbow

## 2.9 Experiments to Understand the principles

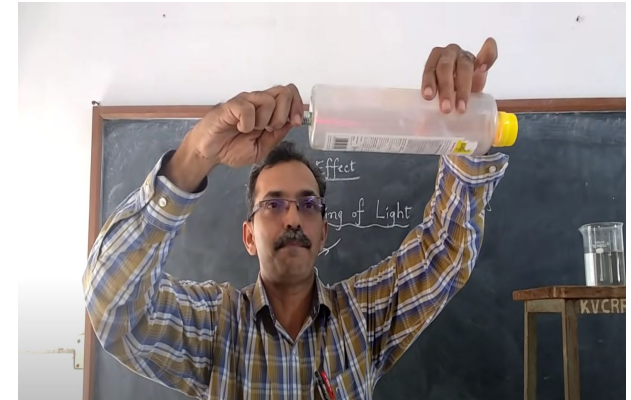
Simple experiments to understand the principles of Optics

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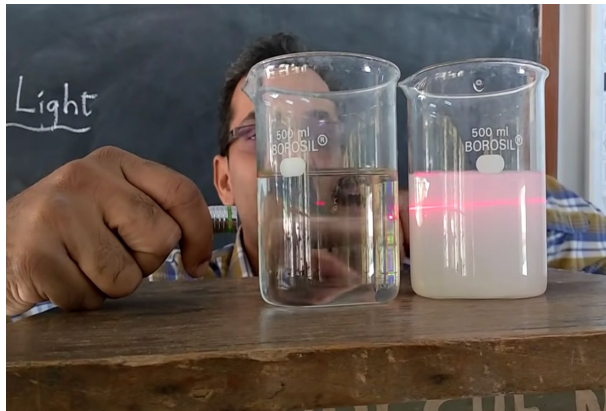
Youtube Channel - [Eswara Venkata Ramana](#)



Laser light invisible in air



Dispersion of light



Visibility of laser when passed through colloidal solution



Orange color of the sun, during sunrise and sunset



Blue color of the sky

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## 2.10 Targeted users

Analysing the optics syllabus, it was found that in 6th grade, basic idea of idea is introduced, in 7th grade the basic principles and their applications are taught, and in class 8th the formulas related to the principles are taught.

Considering these factors, **students of Class 7th and 8th students** were considered as targeted users.

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# 3. Primary research

## 3.1 Visit to Raman Science Centre, Nagpur

The Raman Science Centre Nagpur is an interactive science center affiliated with Nehru Science Centre Mumbai. The center was developed to promote a scientific attitude, portray the growth of science and technology and their applications in industry and human welfare, and hold science exhibits. The centre is named after famous Nobel Prize winner Indian physicist Chandrasekhara Venkata Raman. The Raman Science Centre was inaugurated on 7 March 1992 and the planetarium was started on 5 January 1997.

It is an exciting world on the bank of Gandhi Sagar. Here Science is no more a subject but an experience. Here science is a thing to play with & learn. Here one is free to spend a whole day in play with hands-on exhibits-press lever, turn wheels, roll balls, pull strings, press the buttons, look through the peepholes to make science work & enjoy. One can discover that, here concept of science is different: It is sheer fun.



## 3.1 Visit to Raman Science Centre, Nagpur



**Sun Dial**

The shadow of the rod falls on the scale, marked with numbers, as the Sun move from East to West.

The time of the day can be observed from the scale



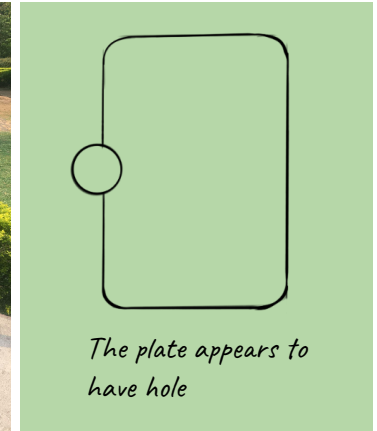
**Bird in the Cage**

Rotate the crank to rotate the plate with image of Bird on one side and cage on another. When rotated fast, it tricks us to see the bird inside the cage.

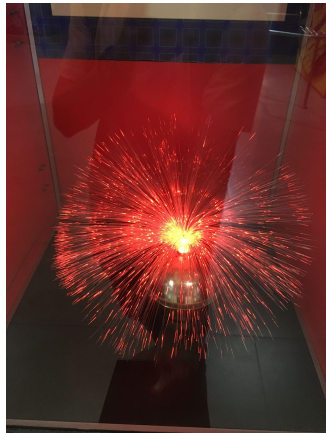


**Illusion of hole in the plate**

The installation has two eye holes, in which one side there's a hollow rod and the other side a plate. When seen through those eye holes it appears that there's a hole in the plate, as shown in the right side image.



## 3.1 Visit to Raman Science Centre, Nagpur



**Optic Cable**

Its based on the principle of total internal reflection (*tir*). The optics cable are attached with a light at one end and the light appears to glow on the other end 'cause of *tir*.



**Symmetroscope**

Also called as Kaleidoscope, it is a big size kaleidoscope, where patterns appear to change when you rotate the crank. It is based on the principle of reflection of plane mirror.



**Installation**

When you see the mirrors from centre of the spherical cut section over which the mirrors have been mounted, you see image of your face from slightly different angle at all mirrors



**Optical Illusion Installation**

Put your head through the hole in the table, When seen from front your head appears to be served in plate along with fruits. The mirrors on the sides of the table reflect the pattern on the walls. This produces the illusion that your body is missing - that there is nothing under the table. The illusion works for someone standing in front of the exhibit.

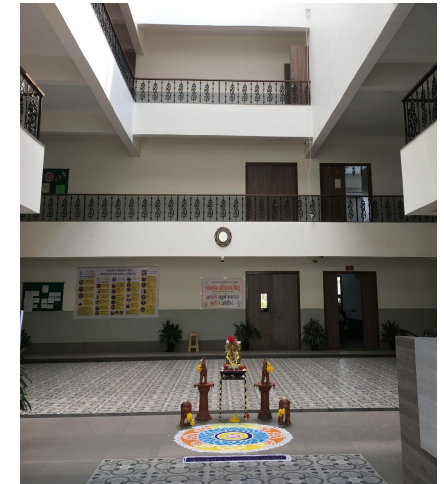
## 3.2 Visit to Govardhan Skill Centre (GSC), Palghar

Govardhan Skill Centre is a non-profit organization (a project by Sri Chaitanya Seva Trust ), with the objective of Educating and Empowering Rural India

It has clearly set four E's as its goal on course to achieve in the next one decade i.e. Education, Empowerment, Employment and Entrepreneurship . It is focused on bringing about a qualitative change in the lives of underprivileged, by giving a different meaning to Education.

Following are the facilities available at the centre

- DBRT Program - Diploma in Basic Rural Technology
- Fabrication Lab
- Access to School children to work on the projects
- Mobile science Lab



### 3.2.1 GSC - Fab Lab (Fabrication Lab)



FabLab



Basic machining tools



Laser Cutter



CNC Machining

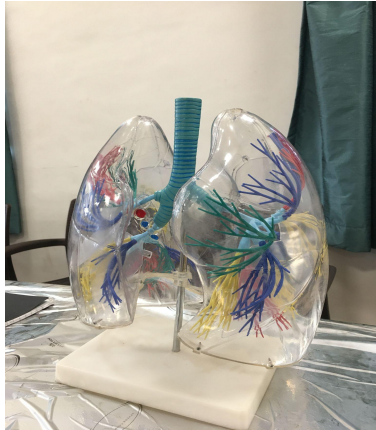
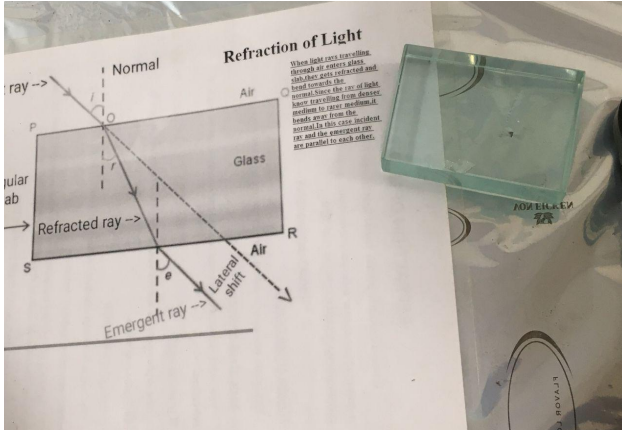
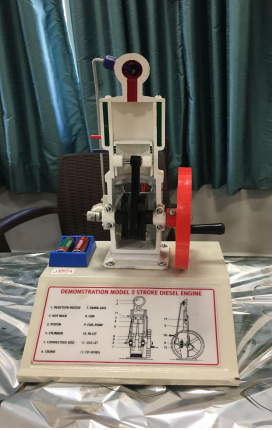
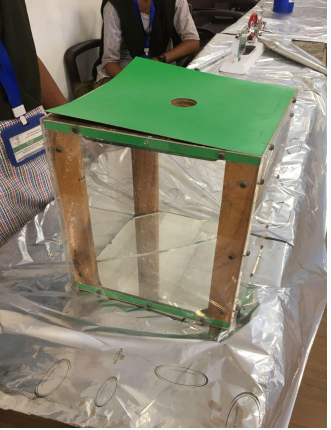


Laser cut products



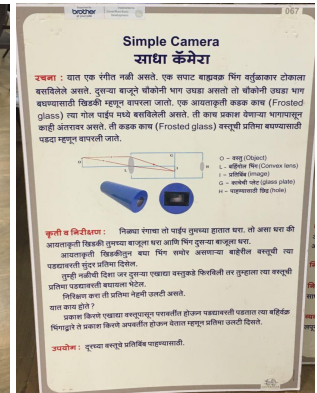
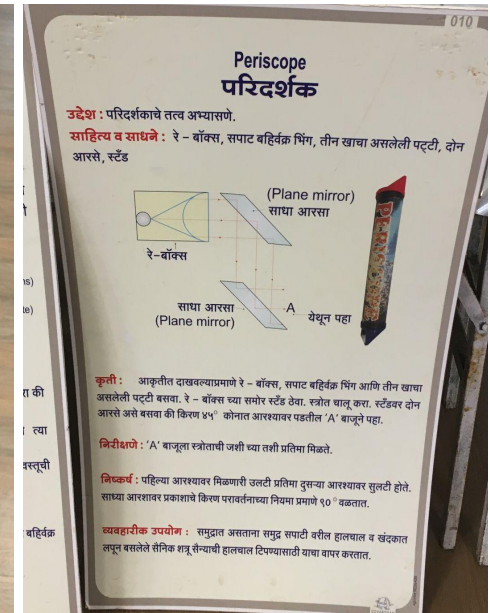
3D Printing

### 3.2.2 Science day, 28th Feb - Exhibition



### 3.2.3 Insights from the visit

- Setup needs to be more clear to explain the principle, a guide book is needed for theoretical understanding
- **Better to make and learn** rather than understand from the existing setups
- Mobile Labs - Visiting nearby schools and teaching students
- **Learning by choice** - children taking projects as per their interests
- Students knew the outcomes, but **stumble** while explaining the **principle, its applications**, and scenario.
- Less engaging experiments



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### 3.2.4 Teacher's POV (Zilla Parishad)

During the visit I talked with few teachers, understanding their perspective on the teaching learning scenario and following were the issues mentioned by them,

- In Rural Schools, the number of students per class are less. So considering number of students the teachers appointed are also less, which means at times just 2 teachers need to take care of 4 class, of different grades. Which makes it difficult to cover the syllabus
- Lack of experimental setup, makes it difficult to give
- More Work load due to Govt. works (Digital Edu. Initiative, Election duty etc.), making it difficult to give proper time to students for their studies.

# 4. Market study

## 4.1 Primary Research

Hamley Toy shop was visited and following products by Smartivity were found to be the best sellers

Smartivity toys were found to have majority of their parts laser cut, and assembled with the help of simple joinery and rubber band.

The quality was found good, in terms of laser cut finish and structurally sturdy after assembly.



# 4.2 Secondary Research



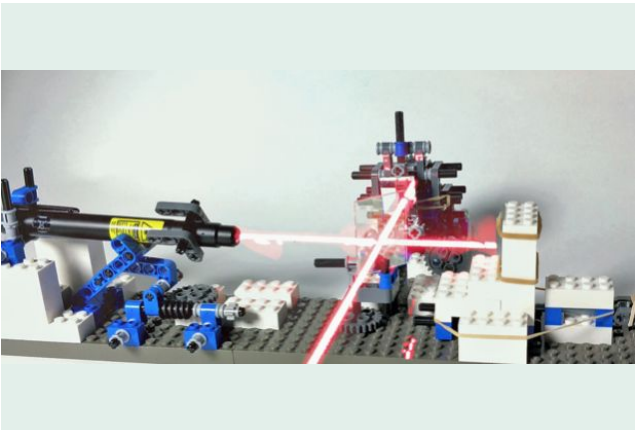
Smartivity Kaleidoscope



Khet 2.0



Skillmatics Buildables 3D Spy



Lego and laser

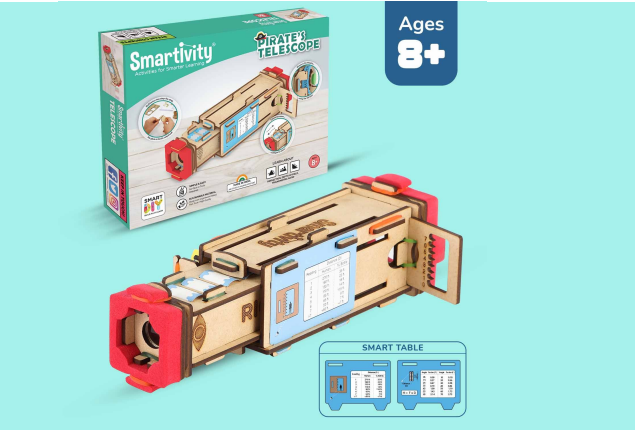


Optics STEM glass toys



Skillmatics Buildables 3D Spy

# 4.2 Secondary Research



Smartivity Telescope



Smartivity Microscope



Viewfinder Toy



Magna Tiles - Clear Colors Set



Gravity Maze



Think Fun Laser Maze

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## 4.3 THE TOY ASSOCIATION STEM/STEAM STRATEGIC LEADERSHIP COMMITTEE REPORT

THE Journal magazine, the leading resource for administrative, technical, and academic technology leaders in K-12 education, has identified **STEAM as one of their red-hot trends in education in a 2017 report**. According to Dr. Rosemarie Truglio, SVP of education and research at Sesame Workshop in New York, “Incorporating the arts into our STEM curriculum was an exciting and natural addition, as Sesame Street has always used music, visual, and performing arts as tools to educate and entertain children. Schools like Northwestern’s McCormick School of Engineering shifted its curriculum by **merging the analytical and technical components of engineering (left brain) with creativity, design, and divergent thinking (right brain)**. They call it “**Whole Brain Thinking**,” and break down the different skills as:

Left Brain • Analysis • Logic • Synthesis • Math • Sequencing • Computation

Right Brain • Intuition • Metaphorical thought • Creative Problem Solving • Holistic Thinking • Visualization

**The “A” in STEAM represents the artistic**, creative, right side of the brain, known as the subconscious or unconscious mind.



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## 5. Design Brief

*“ To design a play based on optics principle, which encourages learning and exploration for students of class 7th ”*

**Objective :** Construction ( teacher’s perspective - ‘ they learn when they are invested’)

Understanding of Optics

Engaging & Immersive

Fun

Knowledge

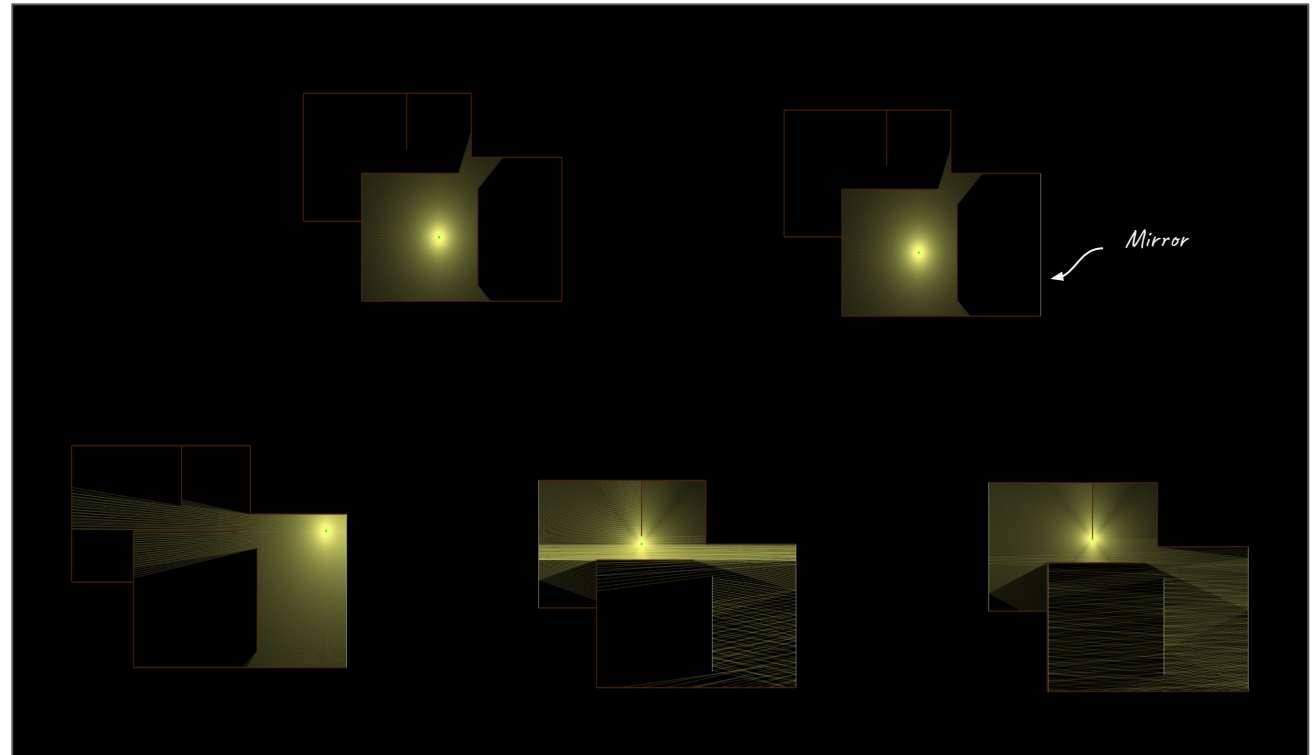
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# 6. Ideation

## 6.1 Light up the room

**Play** : Arrange the mirrors to light up the room

The idea is to have rooms with opaque walls, and a light source, which can be placed at certain locations, and then there can be challenge to lit up the room

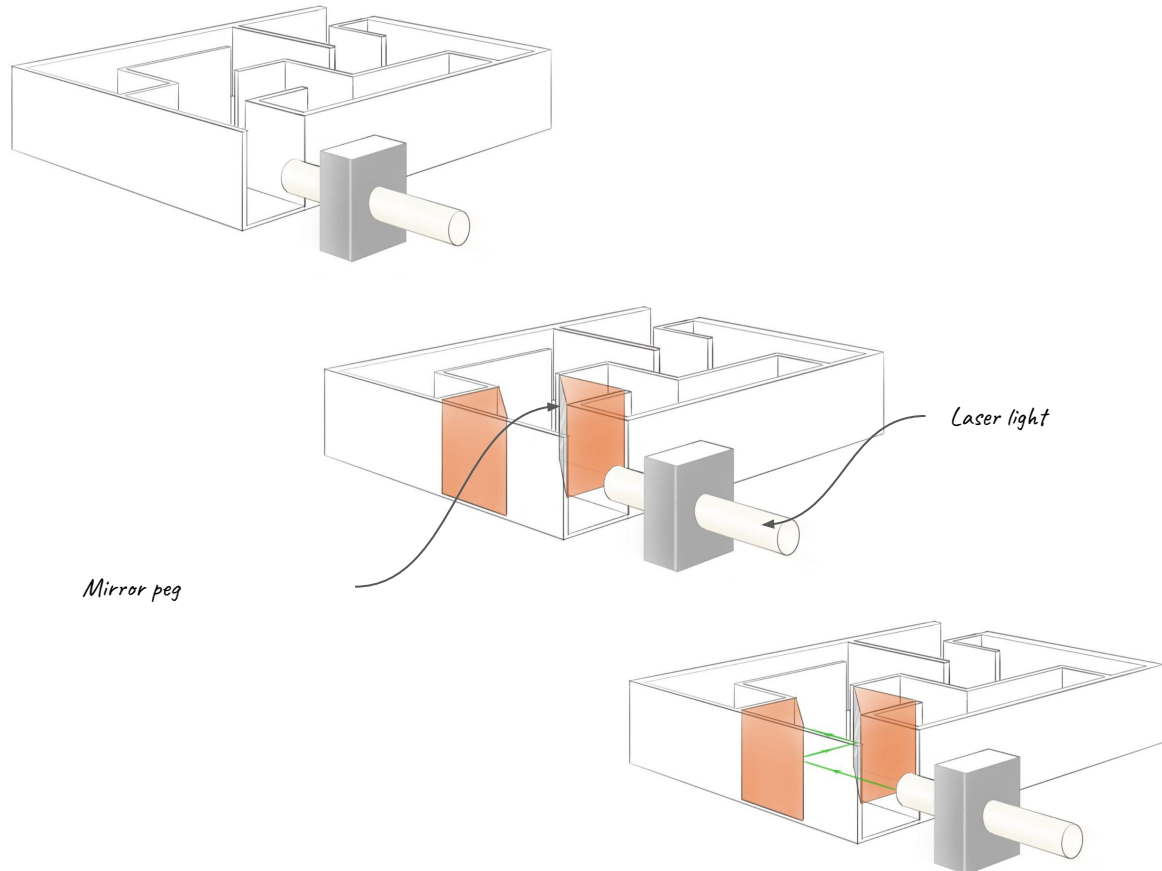


## 6.2 Puzzle

**Play :** Place the mirror pegs in the maze, such that it finds its way out.

The idea is to create play from the principle of reflection from plane mirror, where one needs to place mirror in locations, such that the laser beam can find an exit out of the maze.

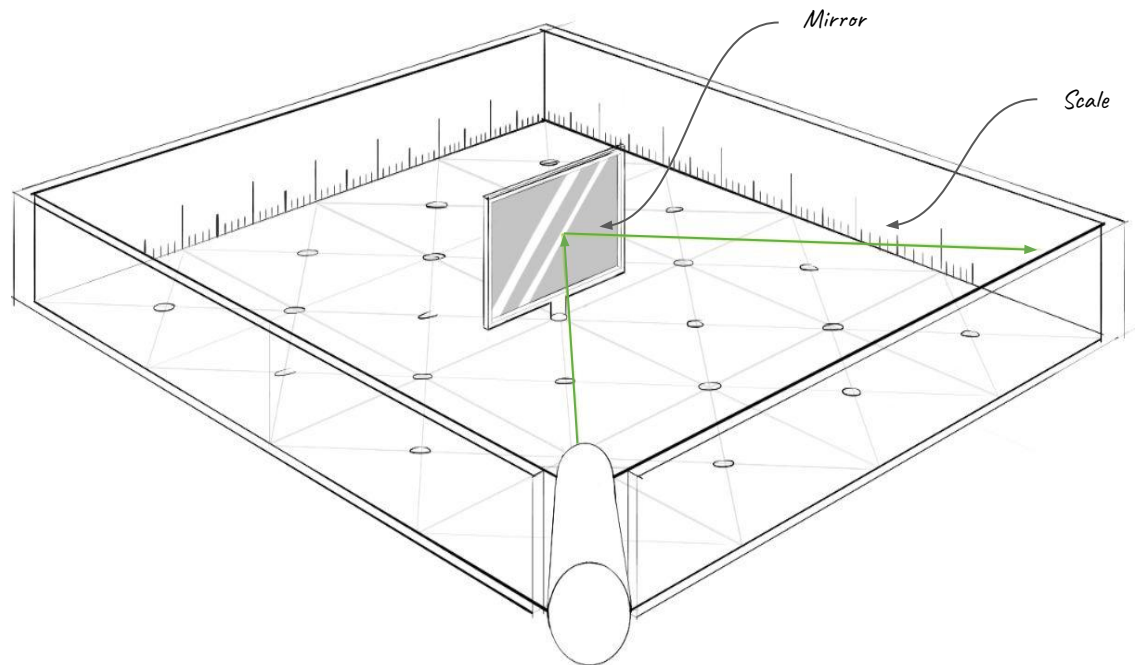
**Feedback :** The play would be only one time, no different solution is possible, play is very solid. Better to make it modular, where the walls can be altered, and would then be more exploratory.



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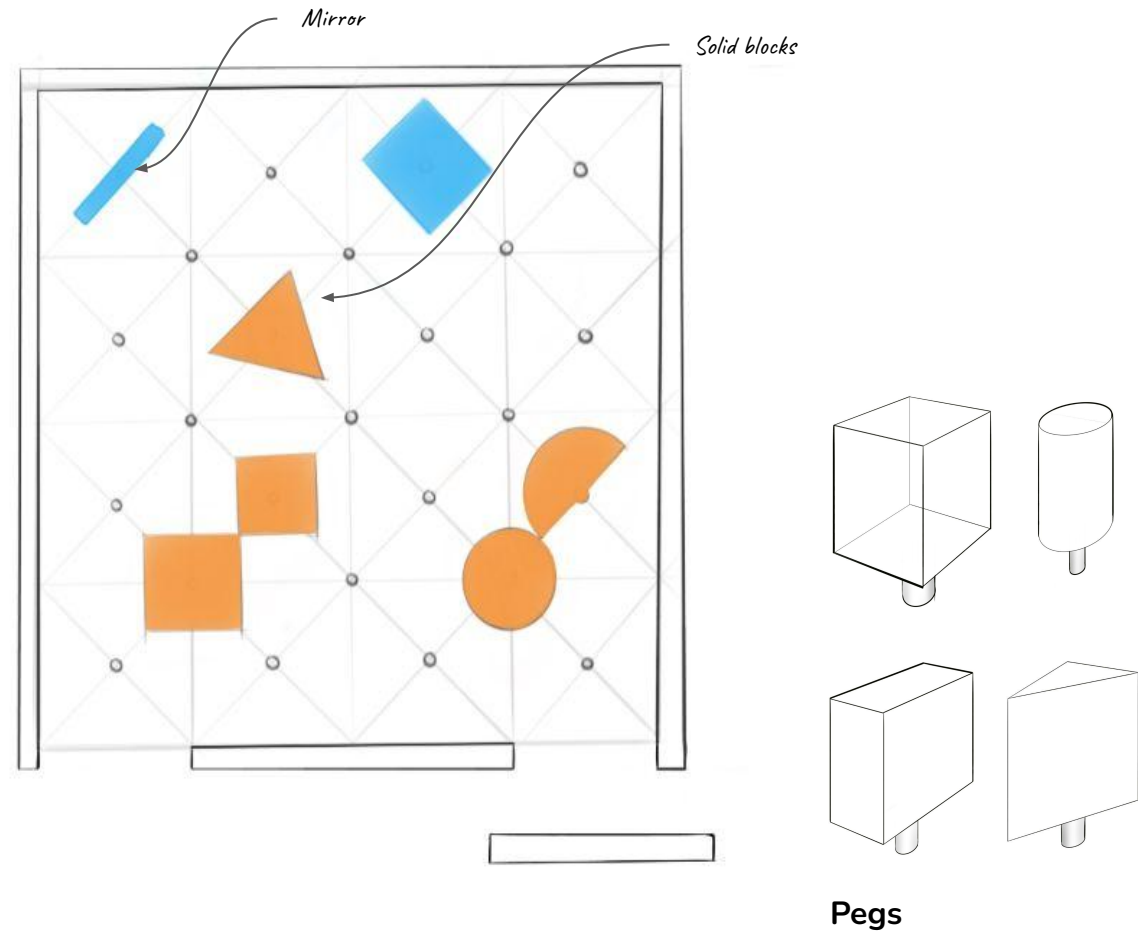
## 6.3 Learning Apparatus

**Play :** Rotate the mirror and check the reading on scale to measure the range of shift of laser pointer, (OR) hit the targets positioned on the wall, when mirror is rotated at certain degree (based on chance, when dice is rolled) and do a fun task.



## 6.4 Maze

**Play :** Place the mirrors, glass slab and prisms in a way that the laser beam finds the way out.  
Its based on the principle of reflection in plane mirror and refraction through glass slab and prism.

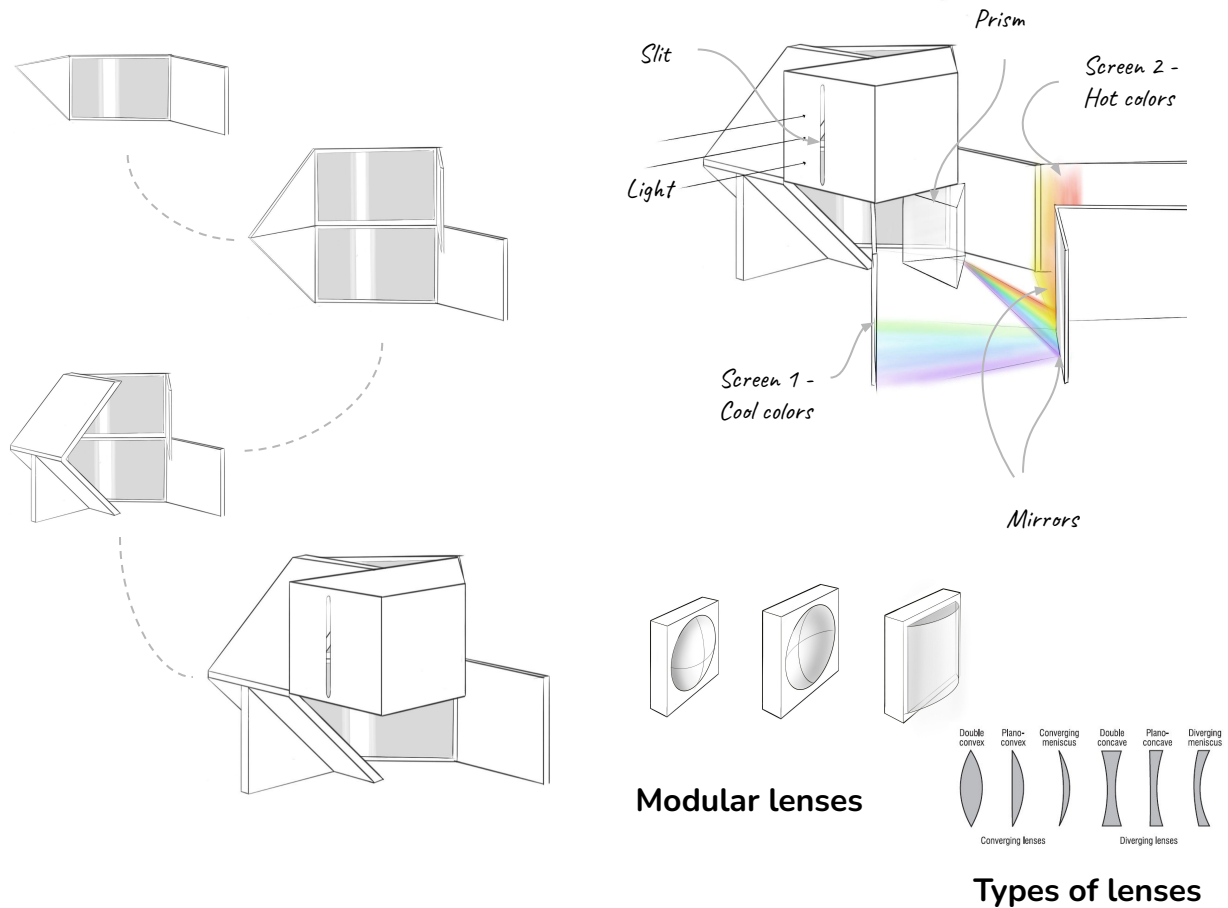


## 6.5 Optics Lego

**Play** : Arrange the blocks to create a structure. The structure then would allow the player to learn and observe the reflection, refraction of light in the structure.

Its a direction of idea, where in the structures can be such that it challenges the player with a task, which would make them actively engage with the optics materials like mirrors, lenses, glass slab, prism etc.

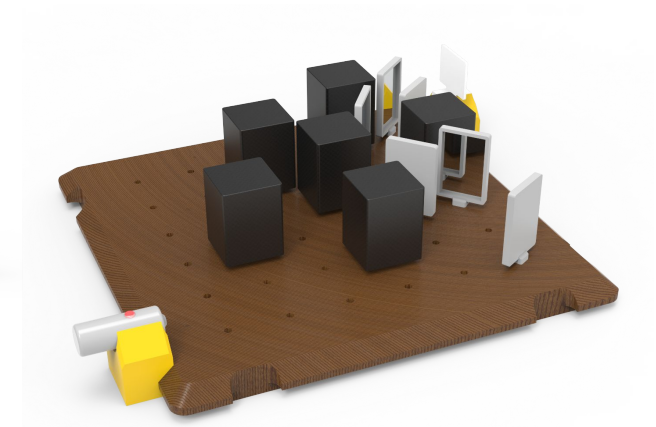
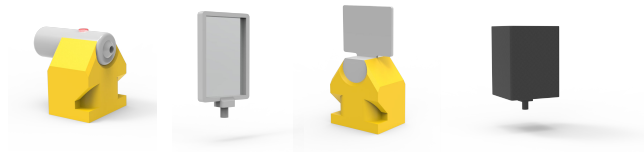
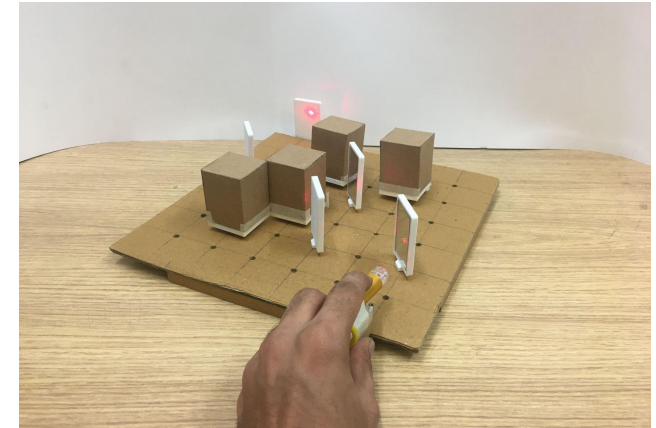
For example : The task in the image shown, is to light up two screens with hot colors and cool colors. For which the player would need to arrange blocks and mirror splitter, to accomplish the task.



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## 6.6 Laser Board Game

**Play :** The play involves finding a way around the obstacles and hit the target. The laser gets reflected when it hits the mirror, and refracted when they hit the splitter.



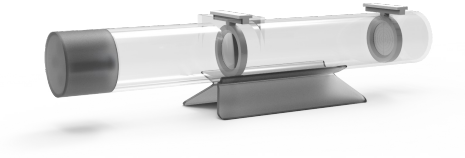
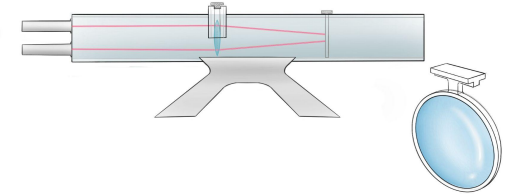
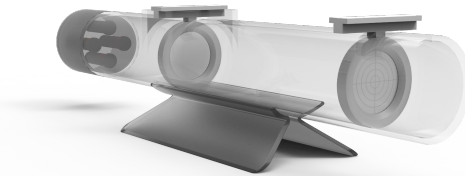
## 6.7 Teaching Learning apparatus

**Working** : The apparatus allows to see the bending of laser light when passed through different lenses.

It demonstrates tyndall effect, i.e. light rays are visible when passed through a colloidal solution.

The scale can move inside the tube allowing to see the magnification at different locations.

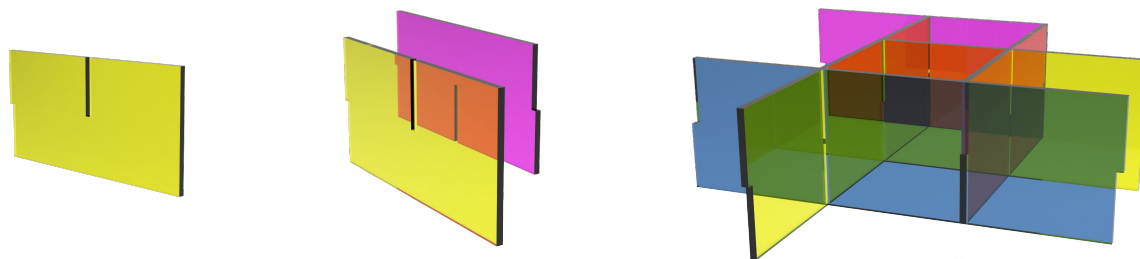
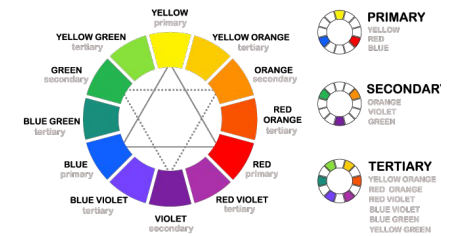
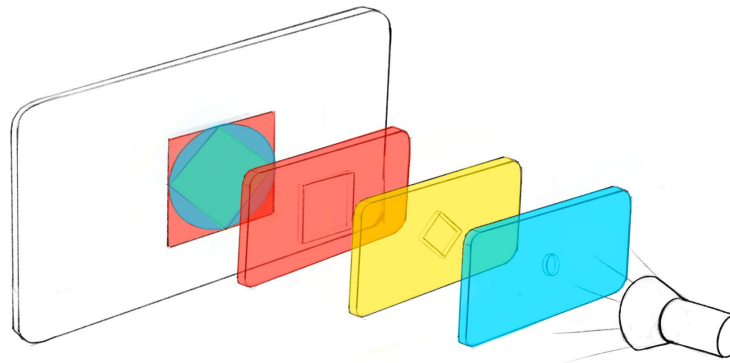
The apparatus contains a colloidal solution (in this case it is water + dettol), the lenses, prism and glass slab can be inserted into the tube from top and the resulting bending can be clearly observed.



## 6.8 Color play

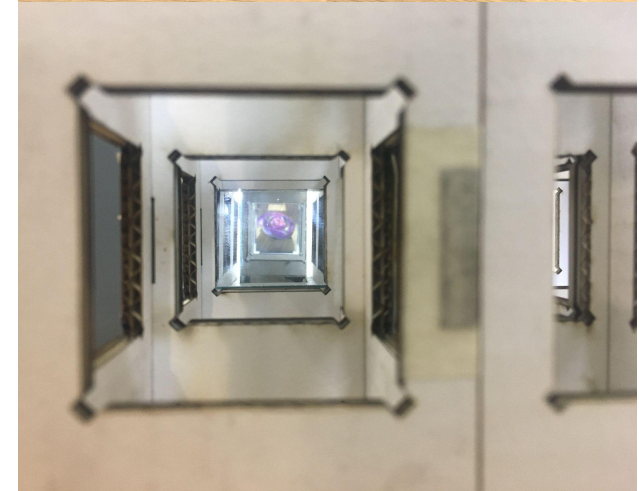
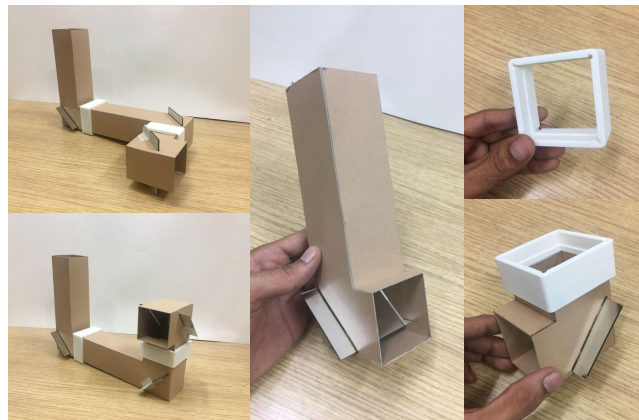
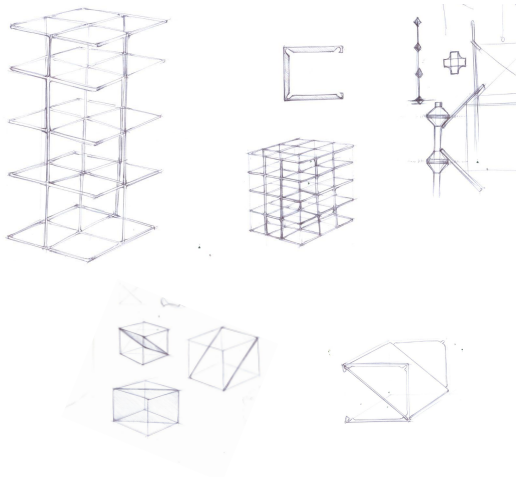
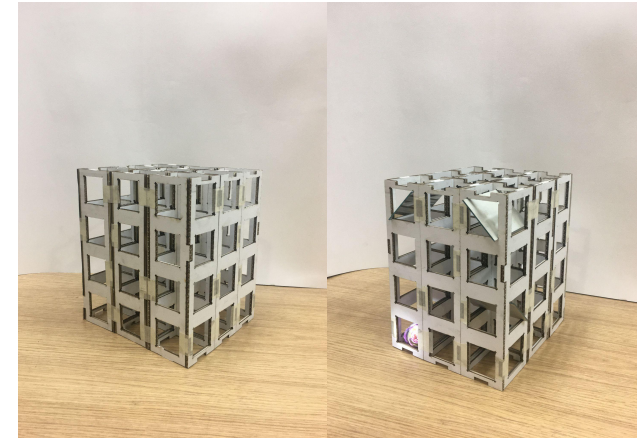
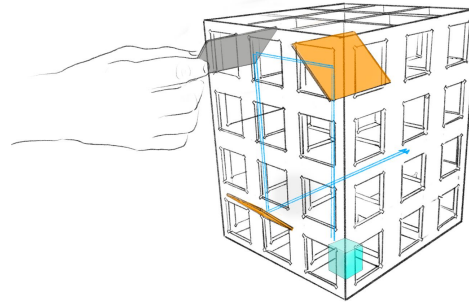
**Play** : The play is based on the principles of color theory.

Play consists of translucent colored graphics on acrylic sheet, when the light is passed through the panels, the color combine to create different colors and new stories can be formed.



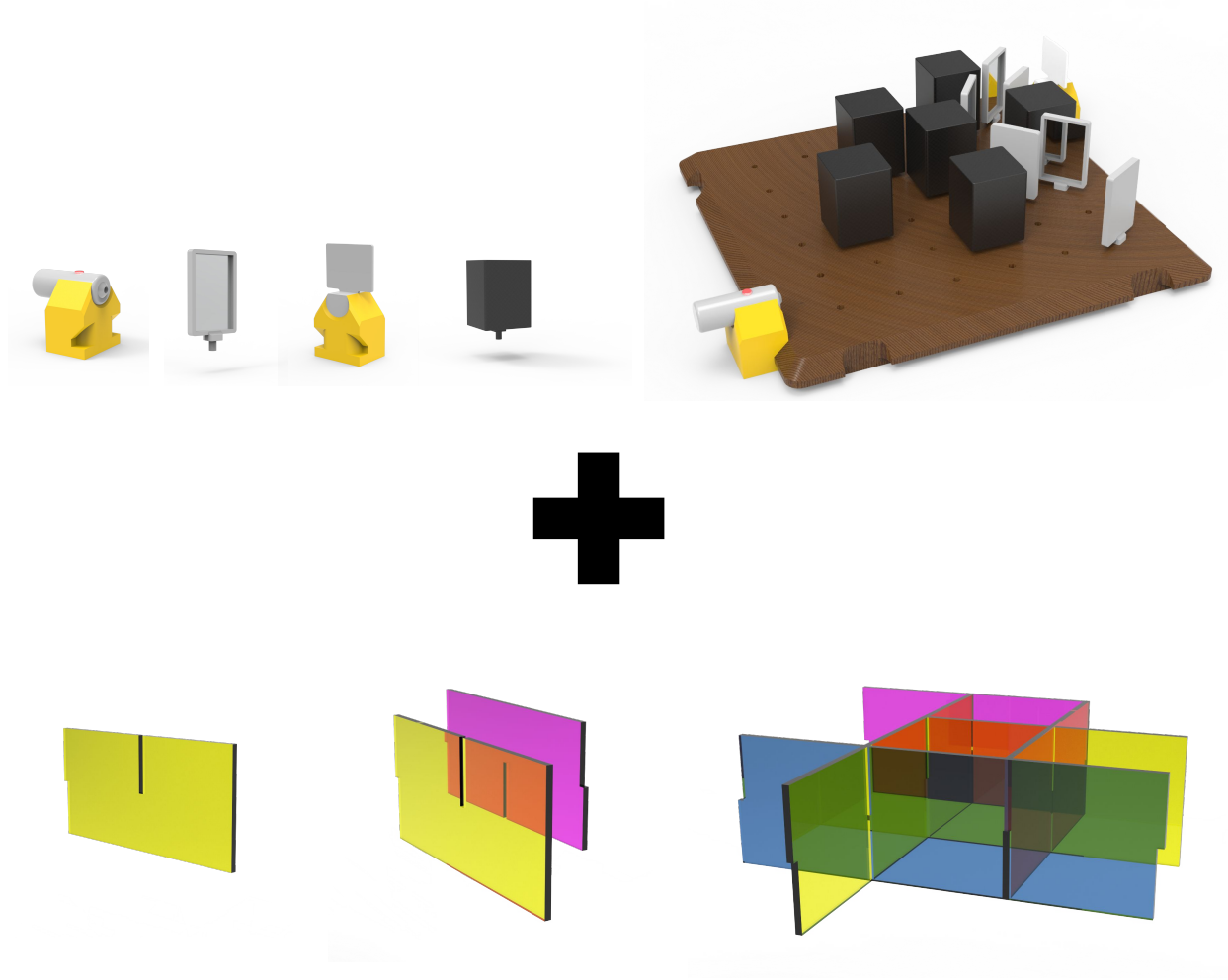
## 6.9 Reflect Tower

**Play** : It's based on the principle of reflection through plane mirror. A model is kept in one corner of the grid, and the challenge is to arrange the mirrors in a way that the model is visible from the other corner of the grid.



# 7. Final Concept

Final Concept was to combine concept 6 and Concept 9. Which was targeted to be based on reflection and color theory. The Idea is to enhance the scope of the play.



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## 7.1 Game 1 - Laser Board Game

### 7.1.1 Theme

Owl is seen as a symbol of wisdom, hence it was chosen as the primary character, a nocturnal bird with night vision symbolising the laser glowing in the dark.

The owls are afraid of loud and shrill sounds because they cause hindrance to their flight hence the obstacles in the game are a symbolic representation of the same.

The Laser Peg and the Target are an abstracted form of parent and the baby owl whose intention is to interact with each other avoiding all the hindrances in their way.

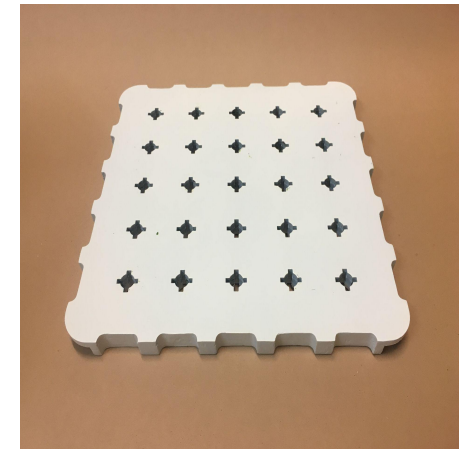
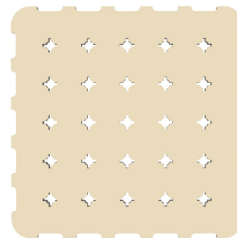
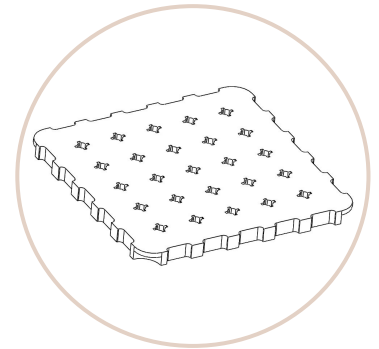
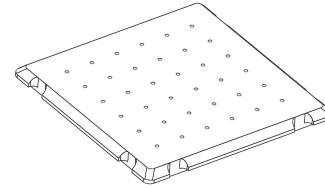
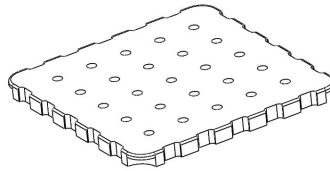


## 7.1.2 Form Development

### Board

The Board Ideation started with trying to understand

- Peg snapping area
- Number of Peg mounting places (the holes) on the Board
- Holding position while lifting the board
- Cleanability



**Final Form**

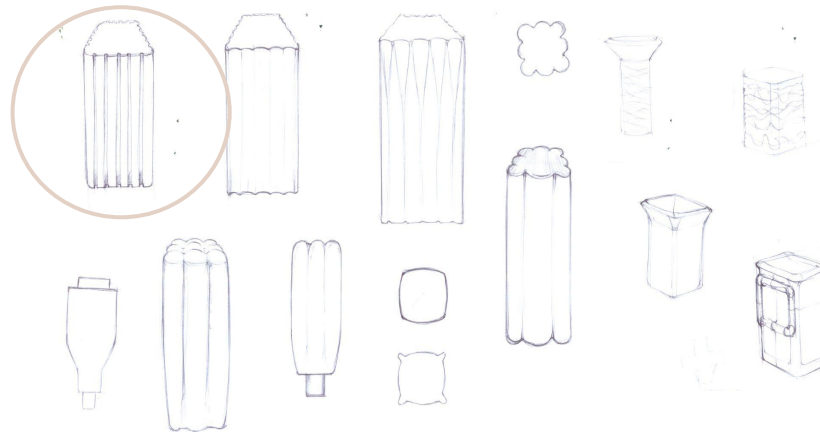
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## 7.1.2 Form Development

### Obstacle

The Obstacle form was to express a loud and shrill sound, according to the narrative.

The form also matched the design language of the board, snap sections as grooves



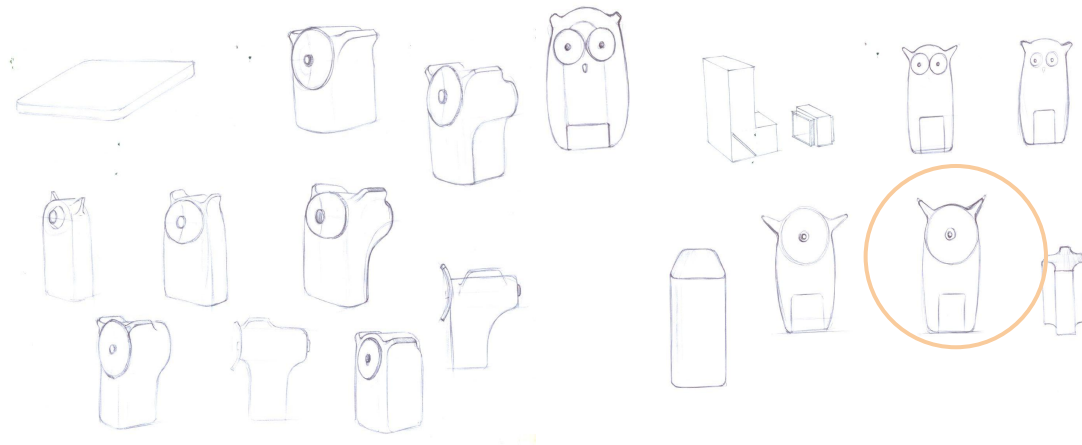
**Final Form**

## 7.1.2 Form Development

### Laser Peg

The Laser Peg had to be an abstracted form of the Owl.

The form was to be made soft and cute, so that children connect with the form.



*Bump to communicate snapping*

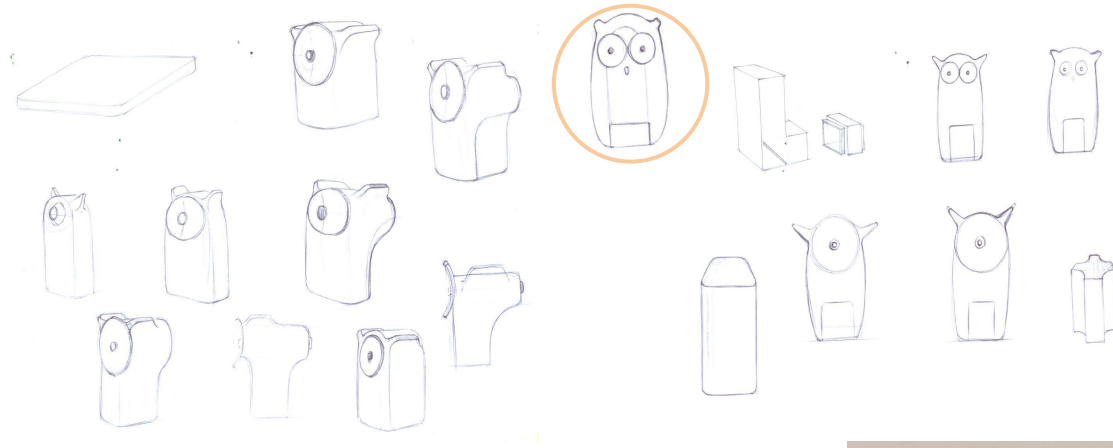


**Final Form**

## 7.1.2 Form Development

### Target Peg /Baby owl peg

The Baby owl peg had to have a similar design language as that of the laser peg so that it connects. Also a small bump in the front would help them to communicate that it can snap to the board.



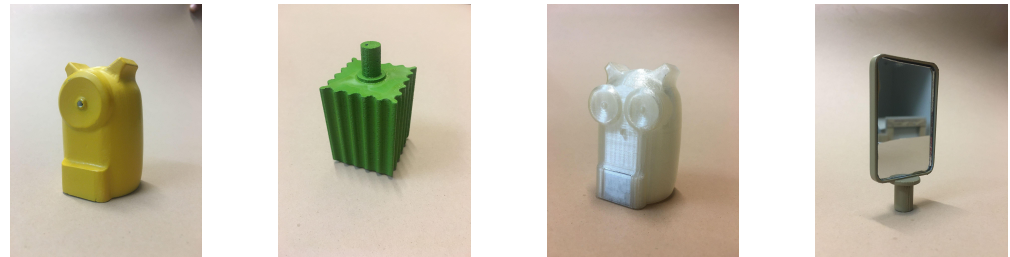
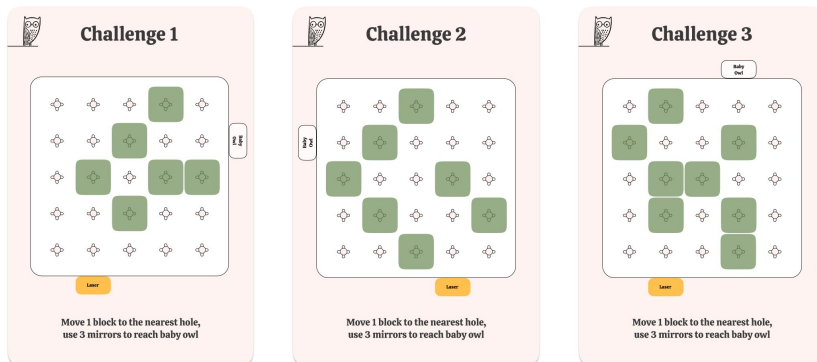
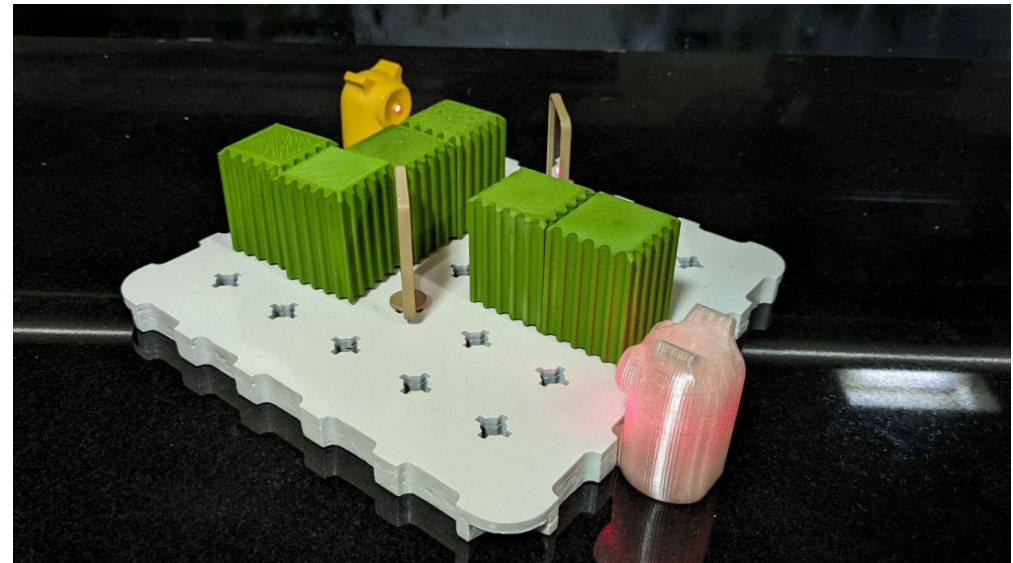
**Final Form**

## 7.1.3 The Game Mechanism

### The play :

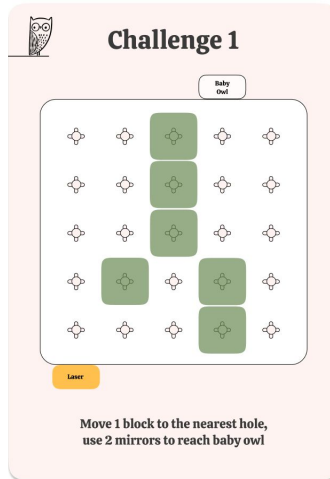
Arrange the obstacle blocks according to the Challenge Card provided. Use the number of Mirrors mentioned in the card to reach the Baby Owl.

Every card comes with a set of conditions, that needs to be followed, to solve the challenge.



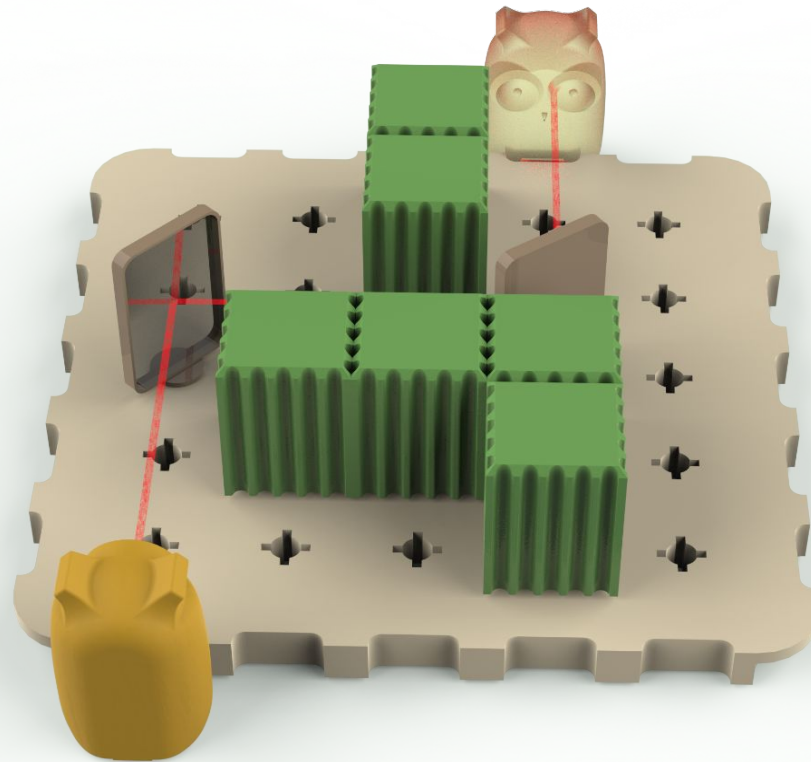
### Challenge Cards

## 7.1.3 The Game Mechanism



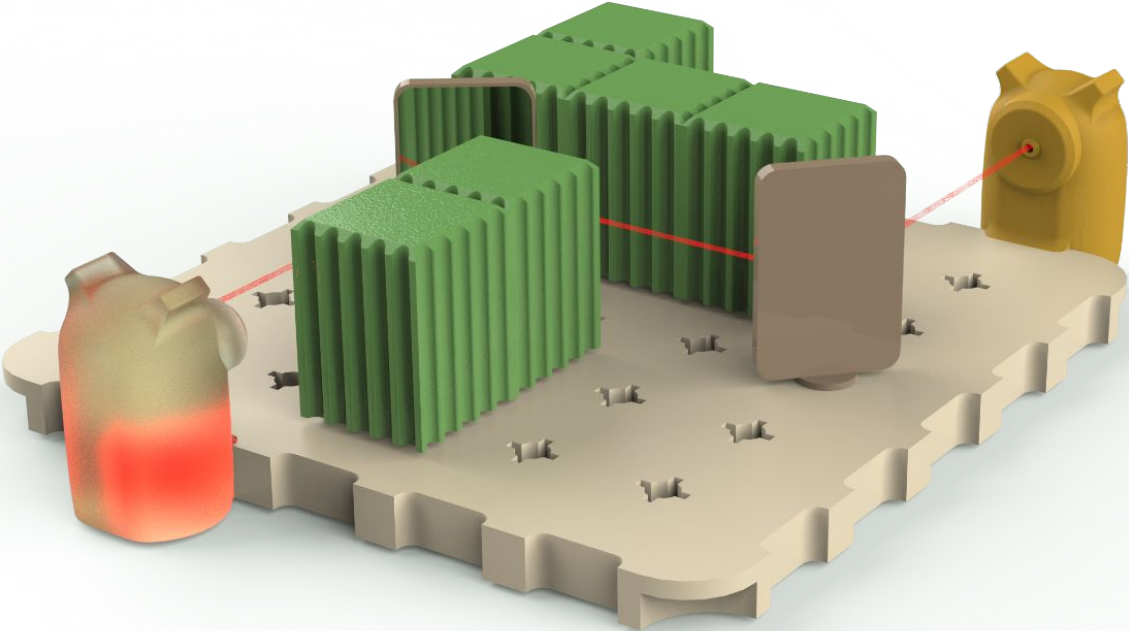
The green squares symbolizes the obstacles and, the Yellow and White represents Laser Peg and Target respectively..

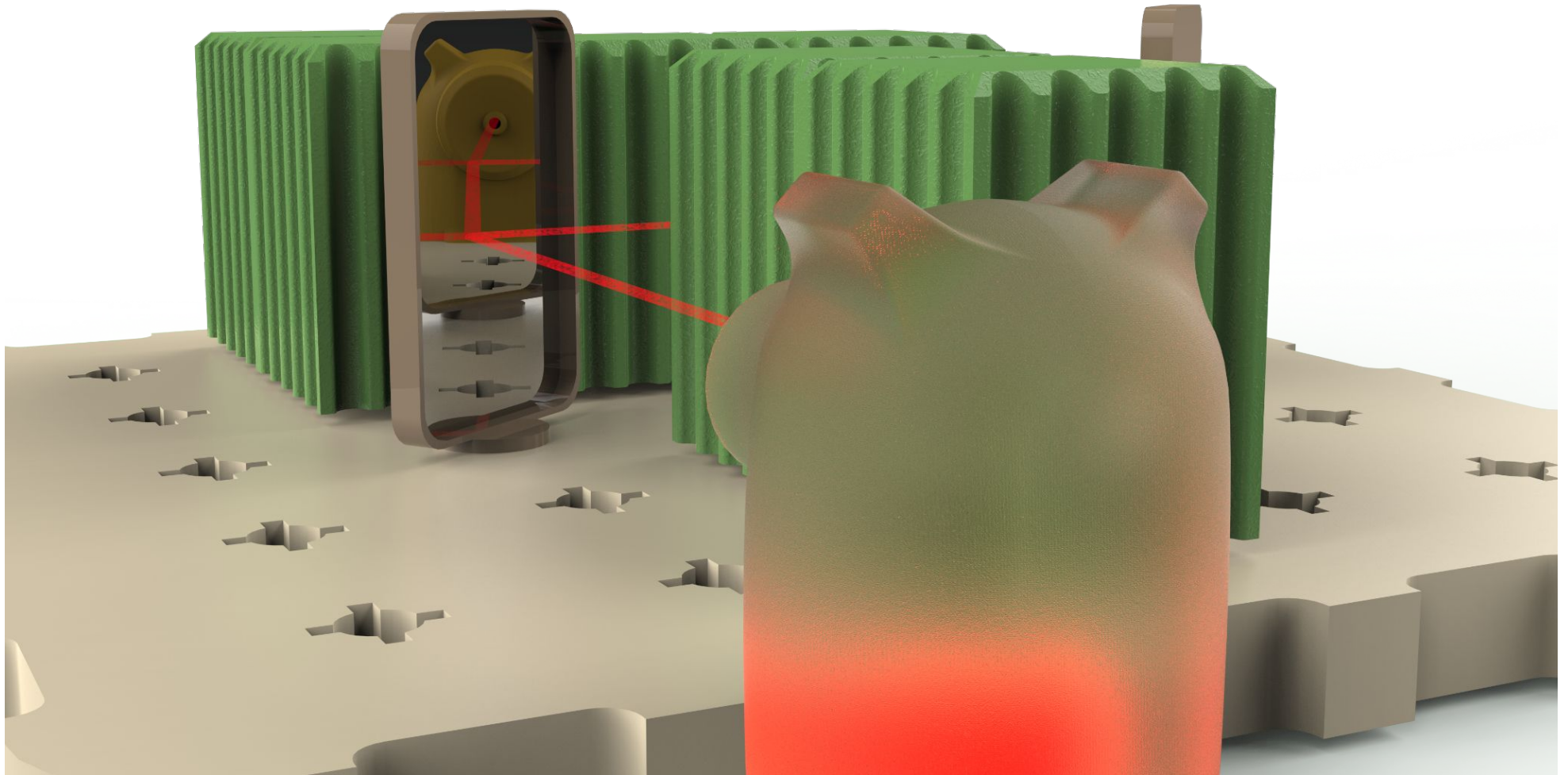
Arrange the following as mentioned, and read the task mentioned below, to start the challenge.

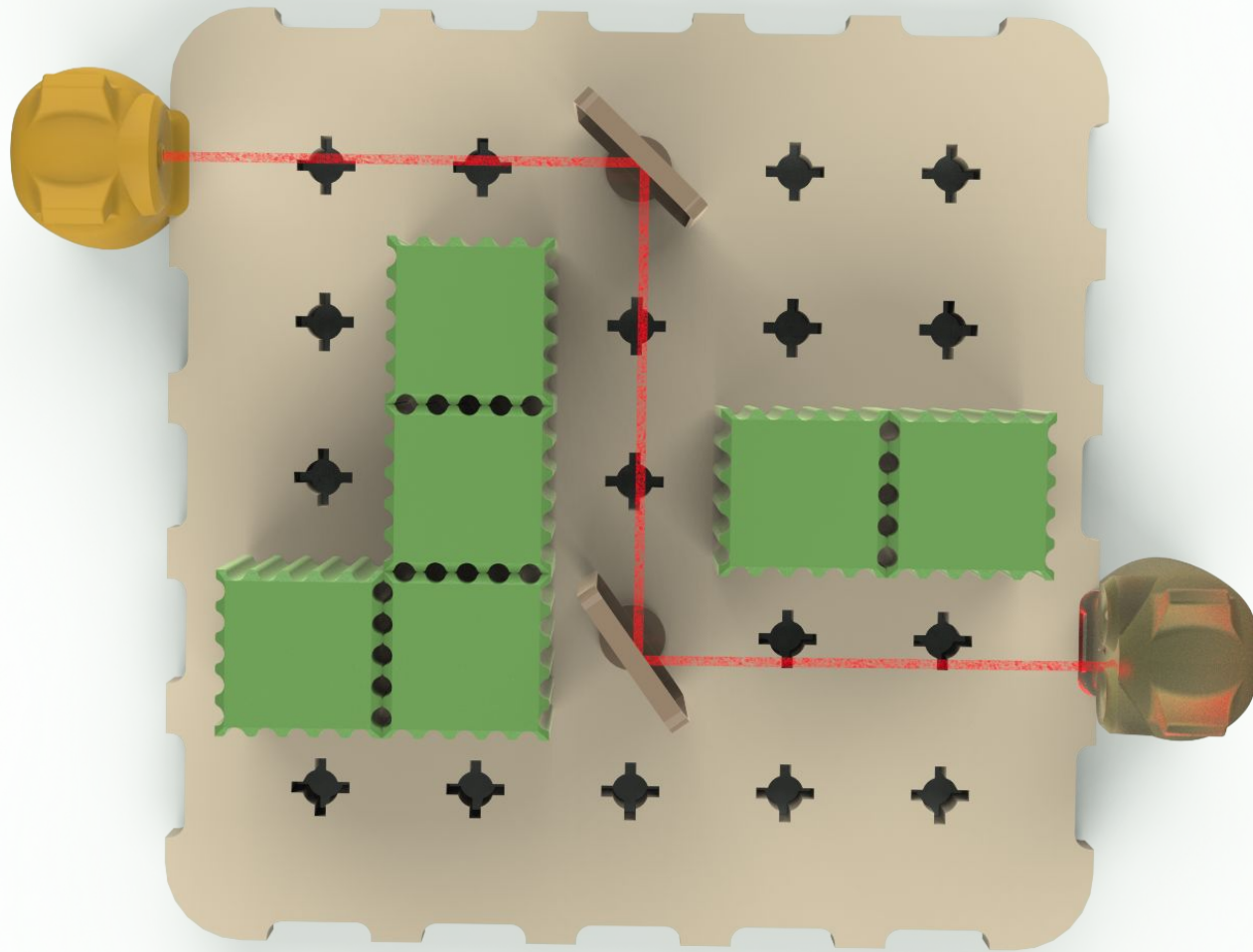


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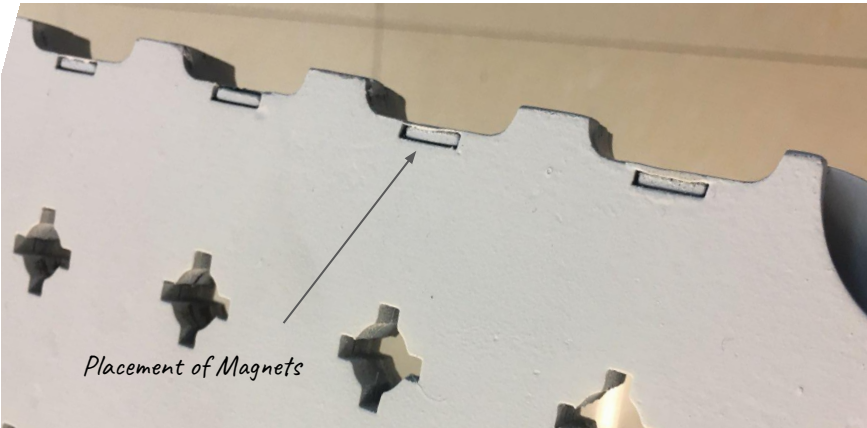
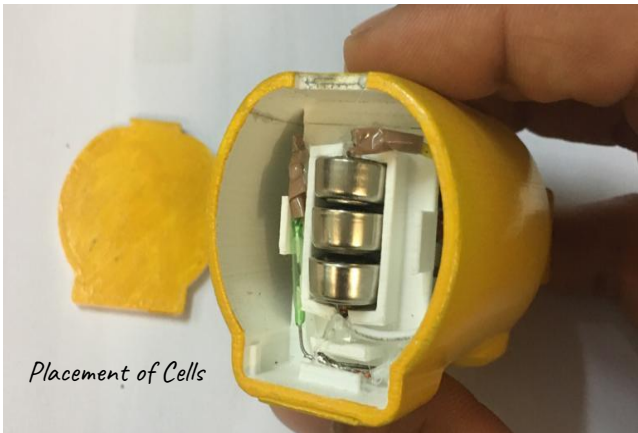
### 7.1.4 Final Model







# 7.1.5 Detailing



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## 7.1.6 Insights from Play Test

Name : Ayan Shende

Age: 11

Class : 6th

Following were the insights from the play test

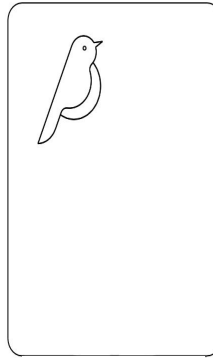
- With Simple explanation of the game, the kid was able to arrange all the obstacles reading from the Challenge Cards.
- And was able to solve the challenges.
- When asked Question he was rightly able to answer them, question was
  - a. What's happening here exactly, and the answer was reflection
  - b. Why rotation of the mirror, and answer was to change the direction.
- The Switching ON of the Laser peg when snapped to the board was found interesting by the Kid.
- He stacked the obstacles one on top of other, as the grooves allowed stacking.

---

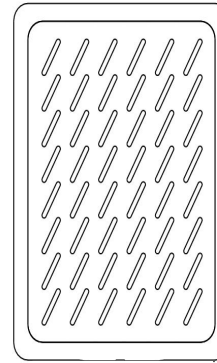
## 7.2 Game 2 - Color Play

The idea is to create stories using different color panels. It is based on the STEAM approach, where in an element of Art is proposed. Where children can create their own stories and the same time learn about color theory. The play was thought of more as an exploratory activity.

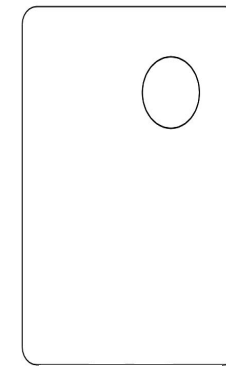
Different panels were made, based on the theme of nature and animals.



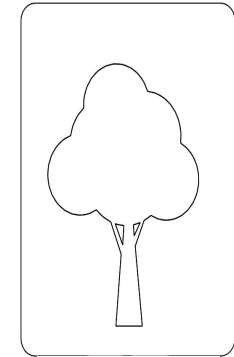
**Bird**



**Rain**



**Sun**



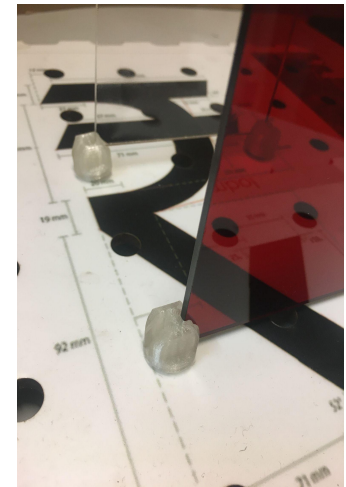
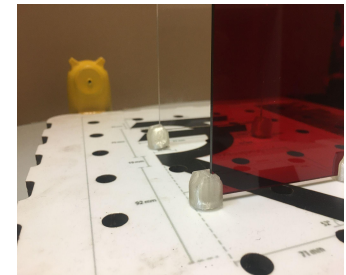
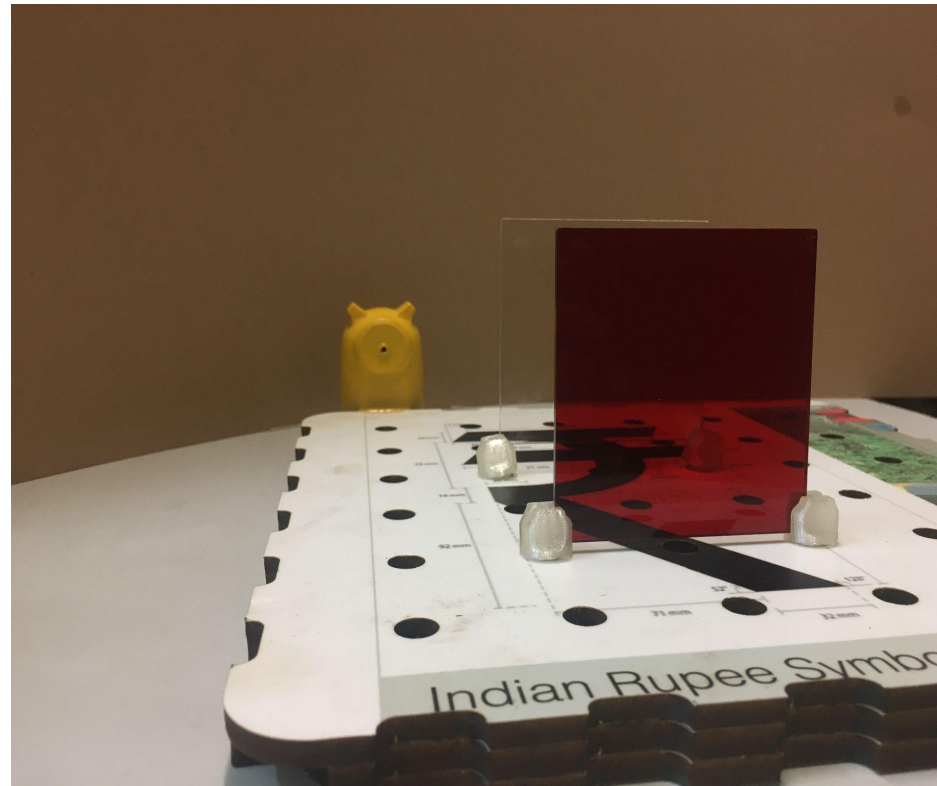
**Tree**

## 7.2.2 Joinery

### Joinery 1 :

Small pegs were made to hold the panel standing.

However the issue was, when seen through at that level, and if the laser is on the board, it might hit the eye of the kid.

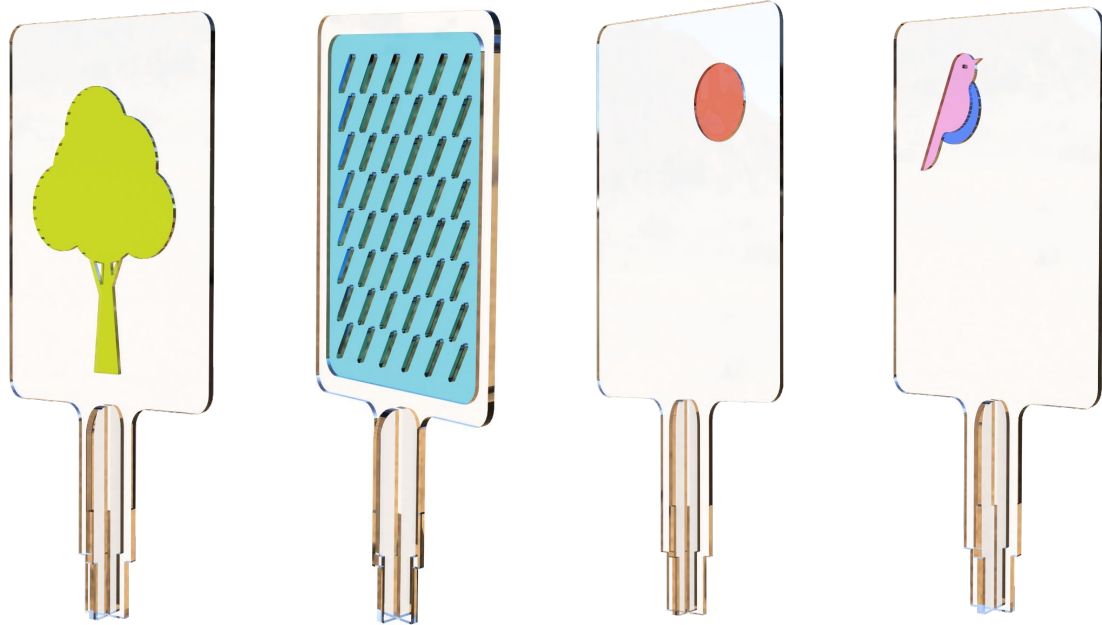


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## 7.2.2 Joinery

### Joinery 2 :

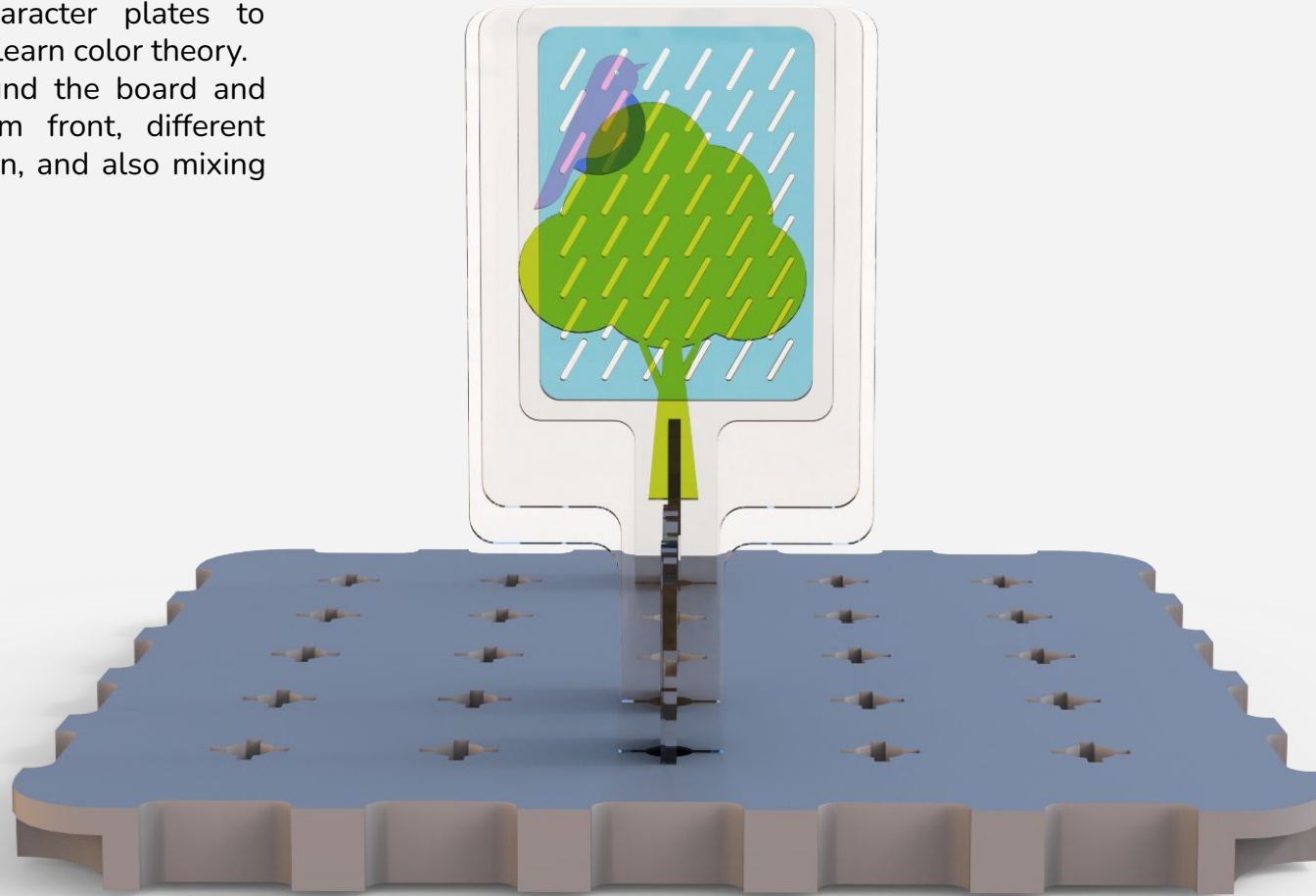
Instead of a separate peg and the panel, the panel itself was thought to be made in a way that it fixes on board

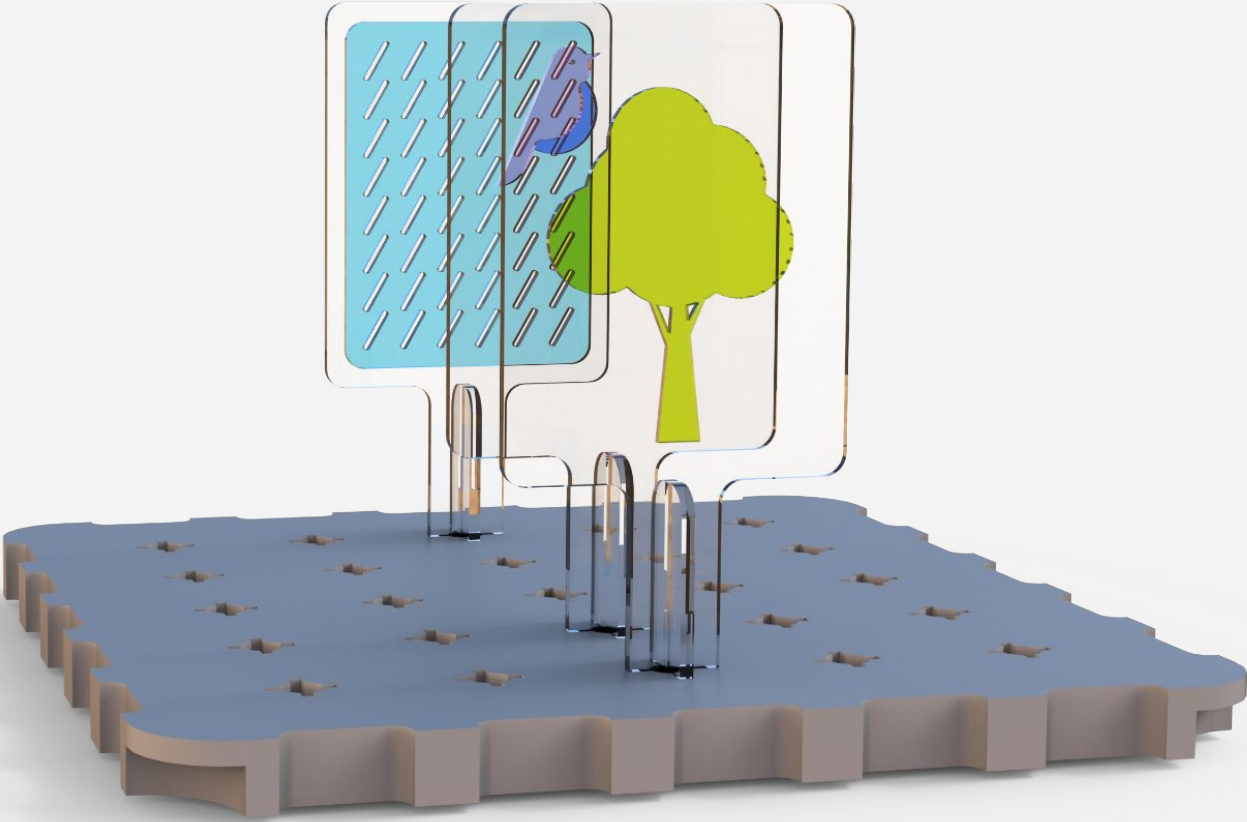


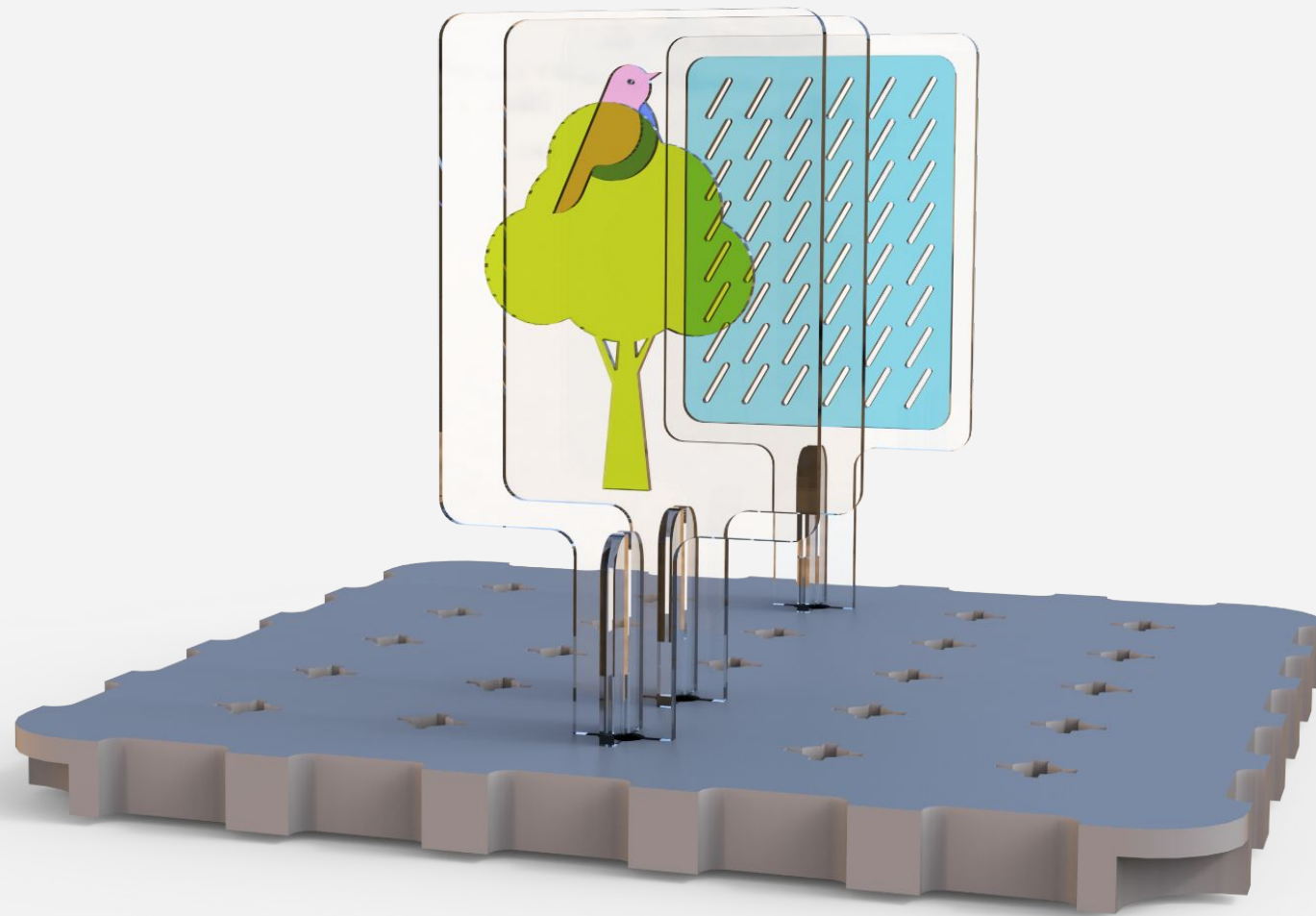
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## 7.2.3 Final Model

Add different character plates to create stories and learn color theory. Place panels around the board and when looked from front, different stories can be seen, and also mixing of different colors.







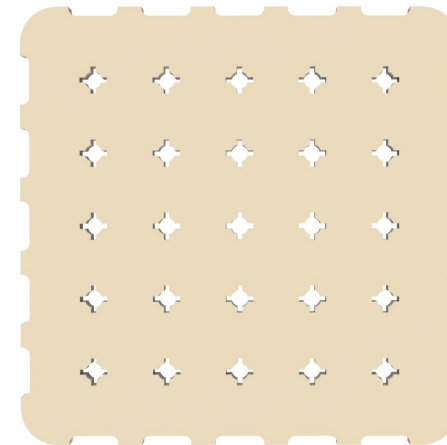


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## 8. Manufacturing

### Board

1. **CNC wood machining** is a good options when considering the batch manufacturing for the game with Wood as a material. The wood can be beech, pine, cherry, walnut and teak wood.
2. **Insert molding** would be best for mass manufacturing of the board. Wherein the Magnets can be fixed in the the main body. Polypropylene (PP) Plastic can be used for its manufacturing, as it is heat resistant and is unlikely to leach even when exposed to warm or hot water. It's also approved for use with food and beverage storage.



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## 8. Manufacturing

### Baby Owl

Material : **Polycarbonate(PC)** with a frosted glass finish

Manufacturing process : **Insertion molding**



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## 8. Manufacturing

### Laser Peg

Material : **Polypropylene**

Manufacturing process : **Insertion molding**



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## 8. Manufacturing

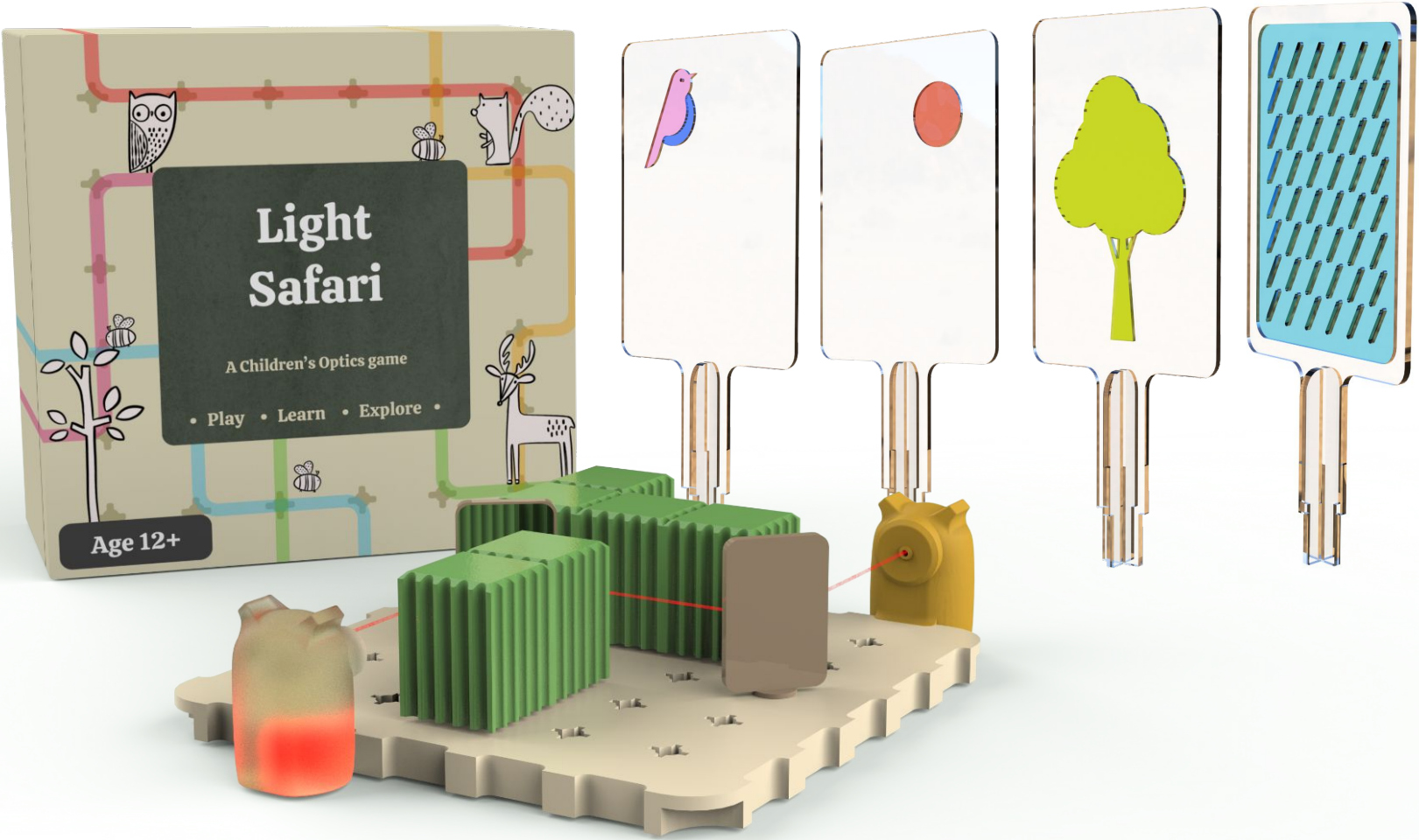
### Obstacles

Material : **Polypropylene**

Manufacturing process : **Blow Molding**



# 8. Packaging



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## References

1. [https://www.questionpapers.net.in/Articles-on-entrance-examination/why\\_physics\\_is\\_difficult.html](https://www.questionpapers.net.in/Articles-on-entrance-examination/why_physics_is_difficult.html)
2. <https://vikaspedia.in/education/education-best-practices/building-as-learning-aid--bala->
3. <https://k8school.com/homeschooling-in-india/>
4. [https://www.youtube.com/watch?v=rhgwIhB58PA&ab\\_channel=Veritasium](https://www.youtube.com/watch?v=rhgwIhB58PA&ab_channel=Veritasium)
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