IDC School of Design
अभिकल्प विद्यालय

TinkerTronix

Project 3: Tinkering Toy to Understand Electrical Circuit and Principles for 11 to 12 years old kids.

By:
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Guided by:
Prof. Avinash Shende

Approval

This is to certify that the industrial design project titled "Tinkering toy for kids to understand electrical circuits and principles for 11 to 12 years old kids" by Prathamesh Sawant (22M2223) of 2nd year industrial design batch of 22-24 is approved for the partial fulfillment of the post graduate degree of masters in Industrial design.

Project Guide:
Prof. Avinash Shende

External Examiner

Internal Examiner
Prof Chorkar

Chairperson
27/05/2024

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.

I understand that violation of the above will be cause for disciplinary actions by the institute and can evoke penal action from the sources which thus have been not properly cited or from whom proper permission has not been taken when needed.

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My special thanks to Mr. Zope, Principle in charge at Kumud VidyaMandir, Deonar 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

Play is vital for a child's growth, enhancing language, cognition, movement, and emotional skills. This project develops a science based educational toy to foster learning through interactive play, focusing on electricity and circuits.

The project is centered on designing a play-based educational toy that integrates hands-on activities, encouraging children to plan, explore, and actively engage with various elements. This innovative toy requires users to apply basic electrical principles to solve challenges and complete tasks, while also becoming familiar with electrical components.

By constructing different circuits and toy gadgets, children will not only learn about these components but will also have the opportunity to create new and inventive items. The toy is designed to foster an understanding of electrical concepts through a circuit construction toy method, enhancing the ability for students to tinker and explore. Aimed at home learning, it is also suitable for use during homework hours, providing a practical learning tool. The primary audience for this toy includes students in 6th, 7th, and 8th grades, targeting the age group of 11-13 years

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Introduction

The TinkerTronix toy is an innovative approach designed to close the educational gap in current science learning tools available for secondary school students. This toy provides 11 to 12 -year olds with a hands -on, interactive experience that brings the theoretical concepts in electricity and electric current of their academic curriculum to life. By offering a modular electrical tinkering kit, TinkerTronix encourages children to engage directly with fundamental electrical components and circuitry.

It empowers them to explore and construct a wide array of toys and gadgets, thus aligning their in school learning with practical, real world applications. This open ended design not only sparks creativity but also allows children to understand and apply electrical principles in a variety of ways.

TinkerTronix serves as a bridge, turning abstract scientific ideas into tangible experiments and competitive game, thereby enhancing students' comprehension and enjoyment of electrical sciences. The ultimate goal is to make science education more dynamic, accessible, and enjoyable, fostering a deeper interest in the STEM fields among young learners.

Recent Trends in Educational System

In India's education system, which serves a vast body of over 250 million young students, traditional teacher-led methods often fall short of addressing individual needs.

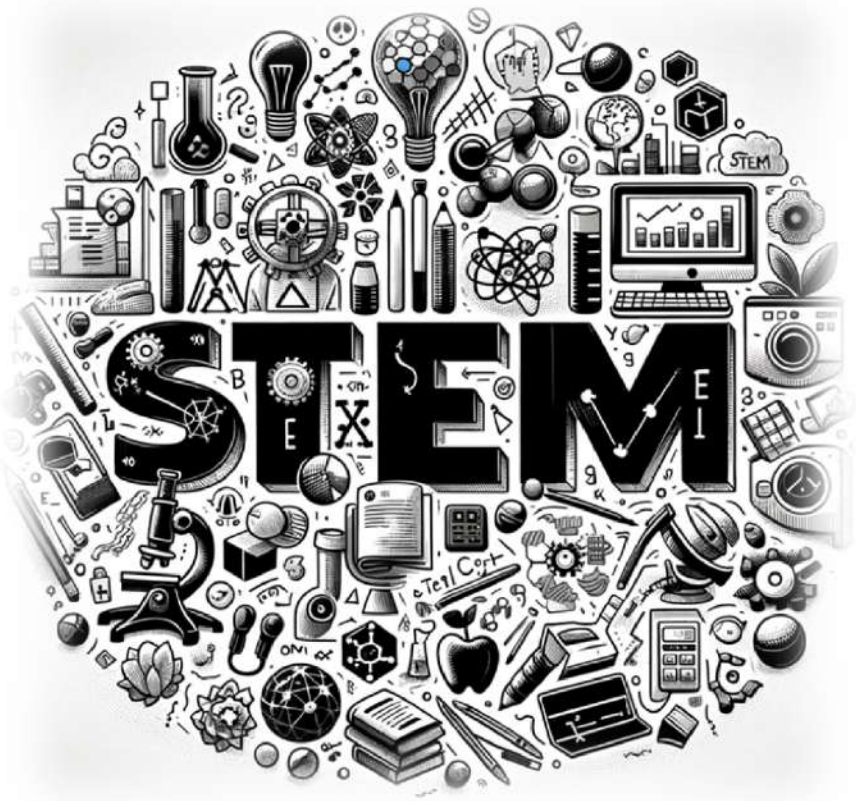
There's been a noticeable shift towards independent learning at home, bolstered by educational technologies, especially following the COVID pandemic. Regarded as cognitive instruments, educational toys are increasingly recognized for their ability to guide children toward targeted achievements.

When provided with engaging experiences and tools that cater to their inherent skills, children not only flourish mentally but also carve out their unique identities. Therefore, to invigorate this learning ecosystem, it is essential to reinforce the connection between play and education, ensuring it becomes a more dynamic and integral part of their development.

Understanding STEM Education in India

STEM education, an integrative approach that includes Science, Technology, Engineering, and Mathematics, emphasizes a hands -on and practical learning style. It is designed to bolster skill sets in engineering and technology, crucial fields for future development. Additionally, it aims to level the educational playing field by addressing gender and socioeconomic disparities through inclusive policies.

However, STEM education in India confronts several hurdles, such as inadequate infrastructure, subpar teacher training, and a curriculum that often lacks applicability to real -world problems. To overcome these obstacles and invigorate the educational process, the market has seen the introduction of STEM -focused toys. These toys represent an innovative method of learning, aiming to inspire creative thinking and problem -solving skills by integrating the arts into traditional STEM subjects.



The Process of Learning

Bloom's Taxonomy serves as a foundational model for understanding the educational journey, advocating for the application and synthesis of knowledge as key steps toward deep comprehension. This framework suggests that authentic learning occurs when students engage in the creation and practical use of their knowledge, solidifying their understanding through active participation.

In the realm of educational toys, the most effective designs are those that encourage children to create and apply concepts, thus fueling continuous exploration and learning. Tinkering and hands -on engagement are more effective than competitive gameplay in this respect, as they align with Bloom's theory by providing an avenue for application and analysis. Moreover, when positive reinforcement is woven into the learning experience, it simplifies complex processes and enhances retention, adhering to the taxonomy's higher levels of learning which include evaluating and creating. This educational philosophy supports the idea that learning is optimized in an environment where children are actively involved in manipulating and experimenting with the material they are learning.

Learning Methods in Kids

Visual learning

- Images, diagrams, and videos.
- Highly effective. Children of all age group are generally responsive to visual stimuli.
- Diagrams of the solar system, videos of chemical reactions, and illustrations of biological processes are beneficial.

Auditory learning

- Listening to information, discussions, and oral explanations.
- Moderately effective.
- Listening to explanations of scientific phenomena, engaging in discussions about scientific theories, and auditory descriptions of experiments..

Reading and writing

- Reading texts and writing notes or essays.
- Variable. While important for developing literacy skills.
- Reading science textbooks, writing lab reports, and summarizing scientific articles..

Kinesthetic learning

- Hands-on activities, experiments, and physical involvement.
- Highly effective. Active participation makes abstract concepts more tangible for children aged 8-12.
- Experiments, building models (like volcanoes or solar systems), and interactive science games.

The Stages of Cognitive Development

To grasp the intricacies of the issues or concepts presented to children, an examination of the phases of child development was undertaken. Jean Piaget's classification of these developmental stages is as follows:

Sensorimotor Stage: Birth to 2 years.
- Sensory exploration and basic motor skills.
- Object permanence develops.
- Early language and communication skills emerge.

Preoperational Stage: 2 to 7 years.
- Symbolic play and language development.
- Egocentrism dominates.
- Limited logical reasoning.

Concrete Operational Stage: 7 to 12 years.
- Improved logical thinking, especially in concrete situations.
- Understanding of conservation and classification.
- Better grasp of cause and effect.

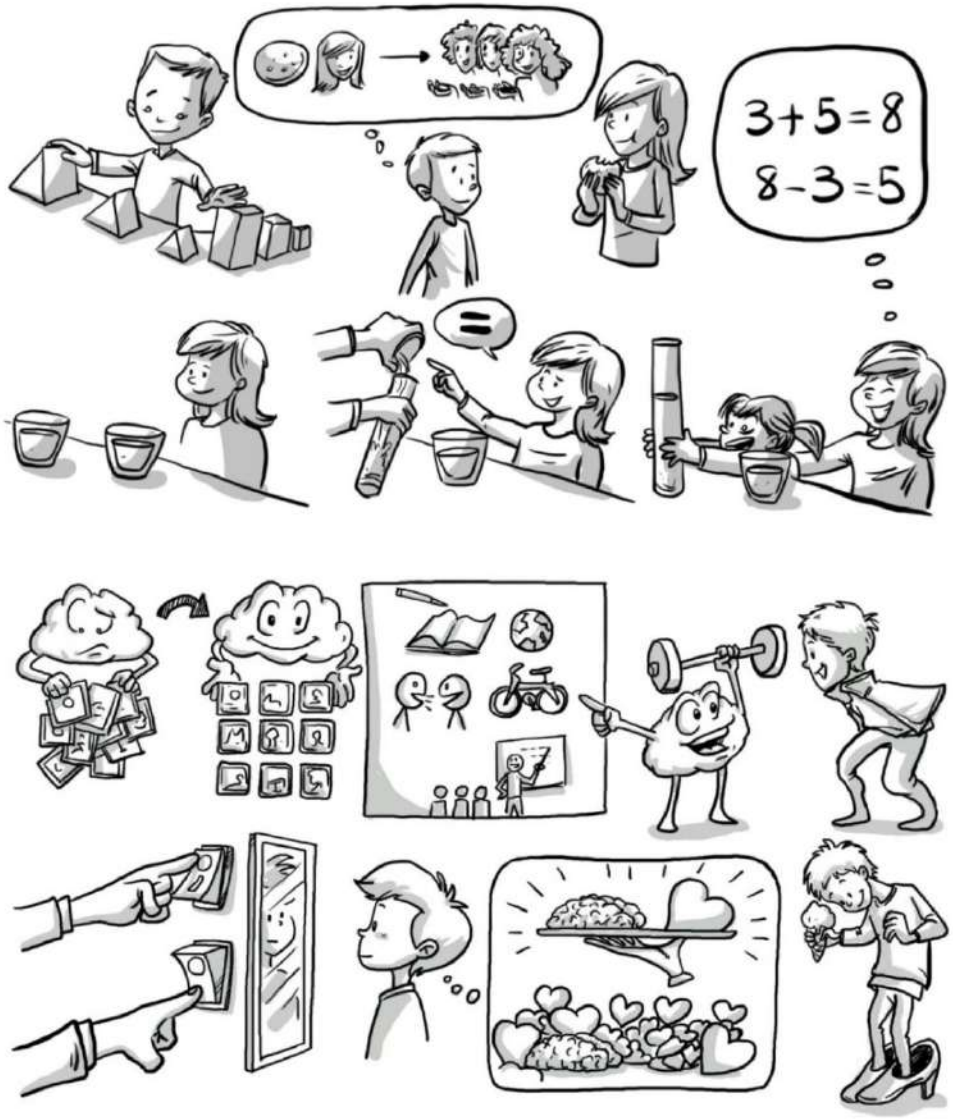
Formal Operational Stage: 12 years to adulthood.
- Abstract thinking and hypothetical reasoning.
- Deductive logic and complex problem-solving.
- Exploration of philosophical and moral questions.

Selecting Concrete Operational Period

From the above cognitive stages, Concrete Operational period was selected.

- Recognize constancy in properties like volume despite shape changes.
- Think logically, using specific information to form general principles.
- Classify objects based on multiple attributes.
- Solve hands-on problems, understanding through practical engagement.
- Understand reversibility, realizing some changes can be undone.
- Transitivity, the ability to recognize logical relationship between A,B and C.
- Sequential understanding: They can understand and follow steps in scientific experiments.

Cognitively, they develop logical thinking skills, understanding concrete information and concepts, and begin to grasp the concept of conservation. Socially, they become more empathetic and capable of understanding others' perspectives, showing more cooperative behaviors and improved problem-solving skills in group settings.



Defining the User Group

Secondary school children progress to logical reasoning with abstract concepts and systematic problem-solving.

- **Target age group:** 11 to 12 years old.
- **School Boards:** SSC and CBSC.
- **Why?**

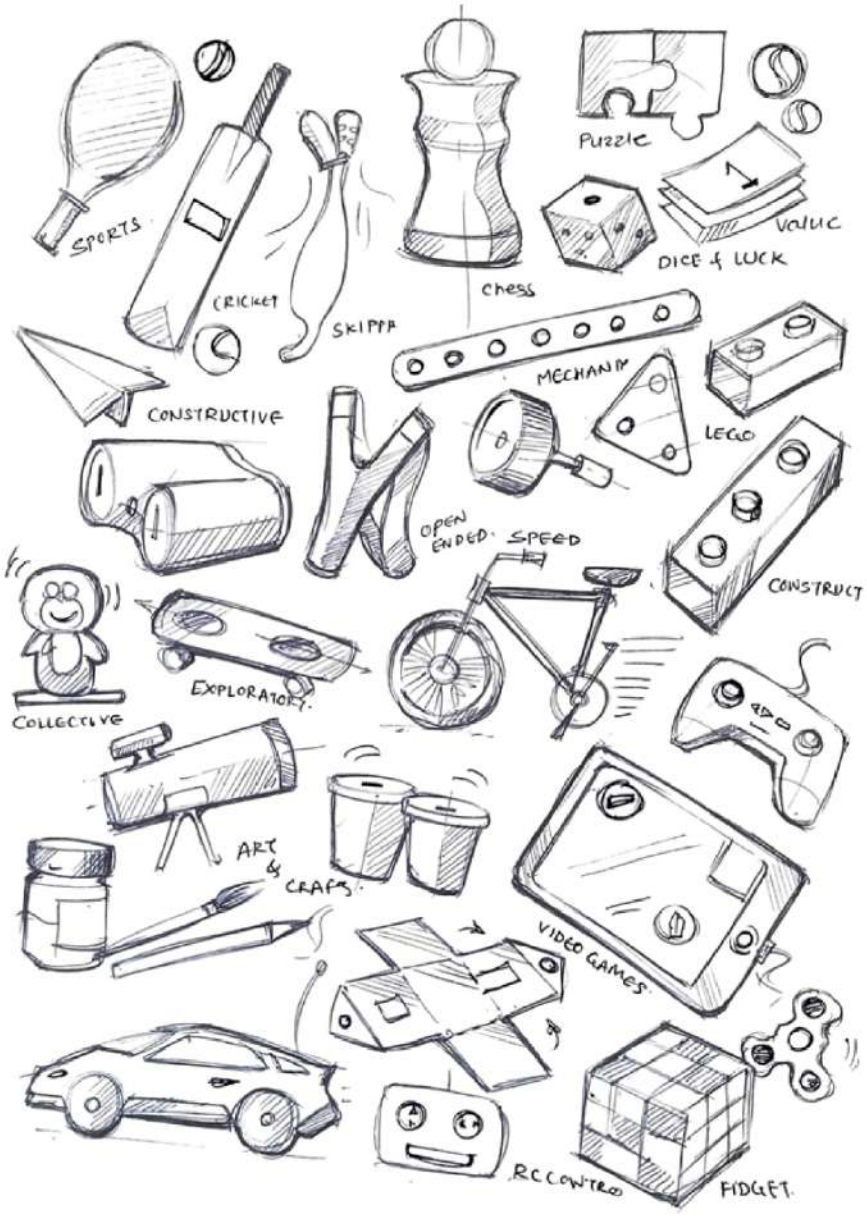
To capitalize on the design opportunity for reinforcing the link between theoretical knowledge and practical application.

- **How?**

Encourage learning in kids through enjoyable activities that integrate theoretical concepts into practice.

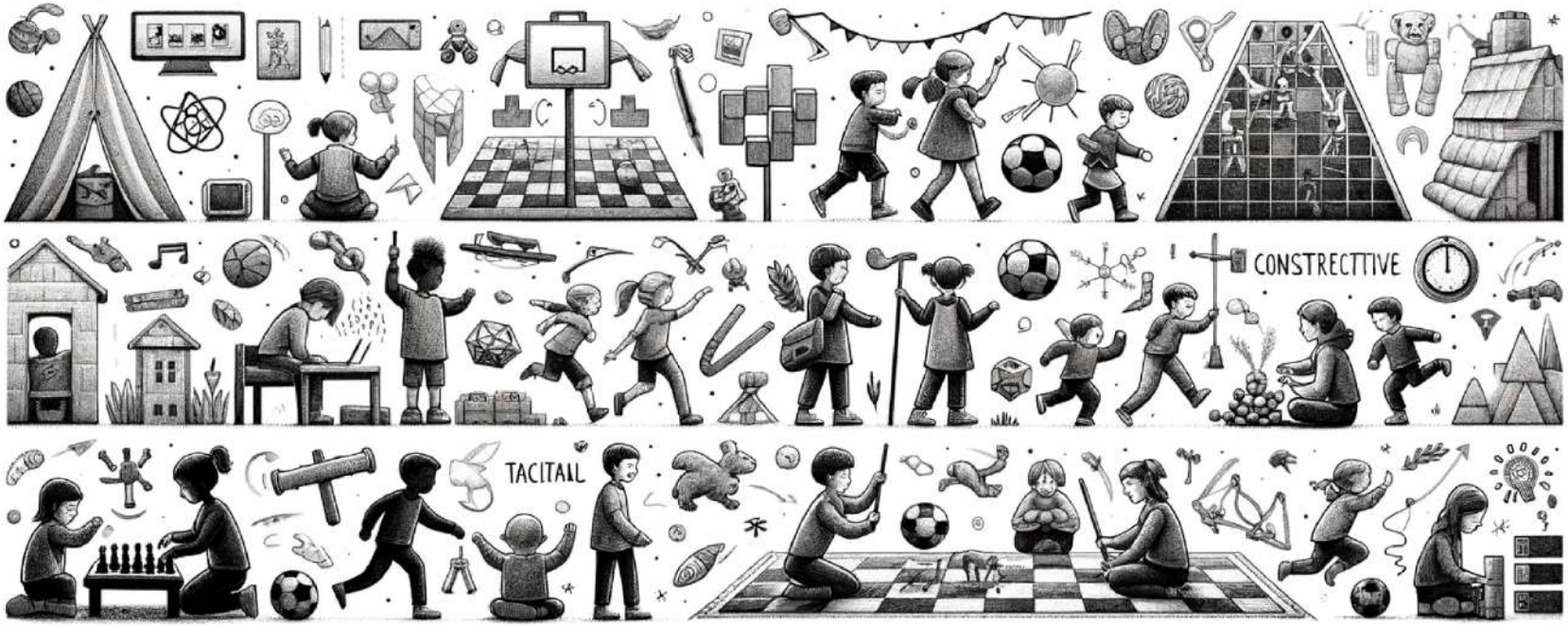
Understanding User Behavior

Age group: 11 to 12 years old (6th and 7th STD)
Preferred toy types:
Sports Toys, Board games, Construction and tinkering toys and Collectables or cool toys
Characteristics of this age group:
Geared up for sports and athletic activities.
Cognitive skills: Capable of solving order-related and quantity-related issues, with abstract reasoning yet to develop.
Motor development: Beginning to handle tools, construct models, and demonstrating adept hand-eye coordination.
Fascinated by mechanical gadgets, cutting-edge tech, and the worlds of science fiction and fantasy.
Takes pleasure in amassing toys, engaging in various hobbies, and keeping scrapbooks.
In a phase of crafting their own identity, seeking both autonomy and social acceptance.



Type of Plays Among the Selected User Group

- **Interactive Social Plays:** Children participate with their peers in activities, navigating and comprehending multifaceted social dynamics and norms.
- **Artistic and Imaginative Plays**: Kids convey their individuality and creativity by engaging in arts, construction, and devising rich, imaginative contexts and stories.
- **Engagement in Physical Plays:** They are active in various forms of physical exercises, including sports and dance, tackling an array of physical tasks and challenges.
- **Virtual Plays:** Engrossing themselves in the digital world through video games, applications, and online resources that offer both fun and educational content.
- **Tactical and Problem-Solving Gameplays:** Children take pleasure in games and activities like board games and puzzles that necessitate foresight, strategy, and critical thinking.
- **Flexible Constructive Plays:** There's an emphasis on building and playing with toys that can be assembled and reassembled over time, adapting to changing scenarios and extending the playtime by altering their structure or purpose..



Science Syllabus for Secondary Schools

SSC and CBSC science books were studied to understand the what science topics and principles are taught.

6th Standard

- Light and shadow experiment
- Force and leverage
- Stored elastic energy
- Motion and types
- Pressure
- Work
- Sound making principles
- Simple machines
- Forces and types
- Magnetic science
- Substances around us

7th Standard

- Physical quantities
- Principles of motion
- Force and work
- Static electricity
- Heat principles
- Effects of lights
- Production of sound
- Magnetic fields
- Space and planets
- Elements and chemistry

8th Standard

- Force and pressure
- Atom and molecular mass
- Electric current
- Magnetism
- Molecular composition
- Chemicals and bonds
- Reflection and refraction of light.
- Space around us
- Measurement and effects of heat.
- Manmade materials

9th Standard

- Work done and energy
- Type of motion
- Potential and potential difference
- Distance and displacement
- Mechanical energy
- Electrical resistance
- Laws of conservation of energy
- Reflection of sound
- Carbon and carbon properties
- Meteorology
- Newtons law of motion

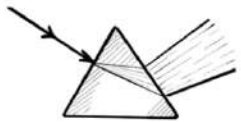
Major Principles from Science Syllabus

Introductory stage: (5th to 7th STD)

In educational settings, the curricula for 5th through 7th grades are strategically designed to unveil various scientific phenomena and disciplines by engaging students' natural inquisitiveness. There is a thoughtful and gradual layering of complexity, ensuring a steady accumulation of knowledge. The approach is particularly crafted to enhance the relevance of science, connecting it to students' everyday experiences and making it more approachable and meaningful in their lives.

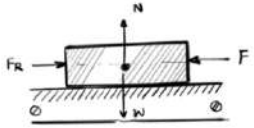
Exploratory stage: (8th to 10th STD)

In the 8th to 10th grade, there is a deep dive into the underlying principles of science, fostering skills in problem-solving and critical analysis. However, students can struggle with grasping abstract concepts like the behavior of atoms, the principles of electricity, and the mechanisms of thermal energy

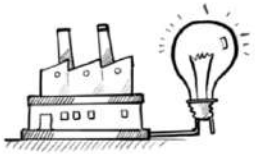


Principles of Light

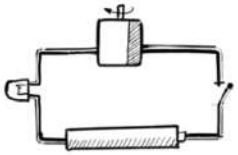
Sound Propagation



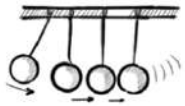
Force and Pressure



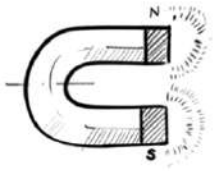
Work and energy



Electric current



Laws of Motion



Magnetism

Heat transfer

Questionnaire for User Studies

Questionnaire for Teachers

1. What teaching methods are most effective for explaining complex scientific concepts?
2. How can educators adapt to different learning styles when teaching science?
3. Which science topics are typically the most challenging for students to grasp?
4. What role does practical experimentation play in the science teaching methodology?
5. What tools are commonly used to demonstrate scientific concepts in the classroom?
6. What are the prevailing views on the use of educational toys and tools in science teaching?
7. How does the implementation of hands-on methods impact student results in science education?

Questionnaire for Parents

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Summary of Parent of Interviews

Mrs. Samita Jadhav
44, Female
Deonar, Mumbai
Kids- Aditya, 13 Male

- Aditya favors outdoor activities and sports.
- Prefers growth-centric toys with real-world use.
- Got a telescope and star map to spark an interest in astronomy.
- Challenges lie in digital-free engagement.
- Enjoys toys that complement his outdoor hobbies.
- Utilizes a reward-based system for screen time..

Mrs. Amruta Gujar
39, Female
Chembur, Mumbai
Kids- Mehak, 11 Female

- Mehak is inclined towards academics and arts.
- Chooses toys aligned with school subjects.
- Engages with a coding robot kit for logic and programming skills.
- Actively participates in selecting intellectually stimulating toys.
- Enjoys educational outings like science museums and documentaries.
- Has a cap on screen time, only using educational apps on weekends for an hour.

Mr. Ajinkya Sawant
48, Male
Chembur, Mumbai
Kids- Saanvi, 11 Male

- Saanvi participates in gymnastics and dance with limited playtime.
- Often watches TV or plays on the phone during free moments.
- Owns a Rubik's cube, chess set, but is unfamiliar with STEM toys.
- Parental controls manage her educational screen time on tablets.
- Utilizes real-life examples and sketches for teaching.
- Follows a reward-based system for screen time.

Summary of Teachers interview

Mr. Dabadde
52, Male
Science Teacher at
Kumud VidyaMandir

- Mr. dabadde teaches physics to 7th and above classes at Kumud VidyaMandir.
- Extensively uses home school DVD video packs and YouTube to demonstrate different concepts.
- Feels the school lab infrastructure is not enough to accommodate a class of 60 students and provide each of them enough time on lab equipment's.
- Some abstract rules about electrons or valency are difficult to grasp by students as it is not interesting enough.
- Methods that involve students extensively increases clarity in the topic.
- It is difficult to calibrate to each students learning style. This is improved by doubt clearing session every week.
- School uses basic craft material to make scientific models or demonstration and encourage kids to do so which improves their learning and participation

Mrs. Sanas
57, Female
Science teacher at
Kumud VidyaMandir.

- Mrs. Sanas teaches physics to 5th to 6th classes at Kumud VidyaMandir.
- Uses a fun story telling or scenario building methods to teach introductory topics to kids of younger age.
- Mostly relies on direct demonstration with equipment in front of class, everyone pays attention to this method but not everyone can grasp it.
- Some topics that are out of students experience are difficult to understand by them.
- Could not understand the concept of electron and electron flow, similarly finds it difficult to understand heat and energy.
- Tuition teacher helps students compete for marks and encourages to mug up which reduces students attention in class.

Insights from User Interviews of Teachers

Current Behavior of Teachers

- Instructive tools for teaching complex physics and biology concepts include items such as bouncing balls, prisms with laser light, water wheel contraptions, elastic rubber bands, constructible paper models, magnetic objects, illustrative 2D mechanism diagrams, and wheels driven by motors.
- Animated media is preferred by educators to simplify and convey intricate subject matter.
- Abstract concepts are made clearer through the use of analogies involving common household items.
- Real-life instances serve to stimulate curiosity; educational toys are valued for their potential to aid learning, though their impact can differ..

Challenges of Teachers

- Students often find it challenging to grasp scientific concepts that are abstract and not directly observable.
- While practical experiments are beneficial, they sometimes fail to offer comprehensive depth and opportunities for thorough exploration.
- Direct, personal demonstrations enhance understanding but become less feasible with increasing class sizes.
- Tailoring teaching methods to individual learning styles becomes challenging in classrooms with a high student-to-teacher ratio.
- The larger the class size, the more difficult it is to implement personalized, hands-on approaches to learning.

Insights from User Interviews of Parents

Current Behavior of Parents

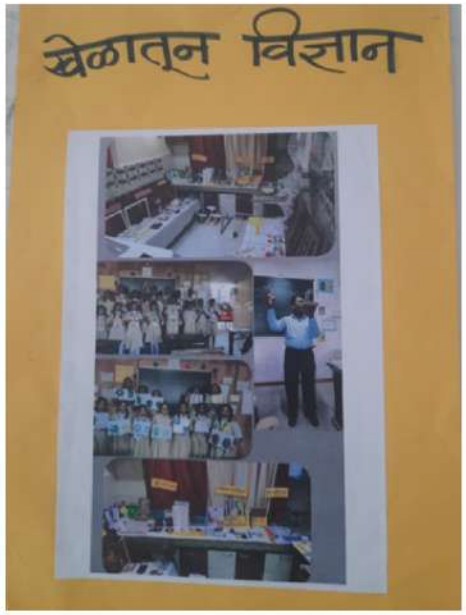
- Parents prioritize the durability and alignment with their children's academic needs and personal interests when purchasing educational toys.
- Kids tend to choose toys based on technology integration, the potential for imaginative play, novelty, and the ability to be used in a variety of ways.
- Mechanix sets, Lego, and clay modeling kits are common gifts from parents to foster creativity, though they observe a scarcity of affordable educational toys in India's offline market.
- To assist with homework and clarify concepts for their children, parents frequently turn to resources such as YouTube videos and notes provided by teachers.

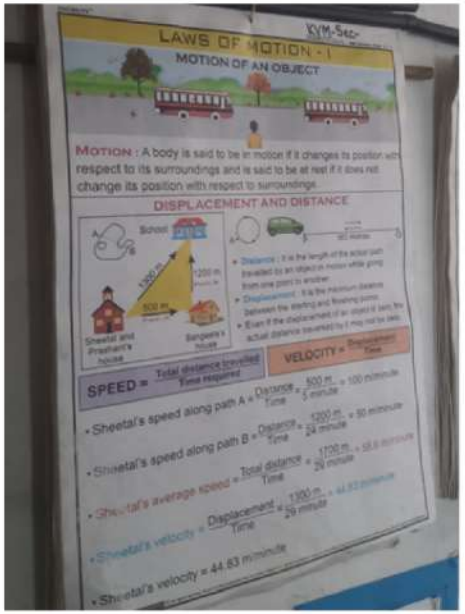
Challenges of Parents

- The rise in coaching and tuition classes for secondary school students is leading to reduced opportunities for collaborative activities between kids and their parents.
- While educational toys are popular, they often fail to deliver the direct academic improvements that parents are looking for.
- Children's inclination to disassemble their toys and build new creations with the parts reflects their innate curiosity and inventive spirit.

Field Photos from School Visits

I conducted a field visit to Kumud Vidya Mandir and BMC Marathi School located in Mumbai, with the intention of engaging with the teaching staff through interviews and gaining insights into classroom dynamics via observations. Here are the photographs of the fieldwork activities.
The images shows Different seminars and activities setup in school to encourage hands on learning experience. And also shows Visual charts and pictures used to demonstrate various scientific concepts to students.





Field Photos from School Visits

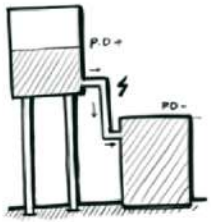
The photos show two projects made by students. The first is a model of a city's power system with colorful buildings, made for a science fair. The second shows a small village with figures and houses, helping kids learn about history. Both projects are well-made and help students learn by showing them how things look in real life.

Selecting and Focusing on Single Scientific Principle

During user studies and field visits, it was noted that many schools lack the necessary lab equipment and facilities for students to practically explore and learn about electrical components and circuits. This highlighted an opportunity to concentrate on electricity as a core scientific concept for the development of a STEM toy. Additionally, the toy could encompass other related scientific principles including simple machines, sound systems, the laws of motion, and robotics.

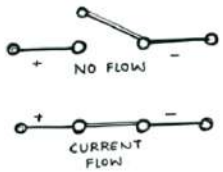
Core Principle
Electric current and electro mechanical concepts

Passive Principles
·Simple machines
·Sound systems
·Laws of motion
·Robotics

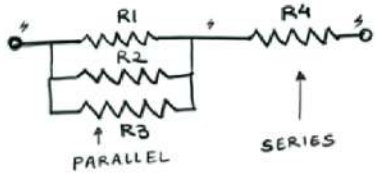


Potential and Current Flow

Electrical Resistance

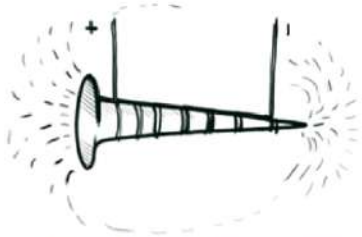


Open and Closed Circuits

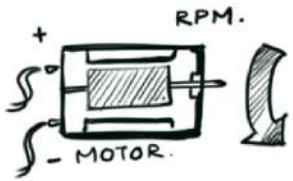


Series and Parallel

Safety in Electricity



Electromagnetism



Electrical Actuators

Application of Actuators

Circuits taught from class 6th to 10th

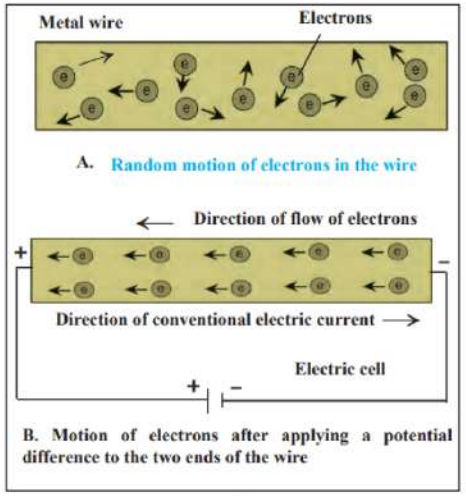
Standard 6th:
Introduction to Electricity: Static electricity, electric buttons, closed and open circuits. conductors and insulators

Standard 7th:
Introduction to electric safety, power grid, different types of switches, introduction to electromagnetism and batteries.

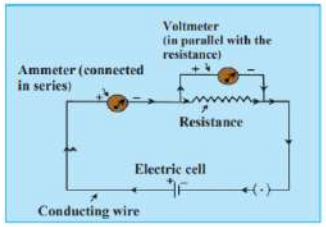
Standard 8th:
AC and DC current, Kirchhoff's law, ohms law, resistance, electric motor, magnetic effects of electric current.

Standard 9th:
Calculations on ohms law, electric power and energy, heating effects of electricity, electromagnetism, elaborate electric symbols

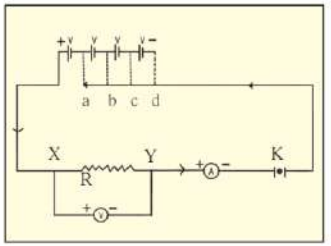
Standard 10th:
Resistors in Series and parallels, bell ringing circuits, solenoids and motors, advanced circuits and more in-depth calculations.



3.4 Motion of free electrons

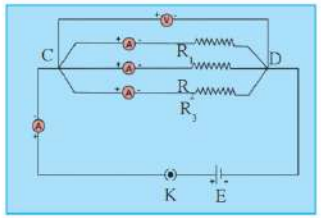


3.5 Electrical circuit

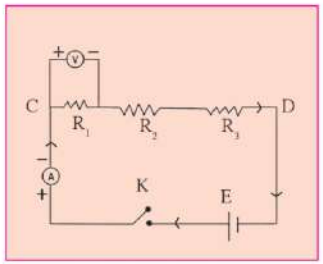


3.7 Verification of Ohm's Law

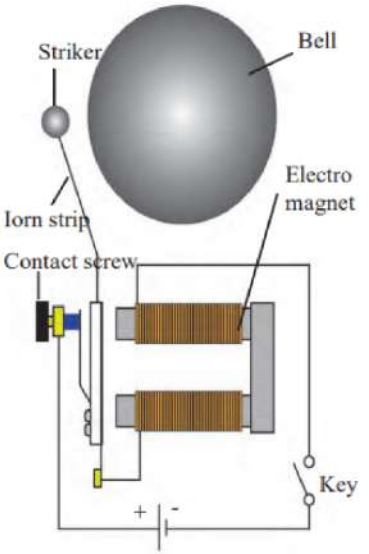
Component	Picture	Symbol	Use
Electric cell			To apply a potential difference between two ends of a conductor
Battery (collection of a number of cells)			To apply a larger potential difference between two ends of a conductor
Open tap key or plug key			To stop the flow of current flowing in a circuit by disconnecting two ends of a wire
Closed tap key or plug key			To start the flow of current in a circuit by connecting two ends of a wires.
Connecting (conducting) wires			To connect various components in the circuit.
Crossing wires			To show wires which cross but are not connected
Light bulb			To test the flow of electricity : Lighted : current is flowing; unlighted : current is not flowing
Resistance			To control the flow of current in the circuit
Variable resistance			To change the resistance as required and thereby control the current
Ammeter			To measure the current flowing in the circuit
Voltmeter			To measure the potential difference between two points in the circuit



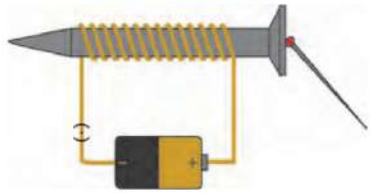
3.9 Resistors in parallel

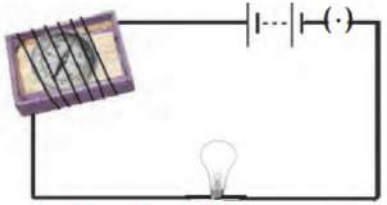


3.8 Resistors in series



4.8 Electric bell

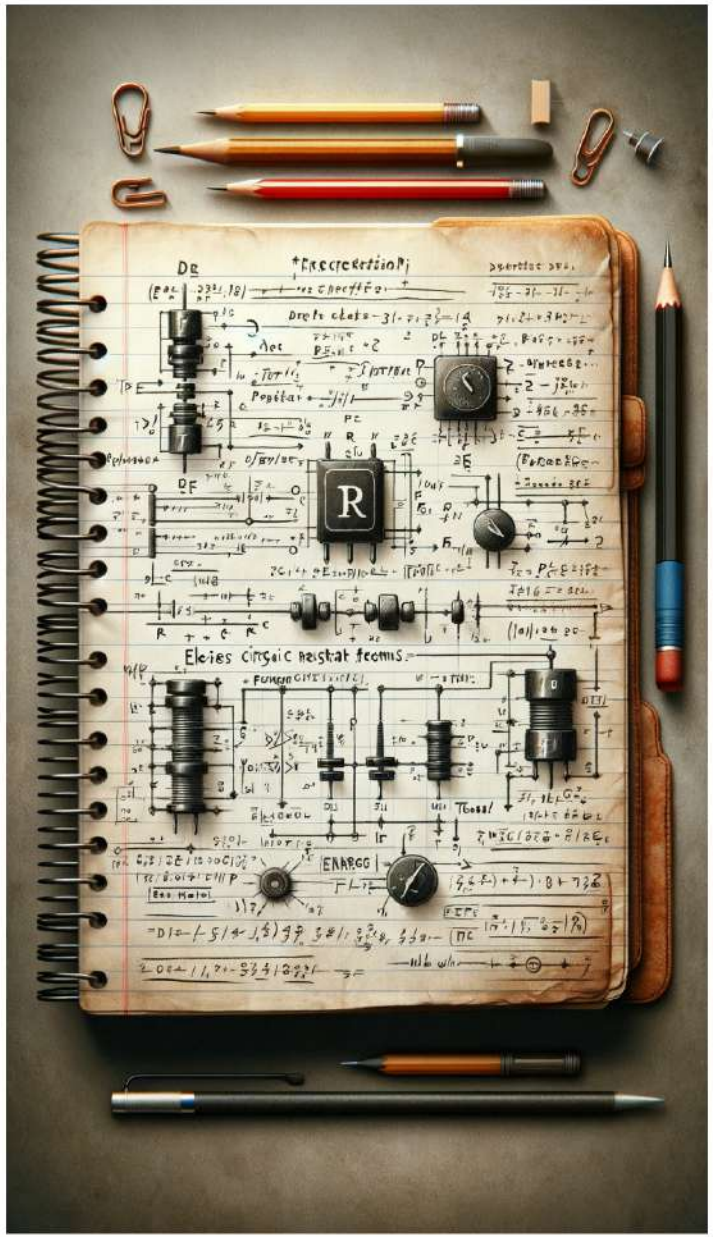

4.7 Electro magnet


4.6 Magnetic effect of current

Circuit diagrams and concepts taught in SSC board from standard 6th to 10th

Theoretical formulas taught in electricity

1. **Ohm's Law:**
   - Formula: $V=I \times R$
   - Where V is voltage (in volts), I is current (in amperes), and R is resistance (in ohms).
2. **Power Formula:**
   - Formula: $P=V \times I$
   - Where P is power (in watts), V is voltage (in volts), and I is current (in amperes).
3. **Energy Calculation:**
   - Formula: $E=P \times t$
   - Where E is energy (in joules), P is power (in watts), and t is time (in seconds).
4. **Series Circuit Total Resistance:**
   - Formula: R total= R1+R2+R3....
   - total For n resistors in series.
5. **Parallel Circuit Total Resistance:**
   - Formula: 1/R total=1/R1+1/R2+...
   - For n resistors in parallel.
6. **Kirchhoff's Laws:**
   - Kirchhoff's Voltage Law (KVL): The sum of the voltage drops in a closed loop is equal to the applied voltage.
   - Kirchhoff's Current Law (KCL): The total current entering a junction is equal to the total current leaving the junction.
7. **Capacitance Calculation:**
   - Formula: C=V/Q
   - Where C is capacitance (in farads), Q is charge (in coulombs), and V is voltage (in volts).
8. **Energy Stored in a Capacitor:**
   - Formula: E=1/2CV^2
   - Where E is energy (in joules), C is capacitance (in farads), and V is voltage (in volts).

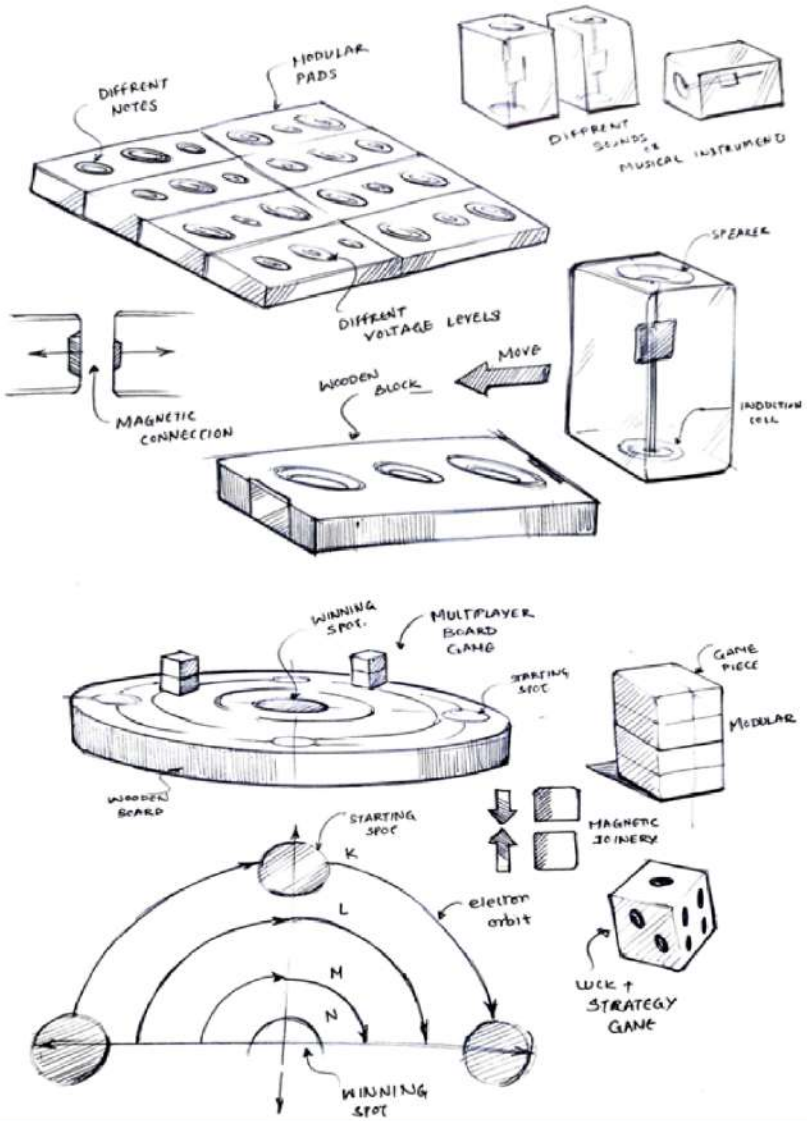


Conceptualization

Concept 1: Creating a board game that uses the selected principle of science explicitly to create activity, fun and element of surprise

Electron orbit based game : In this board game, akin to the classic Ludo, players are immersed in the world of atoms, gaining a better understanding of the atomic structure. The gameplay is cleverly designed around the concept of electron shells designated by the letters K, L, M, N, mirroring real atomic energy levels. To win, participants must tactically navigate their electrons, shedding energy with each move, to ultimately reach the atom's nucleus.

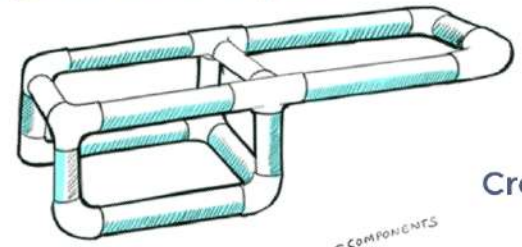
Induction coil based musical game: This activity helps kids learn about how electricity can be sent without wires. It shows them how different amounts of electricity, like high and low, work. The goal is to make learning about electricity fun and easy to understand.



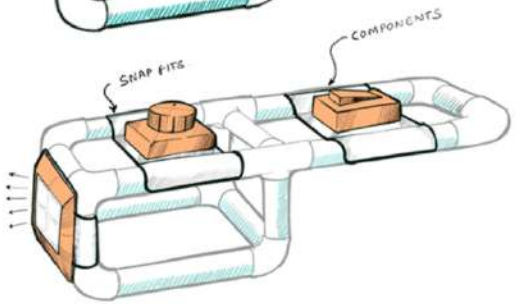
Conceptualization

Concept 2: Designing a construction toy that can help to understand the electrical principles as well as can be modified to build gadgets and toys.

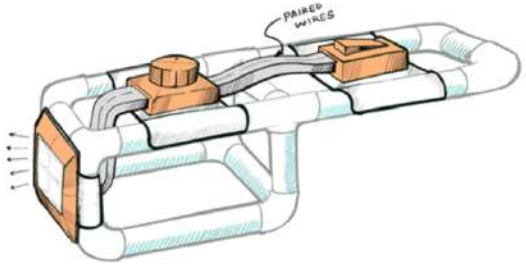
Making a special kind of building block toy that teaches kids about how electricity works. With these blocks, they can either follow simple guides to make cool electric toys and gadgets or use their imagination to create their own. It's a fun way for them to learn and play with building and electricity at the same time.



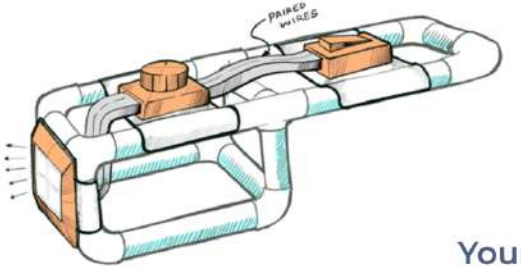
Create structure through modular elements



Attach required components



Complete the circuits using connectors

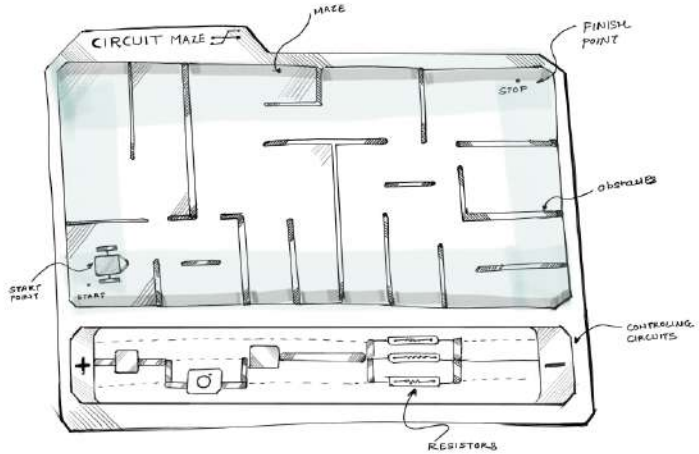


Your Gadget/Toy is ready.

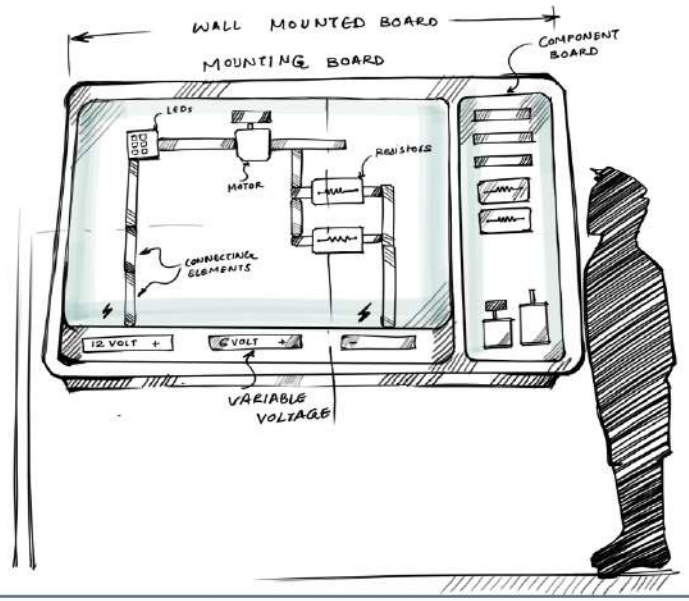
Conceptualization

Concept 3: School Installation- Demonstrates electrical principles and offers fun, electricity-themed games for kids during free time.

Interactive Circuit Builder Playground:
This installation would consist of a large, wall-mounted board filled with slots and connectors where kids can attach various electronic components like LEDs, resistors, switches, and batteries. The design would be similar to a puzzle, encouraging children to connect parts and build simple circuits to power different sections of a game or light up illustrations. This interactive setup not only teaches the basics of electricity and circuit design but also enhances problem-solving skills and creativity.



Electricity Adventure Course:
This concept would incorporate elements of a physical obstacle course with educational puzzles related to electricity. Kids can change the obstacle course on the board depending upon what they want to challenge while other kids have to manipulate the input capacitors and resistors so to overcome obstacles and complete the challenge. this can be used as tangible medium for kids to understand capacitors and resistors.



Concept Selection

A tinkering toy designed for building various circuits and engaging in competitive electricity-themed games with classmates.

Goal:
The goal is to create an adaptable electrical tinkering toy kit for 11 to 12-year-old secondary school students. This kit will provide a hands-on experience with essential electrical components and circuits, educating them on the basics while also encouraging them to use these components to play a single player or a competitive multiplayer game.

Why?:

- Suitable for the age range of 12 to 13 year old kids with their interest and cognitive development.
- Should have a maximum play value as STEM TOY.
- Provide hands on experience with various electrical components and circuits.
- Allow open ended explorations without any hesitation.
- Provide deeper sense of achievement and confidence.
- Good to have scalability to explore more complex ways of play.
- Creates learning encouragement through competition.
- Uses luck as a form of unpredictable element to create fun.

Design Brief

Cause

To bridge the gap between the current educational toy market and practical experimentation in academic curriculum of secondary school to encourage students towards STEM.

User Group:

11 to 12 years old and above kids- 6th and 7th Grade students of SSC and CBSC Board.

Brief

To design open ended electrical tinkering toy kit for children of 11 to 12 year old secondary school student which can facilitate a direct hands on learning experience on various fundamental electrical components and circuitry and encourage the user group to invent and construct diverse range circuits based on gameplay.

Design Considerations

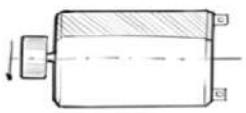
The initial idea was to develop a set of simple-to-use electrical components that could be pieced together to form different circuits in the form of a game aiming to foster curiosity and experimentation among students in creating and exploring electrical setups.

- Develop **a layered system that provides a structured learning curve**, guiding users from elementary to intricate electrical projects.
- Foster innovative thinking by offering versatile part **combinations for endless creative possibilities.**
- Ensure the design facilitates rapid adjustments and fixes, streamlining the **iterative process of invention.**
- Provide **immediate feedback mechanisms** so users can validate their constructions at various checkpoints.
- Allow the toy to grow with the user, offering extensions and complexity for **continued engagement and challenge**.
- **Include diagnostic features** within the toy that empower users to evaluate and refine their designs effectively.
- Design components to serve multiple functions across different builds, enhancing the toy's versatility and value.
- Craft each piece to visually and functionally represent a specific electrical concept, making learning intuitive.

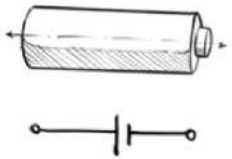
Electronic parts suitable for the toy

After careful thought, various electrical components were identified to ensure that all aspects of the electrical circuit are covered, and children become acquainted with these components.

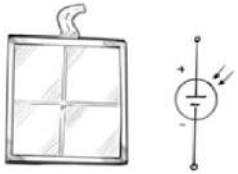
Power supply



Dynamo



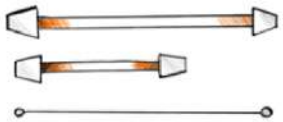
Batteriesc



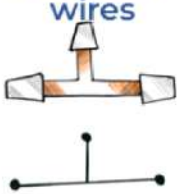
Solar panels

Connectors

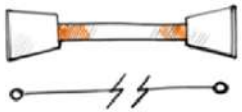
Colored breadboard



Connector wires

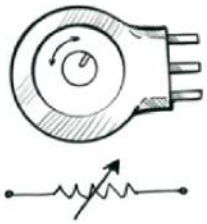


T connectors

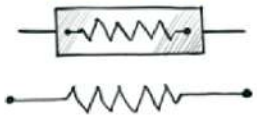


Extenders

Resistors

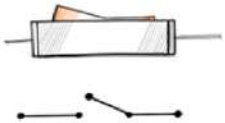


Variable resistance

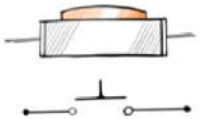


Resistors

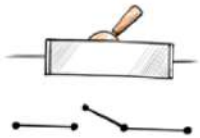
Switches



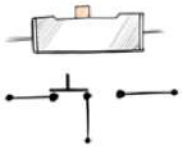
Rocker switch



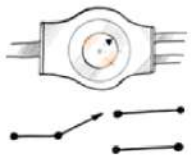
Push switch



Toggle switch

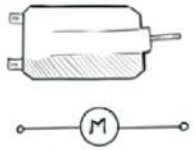


Slider switch

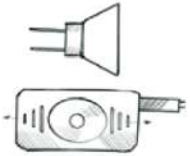


Rotary switch

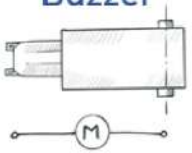
Actuators



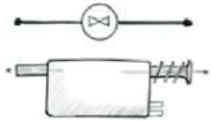
Motor



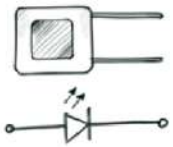
Buzzer



Geared motor



Solenoid



LED Light

Market Research

to understand what has been done in the market as stem toys, games and tools developed on the principles of electricity and electric city and to understand the market gap where the proposed game can address the market gap, following research was done.

Circuit Maze: Electric Current Logic Game

Pros:

- Enhances problem-solving skills and encourages critical thinking.
- Provides progressive difficulty levels that challenge players as they advance.

Cons:

- May be too challenging for younger children without adult guidance.
- Limited replay value once all puzzles are solved.

Einstein Box: Electricity Kit

Pros:

- Educational Value: Encourages curiosity in electronics with hands-on learning.
- User-Friendly: Detailed, clear instructions suitable for children 7-14 years.

Cons:

- Component Quality: Reports of broken or missing parts.
- Battery Issues: Not enough batteries included for all projects.
- Cost Concerns: Perceived as overpriced relative to content.

Market Research

Spintronics:
Build mechanical circuits

Pros:

- Offers a unique approach by using mechanical components to teach electronic concepts.
- Makes advanced concepts like transistors and capacitors understandable through physical interaction.

Cons:

- More expensive than some other educational games due to the quality and durability of components.
- May require initial setup time and learning to understand how mechanical parts relate to electronic circuits.

Snap Circuits:
Build Electrical Circuits

Pros:

- Educational: Enhances understanding of electrical circuits and engineering.
- Safe and Easy: No soldering, tools-free assembly with snap-together parts.
- Award-Winning: Recognized by educational and toy awards for its value.

Cons:

- Age Restrictive: Best suited for children 8 and up, potentially challenging for younger kids.
- Battery Dependence: Requires frequent battery changes; batteries not included.
- Extra Costs: Additional costs for expansion kits.

Market Research

CircuitMAX:
Fun electronics experiments

Pros:

- Educational and Engaging: Suitable for children aged 8+, enhances understanding of electronics with practical experiments involving components like LEDs and motors.
- Creative Development: Promotes creativity and curiosity through 25+ fun experiments, fostering comprehensive STEM education.

Cons:

- Requires Batteries: Needs 2 AA batteries that are not included, possibly delaying use.
- Material Durability Unclear: General positive reception, but lacks specific feedback on durability under long-term use.

Smartivity electricity robot kit:
Fun robotic toy

Pros:

- Educational & Engaging: Teaches robotics and electronics to kids 6-12 years through hands-on activities.
- Creative Development: Promotes innovation and problem-solving skills.
- Complete Kit: Includes all necessary materials for convenience and ease of use.

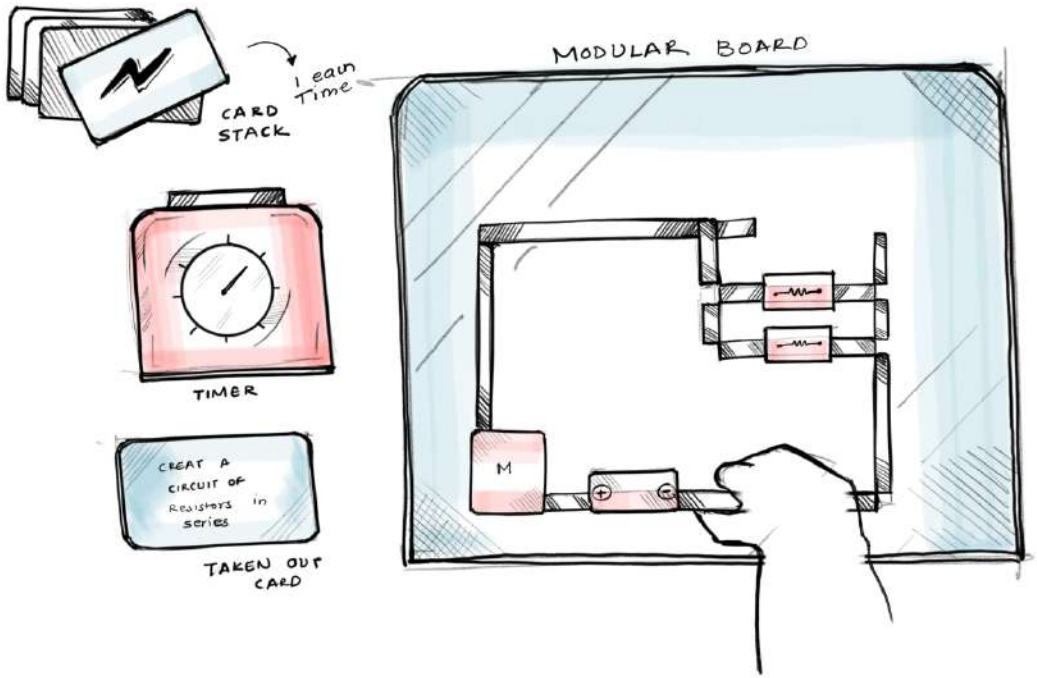
Cons:

- Assembly Required: May need adult help for younger children.
- Battery Dependency: Requires batteries not included, which may affect initial usage.

Game Ideations

Idea 1: Circuit Challenge is a single-player puzzle-solving game where players complete various electrical challenges using components and circuits within a restricted time frame.

- **Type:** Single-player puzzle-solving game
- **Objective:** Complete electrical challenges using components and circuits within a time limit.
- **Components:** Batteries, resistors, capacitors, switches, LEDs, etc.
- **Gameplay Mechanics:**
- Receive a series of challenges to build specific circuits.
- Strategically select and place components on a virtual breadboard.
- Complete challenges within a restricted time frame.
- Progression:
- Successfully completing challenges unlocks more difficult ones.
- Earn points based on completion time and accuracy to unlock new levels.



Game Ideations

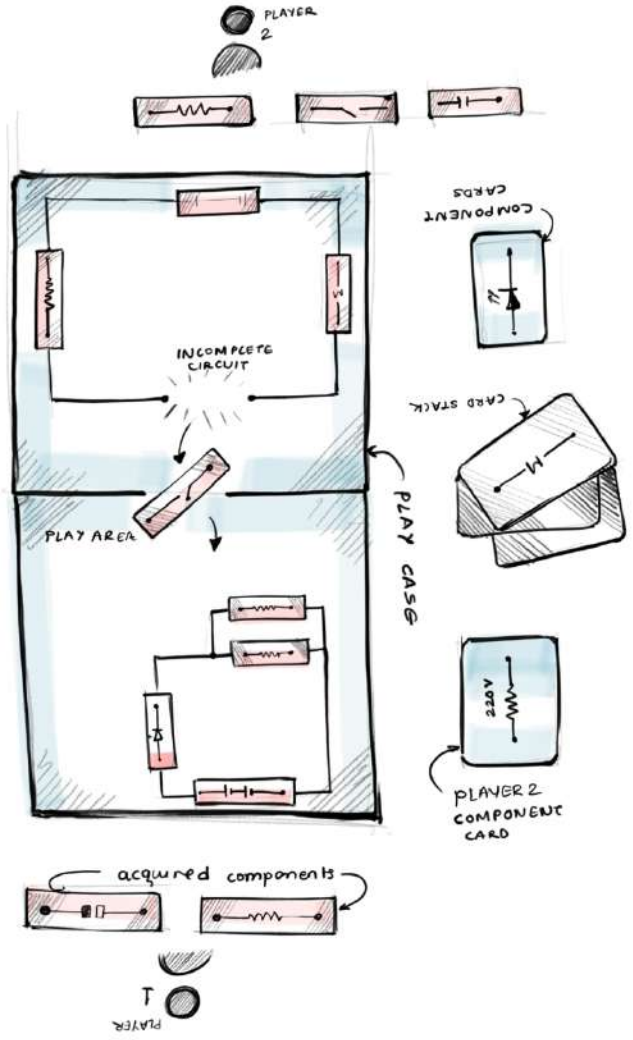
Idea 2: To build circuits that meet predefined challenges while managing interference from the opponent and trying to tactically disrupt the opponent's circuit without breaking core game rules.

Gameplay:

1. **Round Start:**
   - Draw challenge cards.
2. **Building Phase:**
   - Build circuits in 10 minutes.
3. **Interference Phase:**
   - Use tokens to interfere with opponent's circuit.
4. **Judging Phase:**
   - Demonstrate circuit functionality.

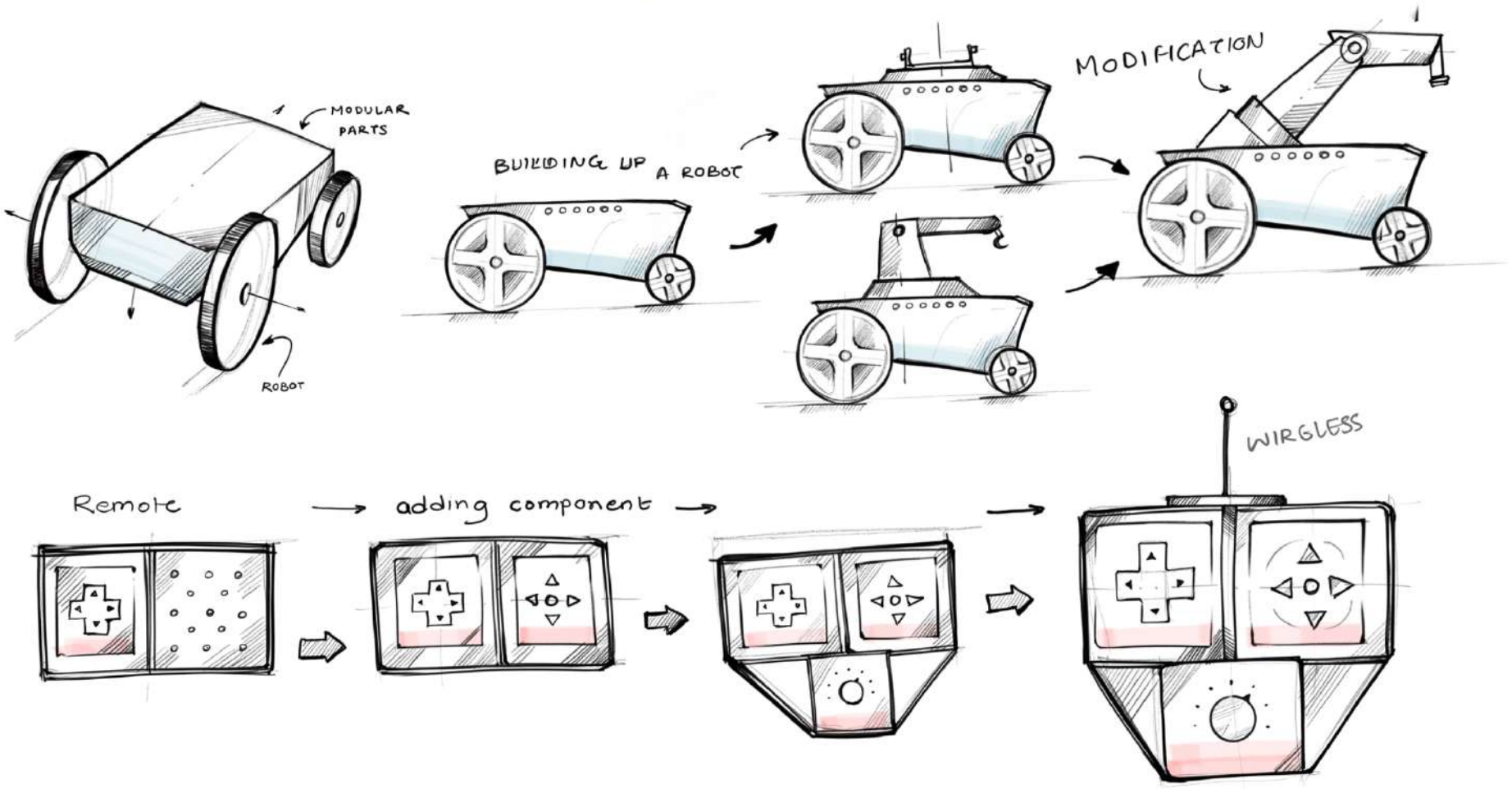
Scoring:

- Completeness: 50 points
- Resilience: 30 points
- Creativity and Efficiency: 20 points
- Winning:
- Highest total score after 5 rounds wins.



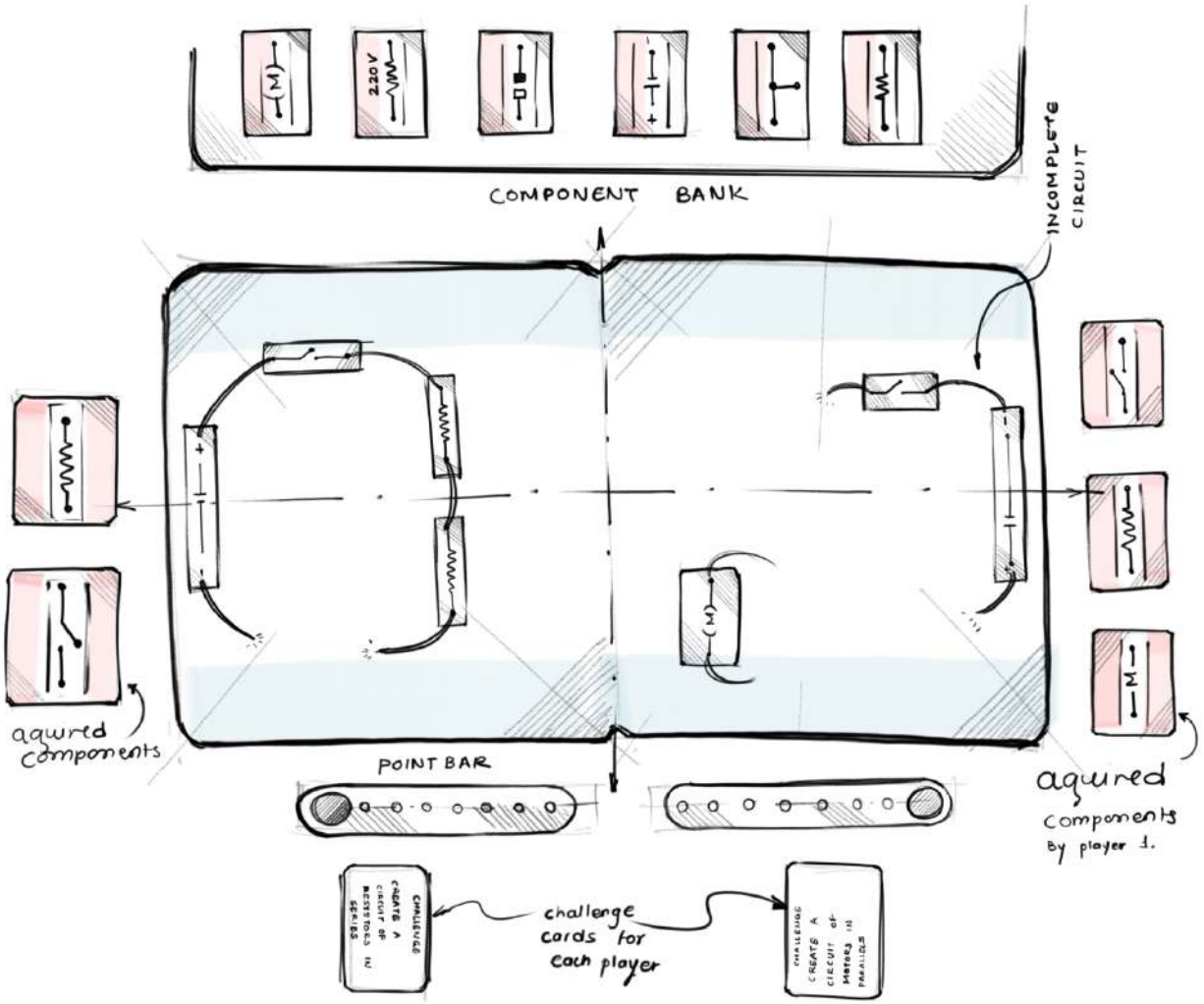
Game Ideations

Idea 3: Players compete to build and optimize a circuit to power a small vehicle (like a mini robot or car) through obstacles. The player who completes the set of obstacles wins. The Obstactles can be instructed through series of cards



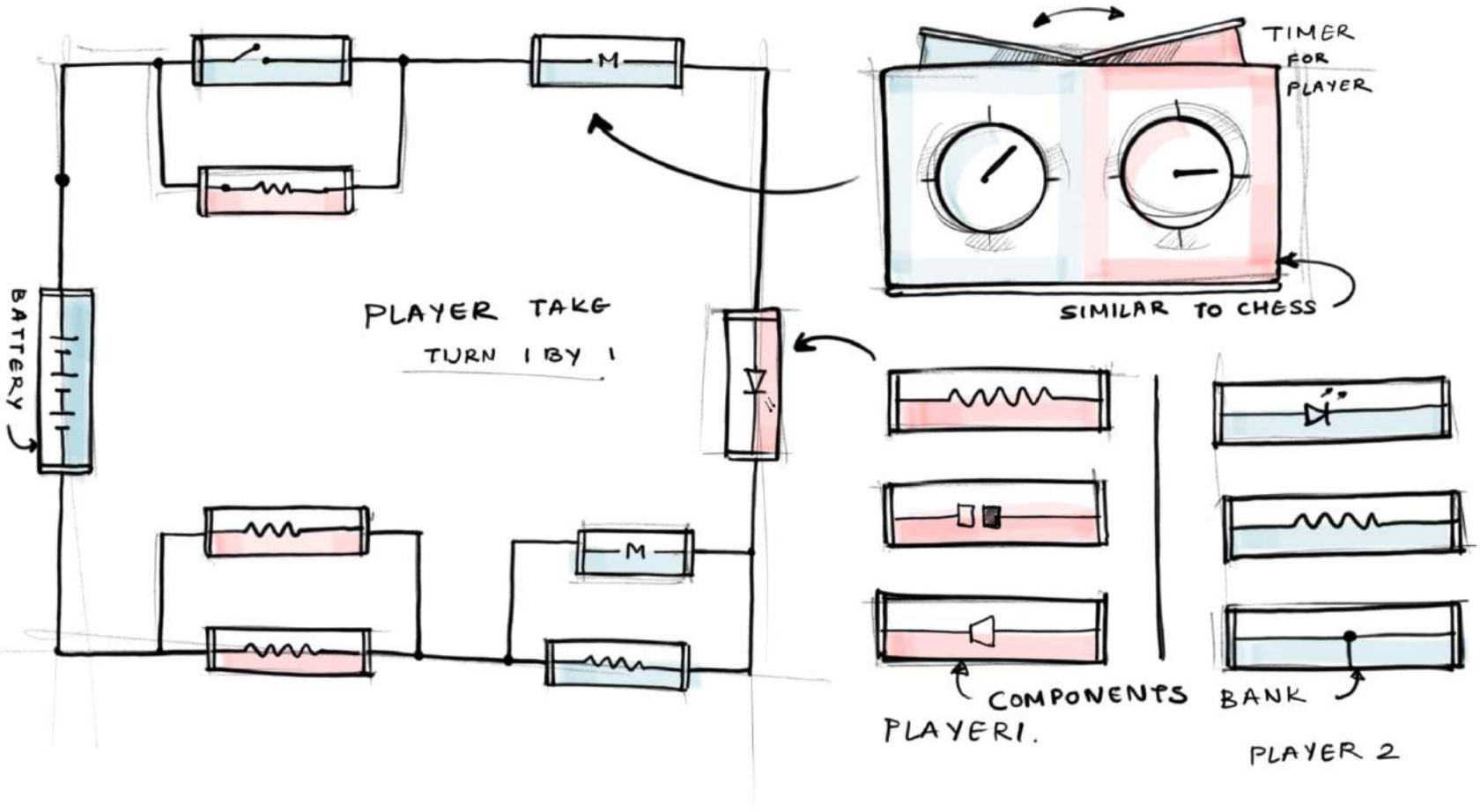
Game Ideations

Idea 4: A Competitive game based on challenge cards, runs across 5 rounds where each player has to pick up a challenge card and complete the given challenge before the opponent to win that round.



Game Ideations

Idea 5: A competitive game where each player is assigned a circuit to make while making sure to use most of the components assigned to that player and sabotaging the opponents circuit with our own components.



Final concept of Game

To adapt the game for the target age groups, two types of gameplay were introduced. The first is a **single-player game** designed with levels to progress through, and the second is a **competitive two-player game** suitable for the specified age group. Here are the game constraints considered when designing both games.

- **Focus on Electrical Concepts:** The game should exclusively involve electrical principles and circuits to avoid overwhelming children with additional scientific concepts.
- **Single-Player Mode:** The single-player game should test the player's knowledge and skills regarding electrical principles and circuitry.
- **Multiplayer Dynamics:** The multiplayer aspect should incorporate elements of luck and unpredictability to enhance the fun and suspense during gameplay.
- **Educational Tools:** The game components should also serve as educational tools, helping players create and understand both new and classroom-taught electrical circuits.
- **Incorporation of Math:** Simple and quick mathematical calculations should be included to assist in understanding and solving circuit problems.
- **Scoring and Progression System:** A system of points and rounds should be included to engage players, encouraging them to test their skills and luck in subsequent rounds.

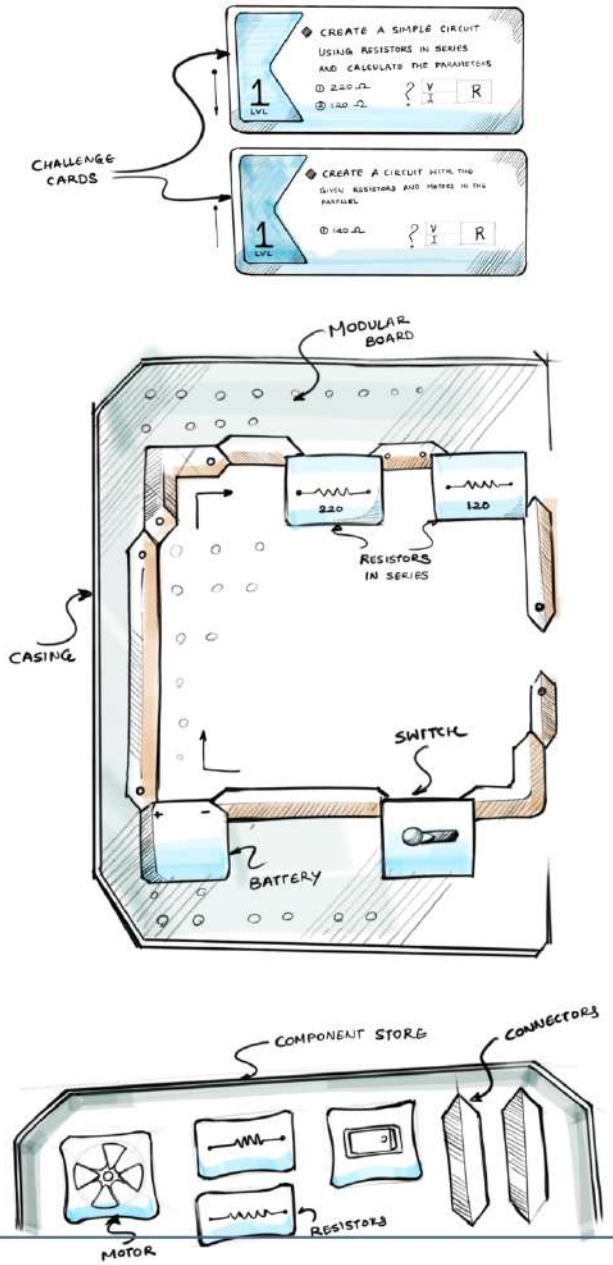
Single Player Game: Circuit Crafter

Game Title: Circuit Crafter

Circuit Crafter is an engaging single-player game designed to enhance understanding of electrical circuits and principles. Players use a modular board and a variety of components such as electrical connectors, actuators, switches, batteries, resistors, and capacitors to complete challenges. The game incorporates elements of luck and unpredictability to increase excitement and fun.

Game Components:

- Modular board with slots for component placement
- Electrical connectors
- Actuators (e.g., motors, LEDs)
- Switches
- Batteries
- Resistors
- Component cards
- Challenge cards
- Dice or spinner for luck elements



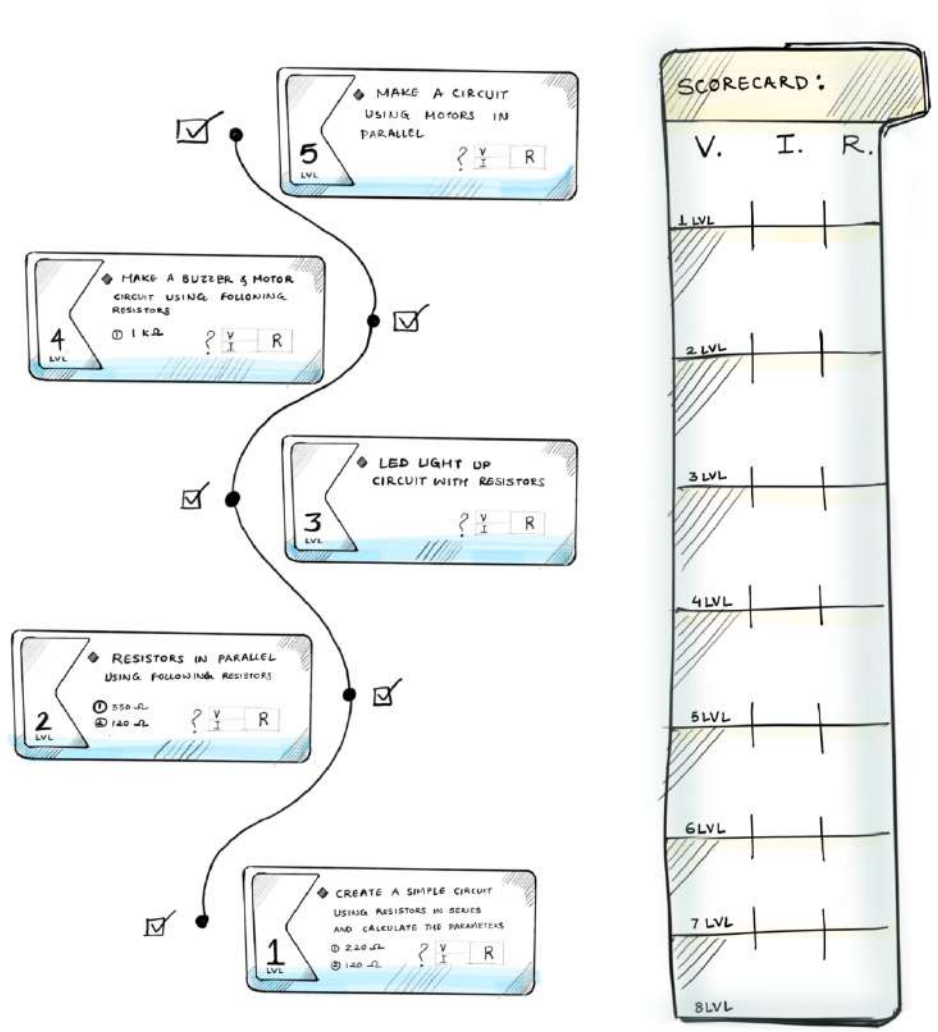
Single Player Game: Circuit Crafter

Single Player Game

the structure of the single player is only to make individual learning effective and in structured manner. each challenge card gives a player a brief for the circuit with required components mentioned. the player needs to complete the circuit on the basis of his knowledge of electrical circuits and components. once the circuit is complete. the player can write down the values of voltage, current and resistance on the scorecard. Kid can take this scorecard in order to recheck with correct answers in order to rate his knowledge of electrical circuits and improve upon it.

Fun Elements

1. **Timer Challenge:** Use a timer to add a time challenge element. The faster the player completes the circuit and calculations, the more bonus points they earn.
2. **Achievement Badges:** Include achievement badges for completing specific tasks, such as "Speedster" for completing a circuit in record time or "Accuracy Master" for perfect calculations.
3. **Mini-Games:** Add mini-games or quick puzzles related to electrical circuits that players can complete between challenges for extra points.
4. **Level-Up System:** Implement a level-up system where players can advance to higher levels of difficulty with more complex circuits as they progress.



Two Player Game: CircuitClash

Circuit Clash is an educational game designed for two players, where participants compete to build and optimize electrical circuits using basic components like batteries, motors, resistors, capacitors, lights, and solenoid linear actuators. The game tests players' knowledge of electrical principles such as voltage, current, series and parallel circuits, and their strategic skills in managing these components to achieve specific objectives.

Objective of the game:
The main goal is to successfully power your assigned devices using a limited set of components. Each player must construct a circuit that meets certain requirements faster than their opponent. These requirements could involve achieving a specific voltage or current, powering a device like a light or motor, or optimizing a circuit for efficiency or speed.

Two Player Game: CircuitClash

Components

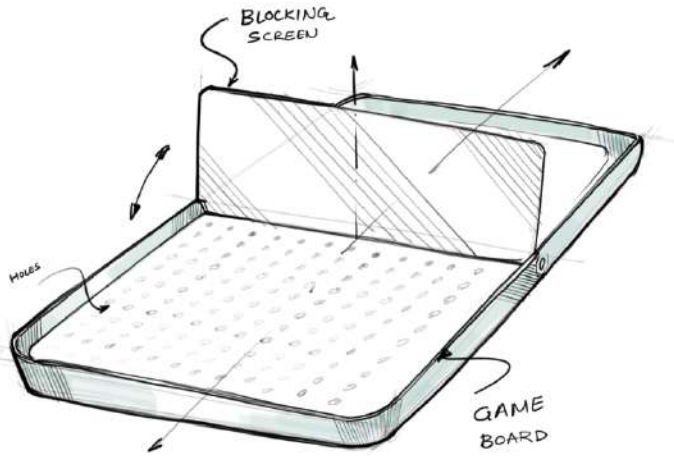
- Game board with component store
- Dice (with numbers 1-6 and special sides)
- Component cards (e.g., resistors, wires, batteries, switches, LEDs)
- Strategy cards (special actions)
- Challenge cards (circuit diagrams)
- Player pieces (markers to indicate progress)
- Testing unit (simple circuit tester to check the completed circuit)

Setup

- Place the game board in the center.
- Shuffle the component cards and place them in the component store on the board.
- Shuffle the strategy cards and place them in a separate pile.
- Shuffle the challenge cards and deal one to each player. Players keep their challenge cards secret from their opponent.

Rules

- Players must follow the circuit diagram exactly as shown on their challenge card.
- Players can only use the components they have drawn or gained through strategy cards.
- Components can be traded or swapped only through the use of strategy cards.
- If a player incorrectly tests a circuit, they must miss their next turn.
- The game continues until one player successfully completes and tests their circuit.

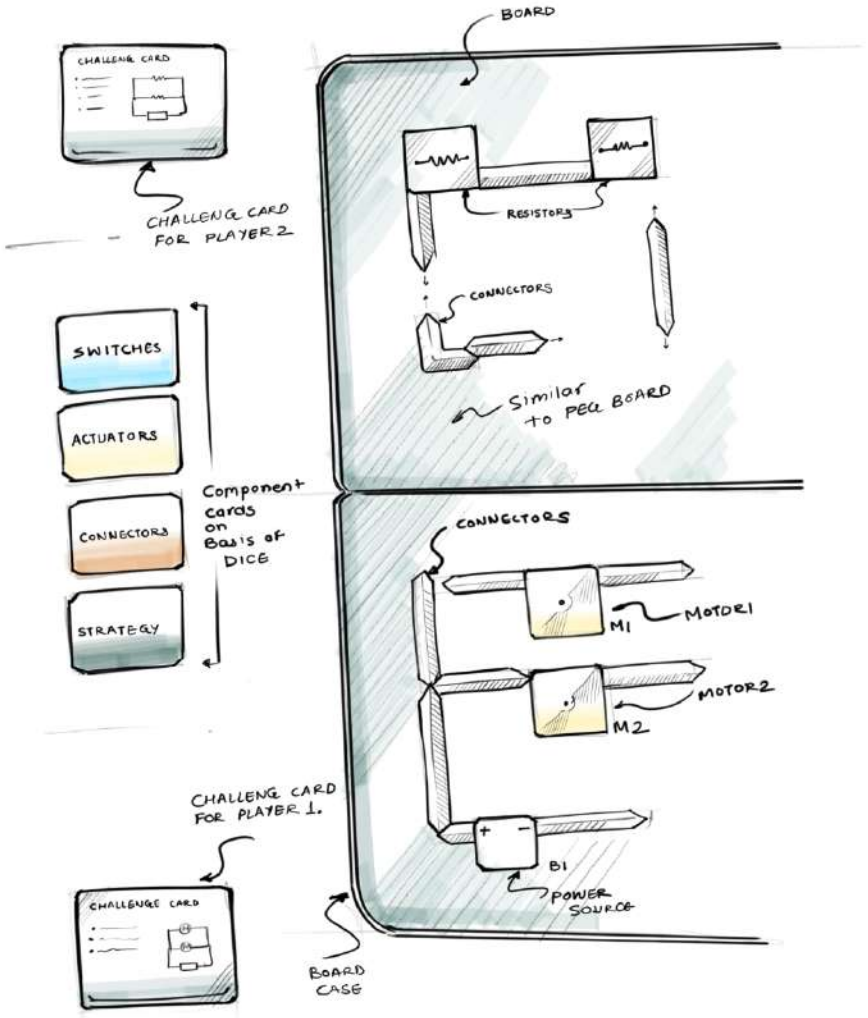


Setup of the 2 player Game

Two Player Game: CircuitClash

Game Play

1. Turn Order: Players take turns rolling the dice.
2. Dice Roll:
   - Numbers 1-6: Draw that number of component cards from the store.
   - Special Side 1: Draw a strategy card.
   - Special Side 2: Swap a component card with your opponent.
3. Building the Circuit: Players use the components they draw to build their circuit according to their challenge card. Components must match exactly as shown on the card.
4. Using Strategy Cards: Players can use strategy cards to perform special actions, such as:
   - Take a component of choice from the store.
   - Remove a component from the opponent's half-made circuit.
   - Swap one of your components with one from the store.
5. Completing the Circuit: Once a player thinks they have completed their circuit, they must test it using the testing unit. If it works, they win the game. If not, they continue to draw and place components until they get it right.



Gameplay of the circuit clash

Toy kit as tool for learning: Tinkertronix

Using the components from the game as tools, students can directly replicate circuits found in textbooks or taught by teachers in class. This hands-on approach enhances learning experiences and offers a practical way for students to reinforce theoretical concepts. Additionally, it provides an opportunity for students to verify their mathematical calculations related to Ohm's Law, resistors in series and parallel, and other circuit calculations.

Components included with the kit.

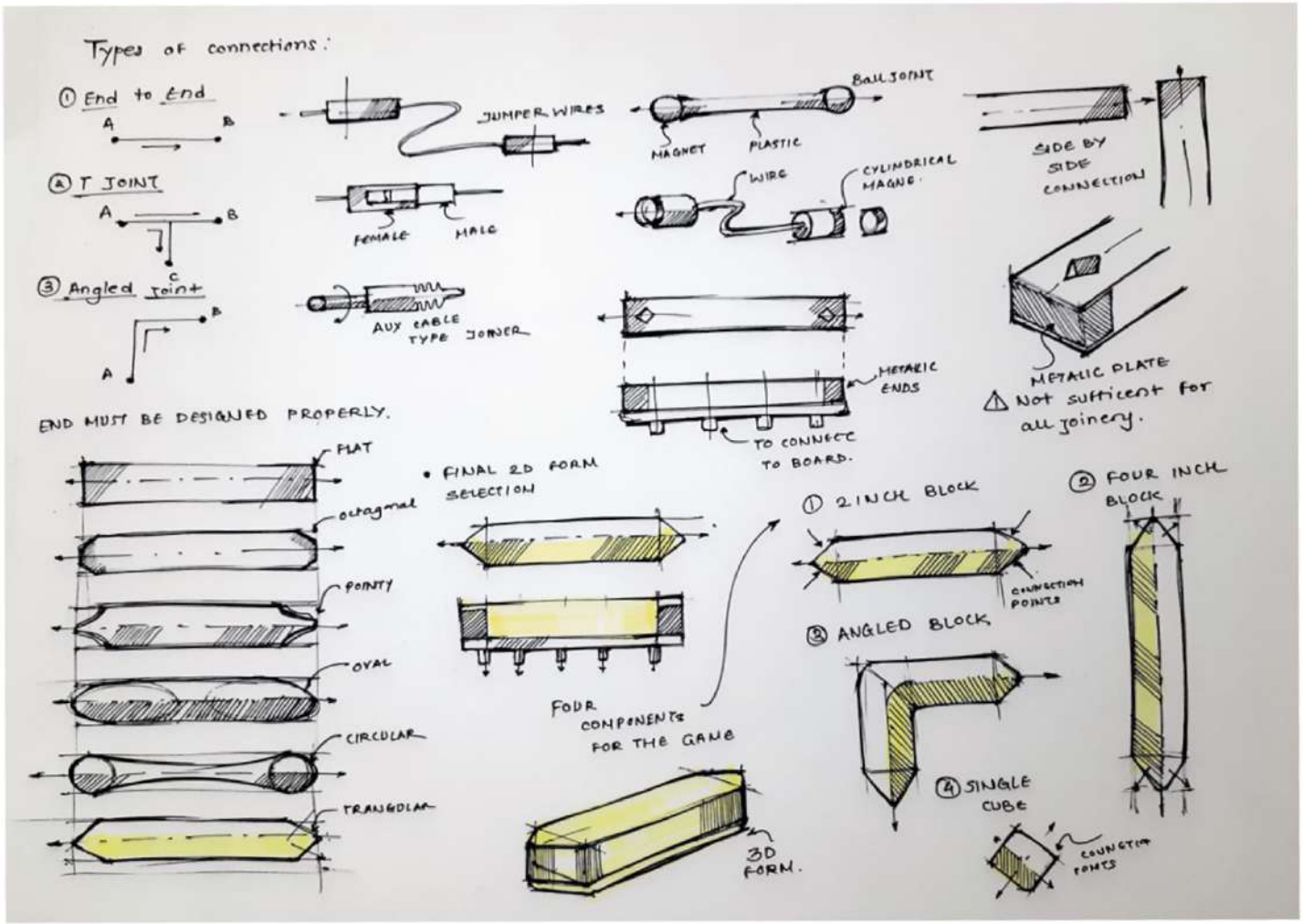
- Modular board with slots for component placement
- Electrical connectors
- Actuators (e.g., motors, LEDs)
- Switches
- Batteries
- Resistors
- Capacitors
- Component cards
- Challenge cards
- Dice or spinner for luck elements

Circuits and principles that can be made using the given components.

- Validation of Ohms law
- Resistors in series
- Resistors in parallel
- Capacitor circuits
- Motor speed control circuits
- Electric door bell circuits
- Capacitors
- Electromagnetic circuits

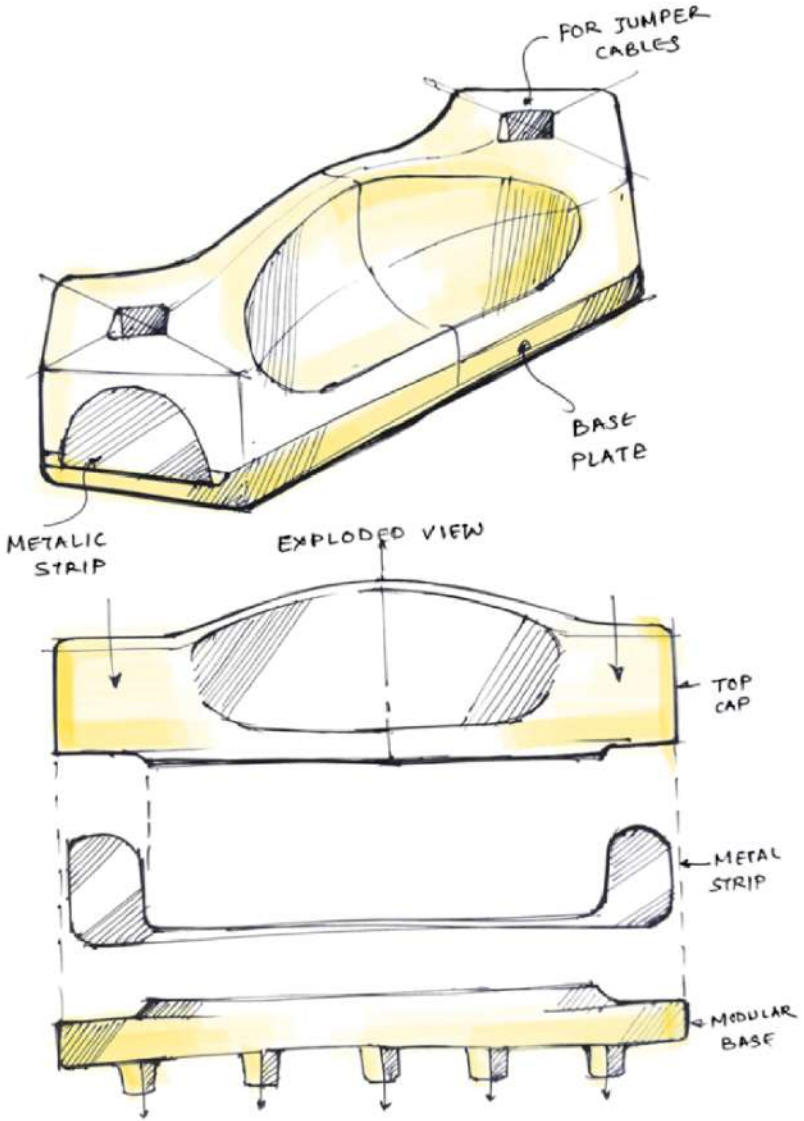
Refinement

Concepts were developed to create electrical connectors designed for easy attachment between two components. The final design features a 45-degree angle, allowing the connectors to form various configurations such as L-shaped and T-shaped joints. This innovative approach provides flexibility in creating different types of electrical connections, enhancing the versatility and functionality of the connectors.

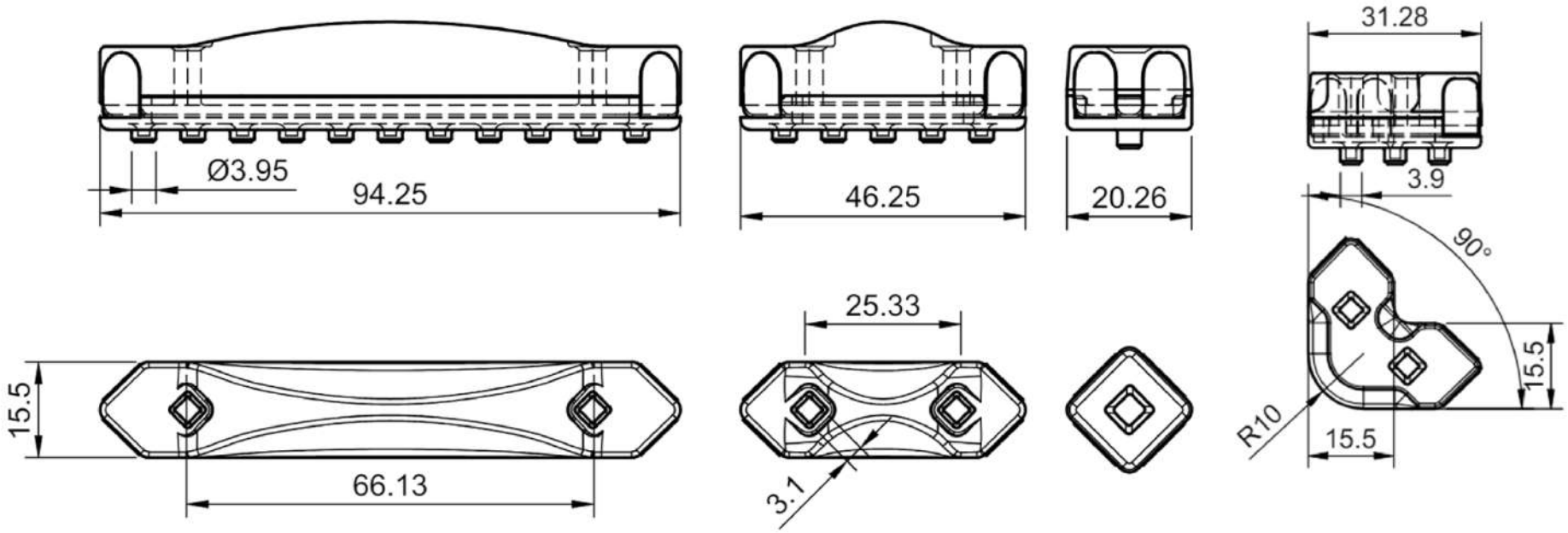


Component form and detailing: Connectors

Detailing:
The two-piece connecting element contains a nickel sheet in the center, offering connection points on four sides. The top holes allow access for jumper cables to connect a voltmeter and ammeter.



Component form and detailing: CAD details and Dimensions



FOUR INCH ELEMENT

TWO INCH ELEMENT

ANGLE

Component form and detailing: Connectors Design

Materials:

- ABS Material: For plastic parts, known for strength and ease of molding.
- Nickel Strips: For conductive elements, offering excellent conductivity and corrosion resistance.

Manufacturing:

- Injection Molding: Used for creating precise plastic parts.
- Stamping and Bending: Used for forming nickel sheet metals into conductive elements.

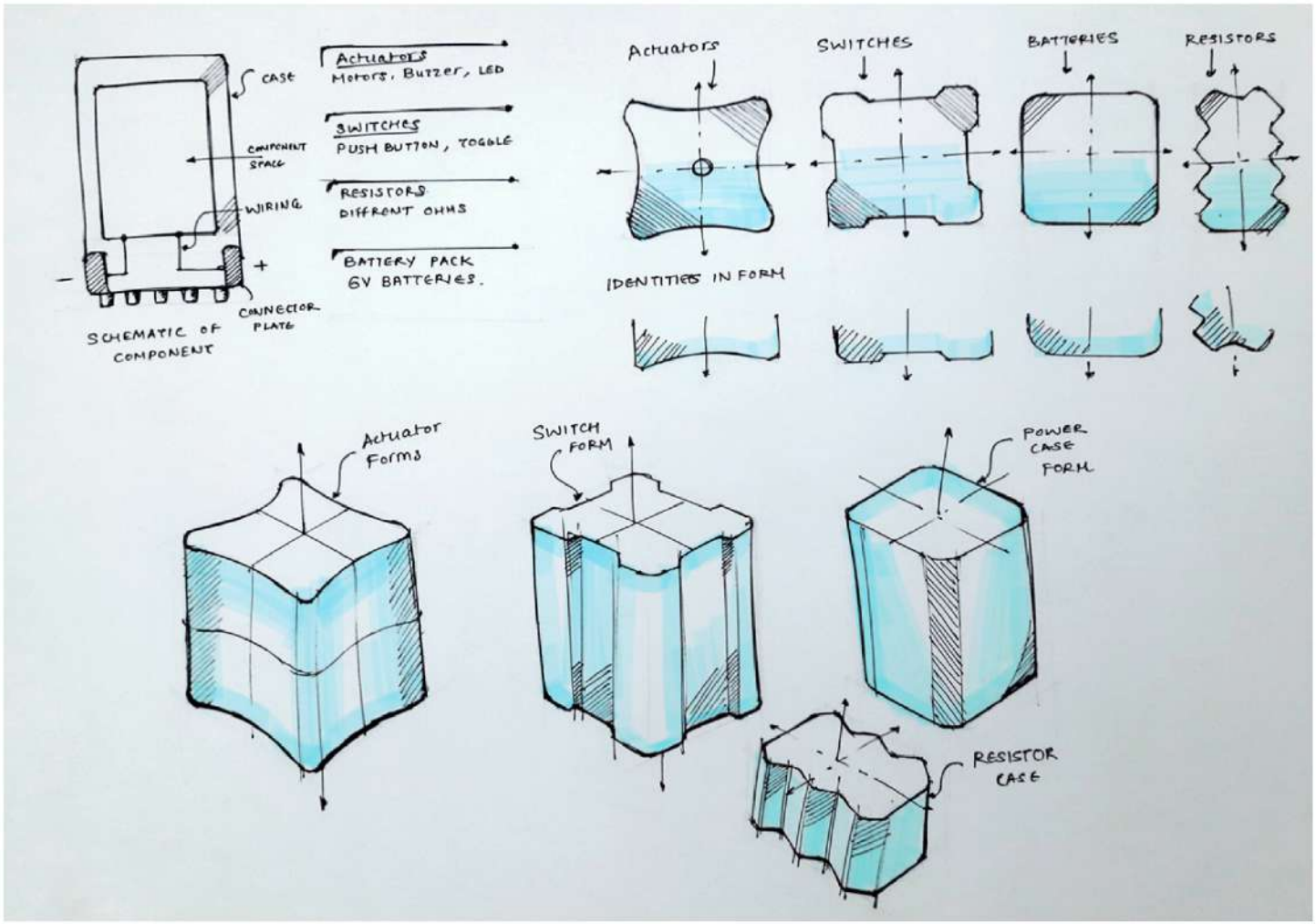
Connectors:

- Linear 2-inch Connector: For short-distance connections.
- Linear 4-inch Connector: For long-distance connections, aiding in circuit completion.
- 90° Angled 2x2-inch Connector: For angled connections, providing flexibility.
- Single Cubic Connector: For correcting small mistakes.

Component Form and Detailing: Electronic Components

Form of the products

The product design features components with a uniform cubical size and shape, with slight variations based on the component type, such as motors, batteries, resistors, and switches.



Component form and detailing: Actuators

Specifications:
Voltage: 4.5 V TO 12 V
Amp: 70 to 250mA

Material:
ABS material can be used for plastic parts.
Nickel strips used for making conductive elements.

Manufacturing:
The plastic can be injection molded while stamping and bending can be done to manufacture nickel sheet metals.

Component inside:
DC brushless toy motor, LEDs, buzzer and beeping buzzer and Electromagnet

Component form and detailing: Battery Pack

Specifications:
Voltage: 6V
Amp: 50 to 100mA

Material:
ABS material can be used for plastic parts.
Nickel strips used for making conductive elements

Manufacturing:
The plastic can be injection molded while stamping and bending can be done to manufacture nickel sheet metals.

Component inside:
4 AA batteries connected in series.

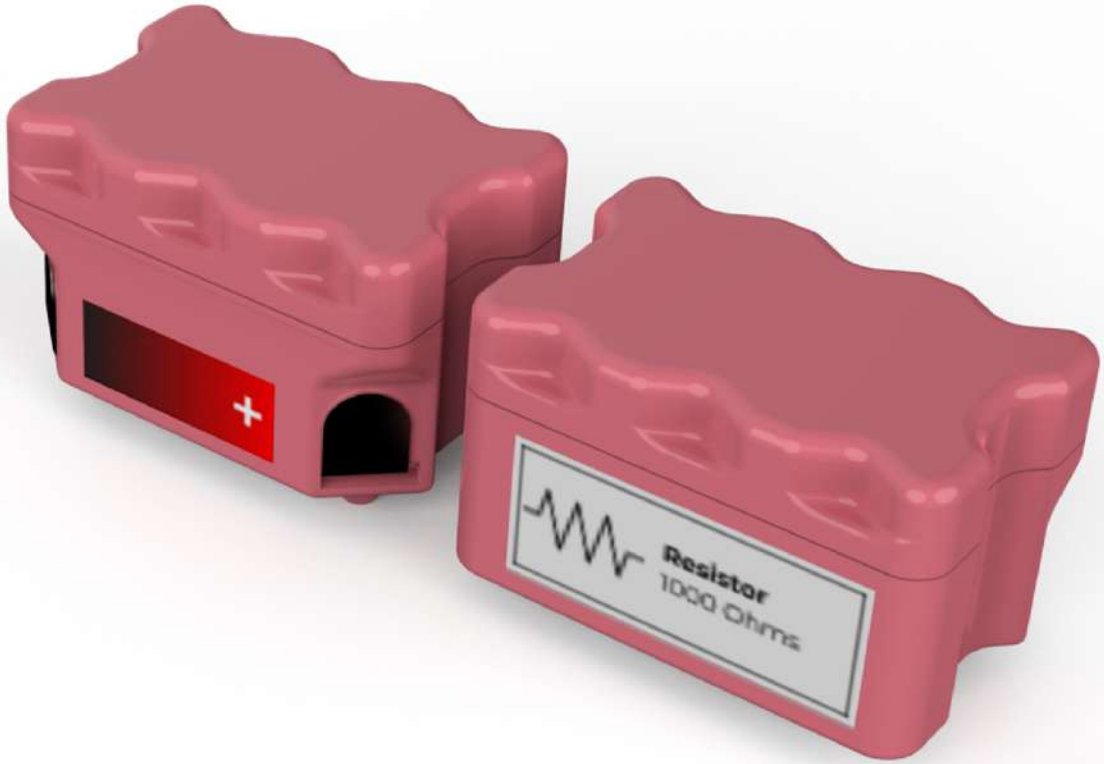
Component form and detailing: Resistors

Specifications:
Voltage: 6V
Resistors: different resistor ohm values

Material:
ABS material can be used for plastic parts.
Nickel strips used for making conductive elements

Manufacturing:
The plastic can be injection molded while stamping and bending can be done to manufacture nickel sheet metals.

Component inside:
Two terminal resistors of 22 ohms, 47 ohms, 110 ohms, 220 ohms, 330 ohms, 470 ohms, 1000 ohms and 4700 ohms



Component form and detailing: ON/OFF Switches

Specifications:
Voltage: 4.5 V to 12 V
Current: 70 to 250mA

Material:
ABS material can be used for plastic parts.
Nickel strips used for making conductive elements

Manufacturing:
The plastic can be injection molded while stamping and bending can be done to manufacture nickel sheet metals.

Components inside:
Regular rocker switch and push button switch.

Component form and detailing: Voltmeter/Ammeter

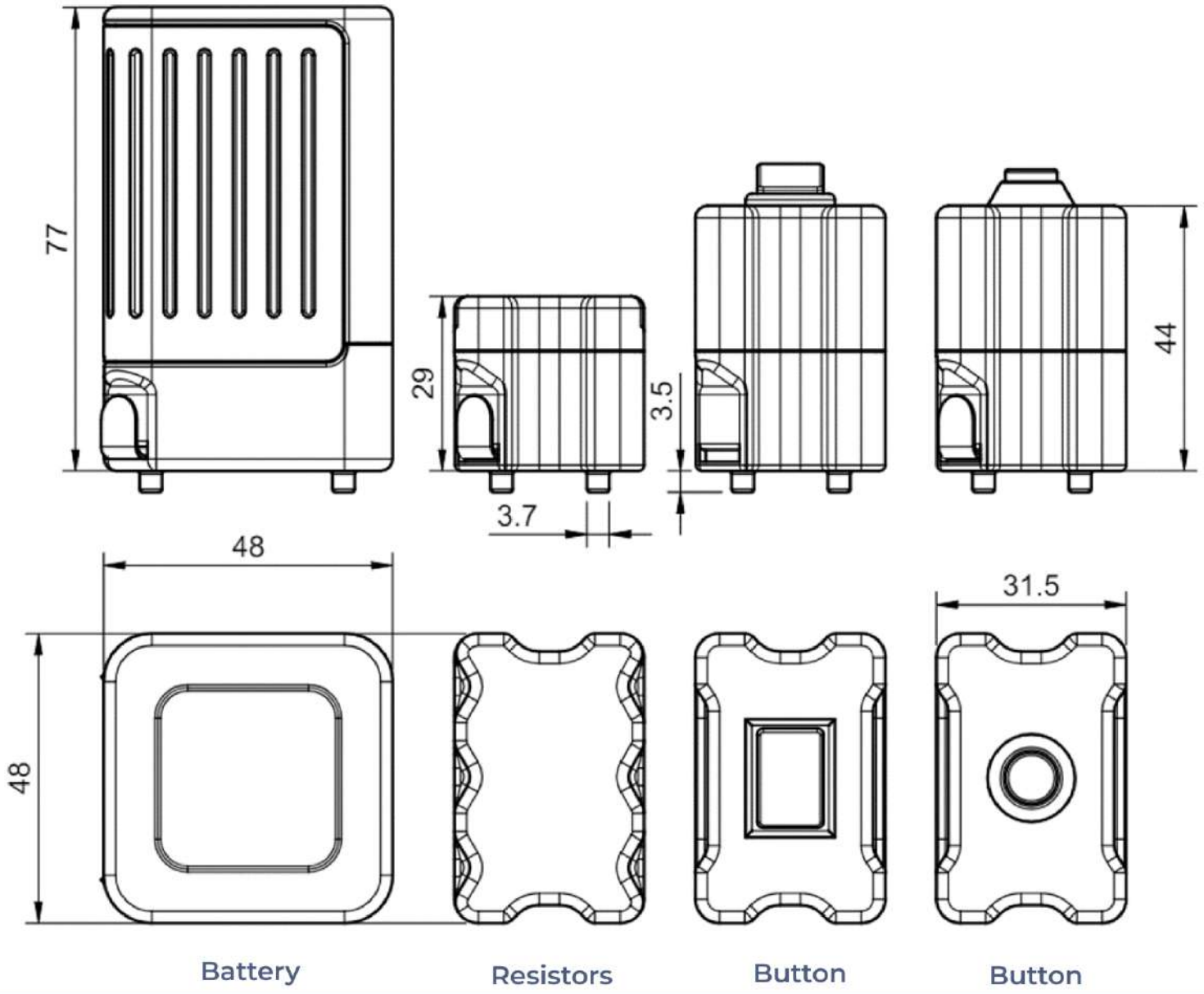
Specifications:
Voltage: 100 V
Current: 100 A

Material:
ABS material can be used for plastic parts.
Nickel strips used for making conductive elements

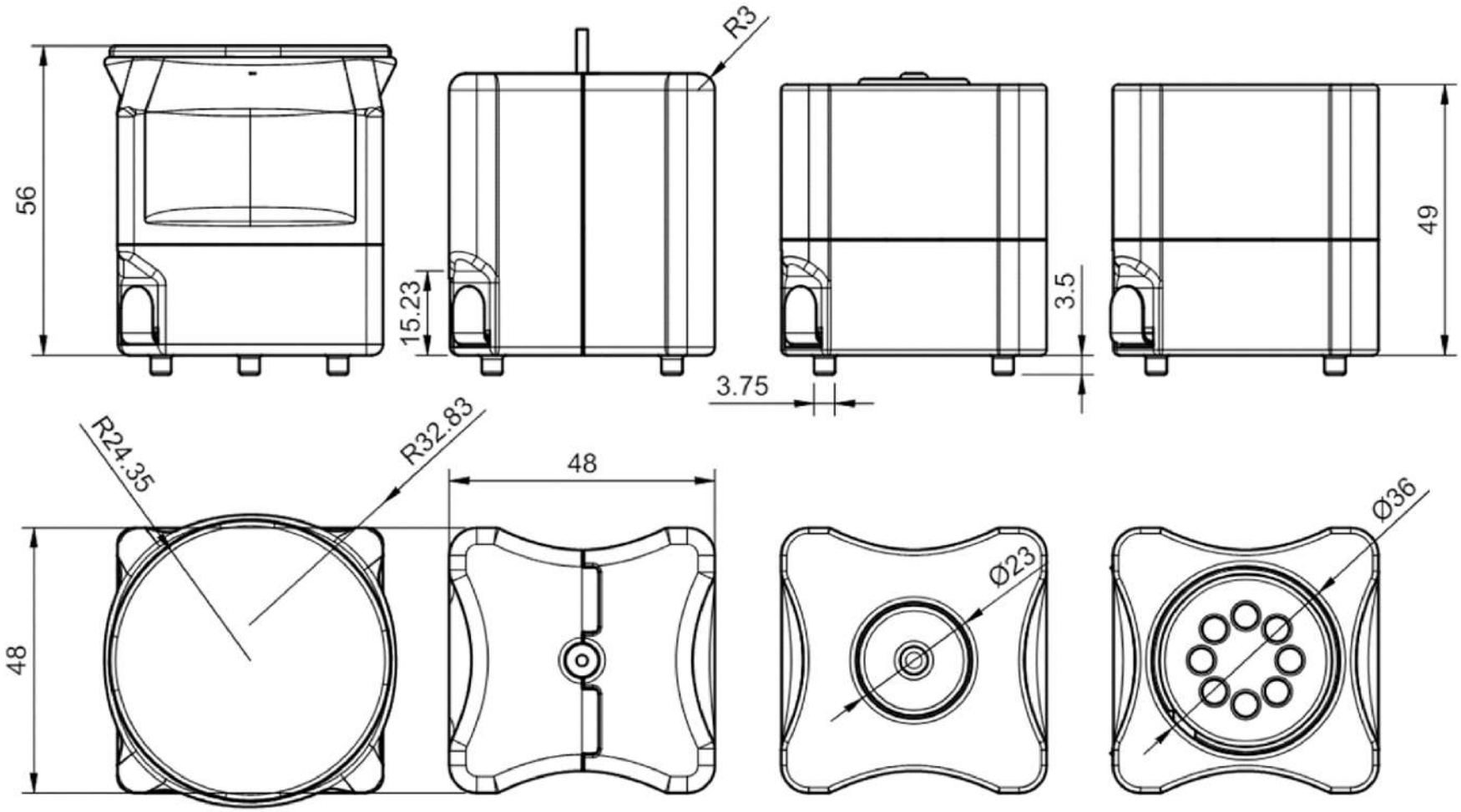
Manufacturing:
The plastic can be injection molded while stamping and bending can be done to manufacture nickel sheet metals.

Components inside:
Combined voltmeter and ammeter with four terminal.

Details and Dimensions: Other Components

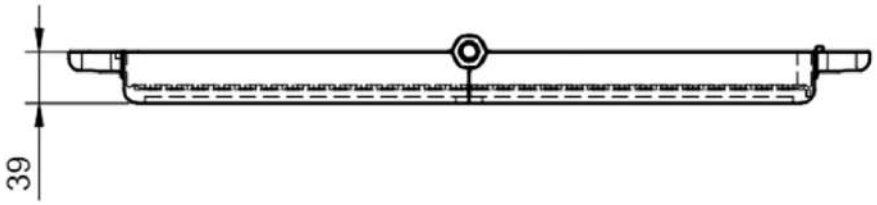


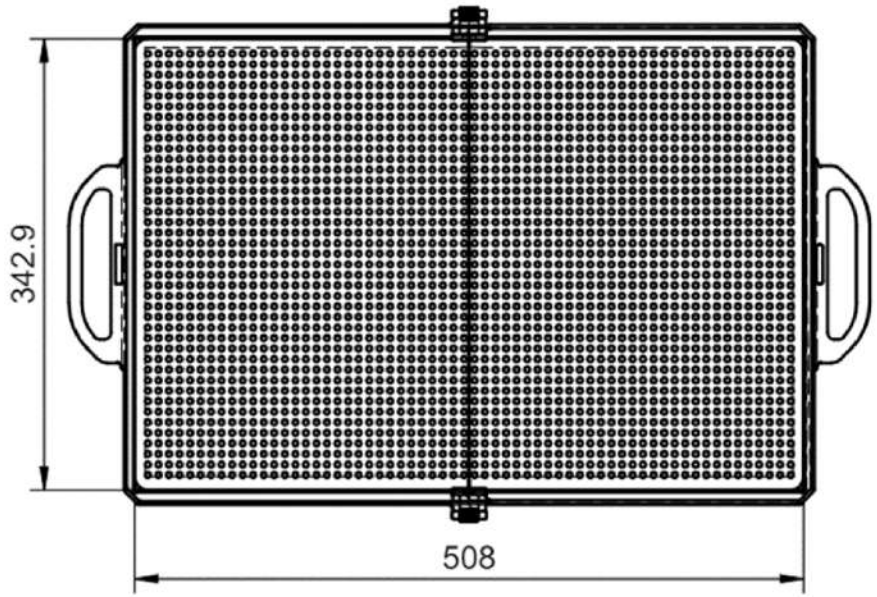
Details and Dimensions: Actuators

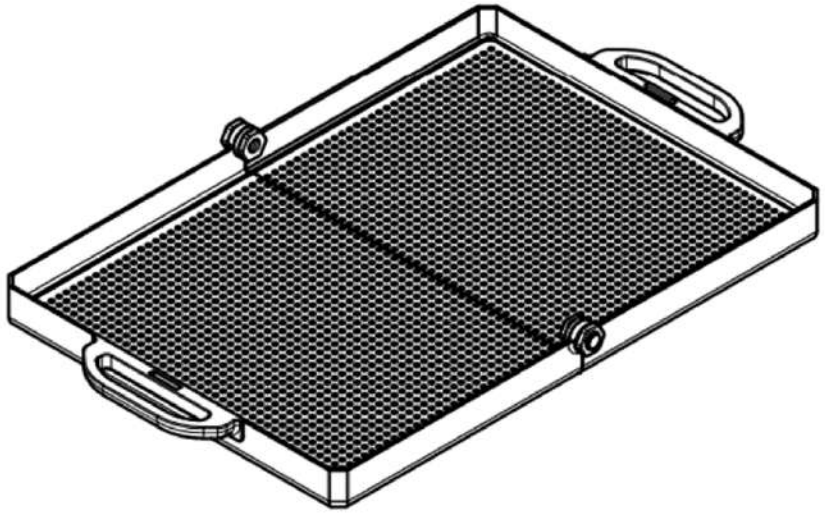


LED Motor Solenoid Buzzer

Details and Dimensions: board case







Board and Case

Specifications:
500 mm to 300 mm game board.
4 mm diameter holes.

Material:
Acrylic material is to be used for plastic modular board
ABS material is used for making outside case.

Manufacturing:
The plastic can be injection molded while board plate can be drilled or machined.

Introducing Circuit Clash: Competitive TinkerTronix Game

Circuit Clash is both fun and educational, making concepts like Ohm's Law and series and parallel circuits easy to understand and exciting to explore. Whether you're a budding engineer or just curious about how things work, this game will challenge your mind and ignite your interest in STEM.
Get ready to connect, compete, and conquer the world of circuits!

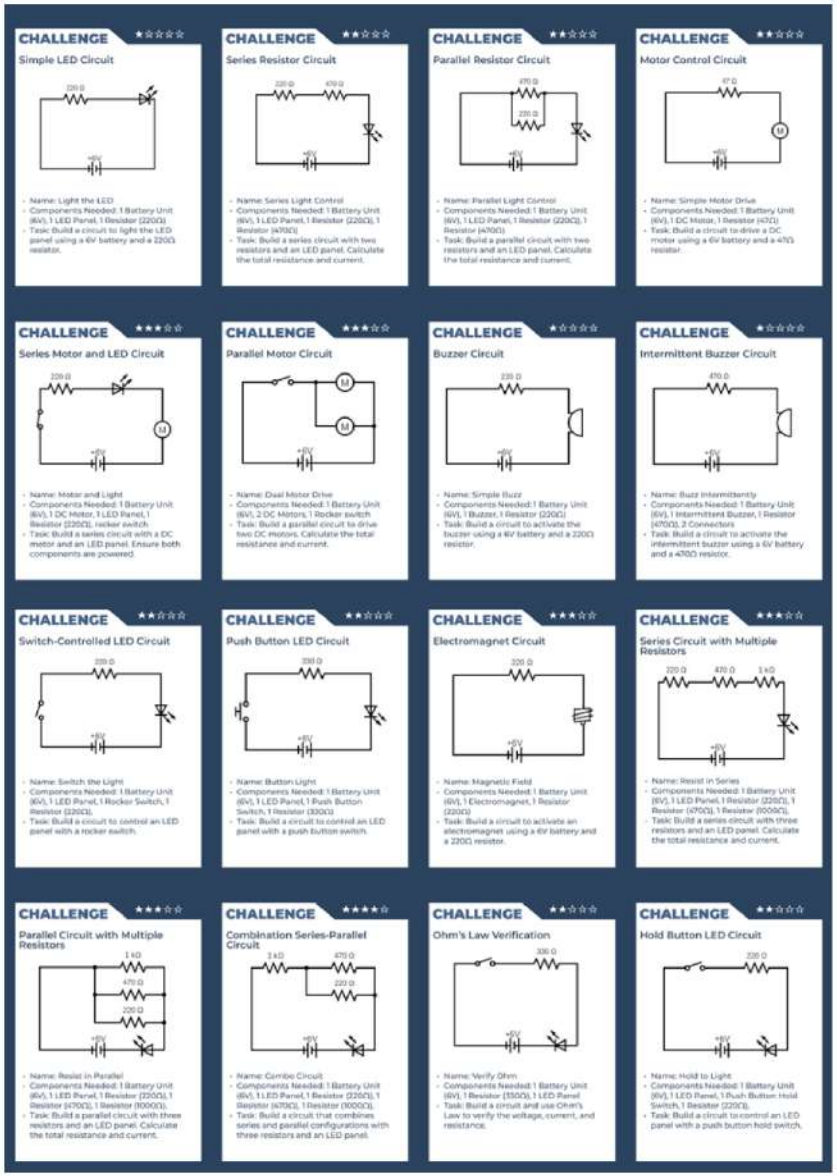
LUCK + SCIENCE + COMPETITIVENESS

Components of the Circuitclash

1. Tinkertronix board.
2. 4 types of connectors
3. All actuators
4. All switches and battery packs
5. 8 types of resistors
6. 6 sided unbiased dice
7. 5 types of component cards
8. Strategy cards
9. Challenge cards

Challenge cards

1. Challenge cards are drawn randomly without looking into the contents of the cards from well shuffled deck.
2. Each challenge card has a difficult level shown by star rating, player will get that much amount of score if he completes the circuit in the card on that round.
3. Player has to complete the given circuit with specificized component in circuit card.
4. Once the round is done, both of the challenge cards are kept away making sure these cards don't repeat in the next rounds.
5. Players can note who won and by what margin of score in separate notepad.
6. Total 21 strategy cards are available with the kit



Component cards

1. Component cards are drawn based on dice role of the player.
2. Each component card corresponds to number on face of the dice.
3. Player can draw the component assigned on the component card
4. If the component is required by the player he can keep it in his circuit or if not required it is mandatory for the player to pass that component such that the opponent can chose to take that component if he wants.
5. No player can keep components in reserve if he doesn't have a reserve strategy card.
6. After completion of round, all the cards must be shuffled and kept back in card stack.

Strategy cards

1. The kit contains 32 strategy cards.
2. Player can only draw strategy card if he gets 6 on dice face or as per strategy cards instruction.
3. Each strategy card has unique tactical gain or lose that can affect the player.
4. Every strategy card can be played on the same turn as it was drawn or some cards can saved for later.
5. After completion of round, all the cards must be shuffled and kept back in card stack.
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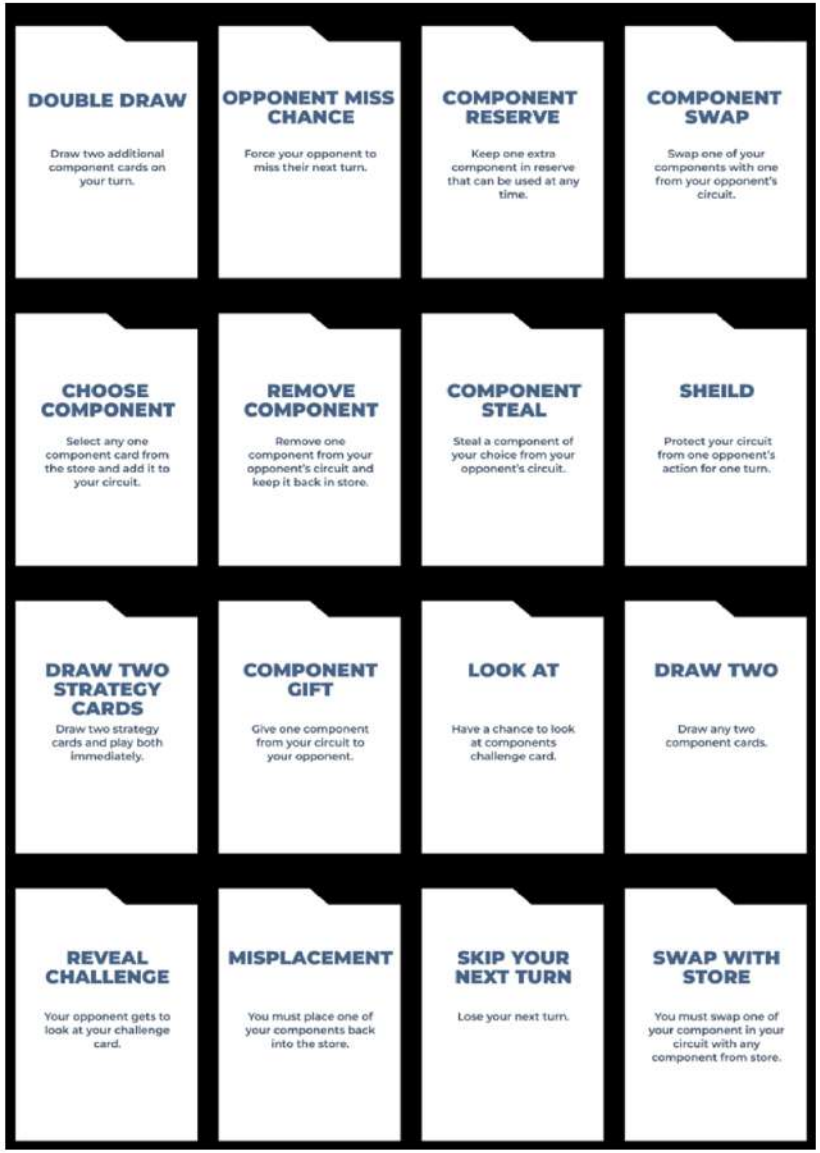

The rulebook

How to Play?
Turn Order
Players take turns rolling the dice.

Rolling the Dice
Numbers 1-5: Draw the corresponding number of component cards from the store.
Number 6: Draw a strategy card

Drawing Component Cards
Pick the top card(s) from the component store.
Decide if you want to use the component in your circuit or pass it to your opponent. (Yes, you read that right – be nice or be tricky!)If you choose to keep the component, place it in your circuit.

Drawing Strategy Cards
When you roll a 6, draw a strategy card and follow the instructions. Strategy cards can help you or create hurdles for your opponent. Use them wisely!

The rulebook

- **Building Your Circuit:**

Use the components you draw to build the circuit described on your challenge card.
Connect components using connectors and ensure the circuit matches the diagram.

- **Testing Your Circuit:**

Once you think your circuit is complete, test it using the testing unit. If the circuit works, you win the game! If it doesn't work, check your connections and try again.

- **Winning the Game**

The first player to complete and test their circuit wins! But remember, it's all about having fun and learning along the way. So, even if you don't win, you're still a brilliant engineer in the making!

The Prototype: challenge cards and component cards

Building Your Circuit:
Use the components you draw to build the circuit described on your challenge card.
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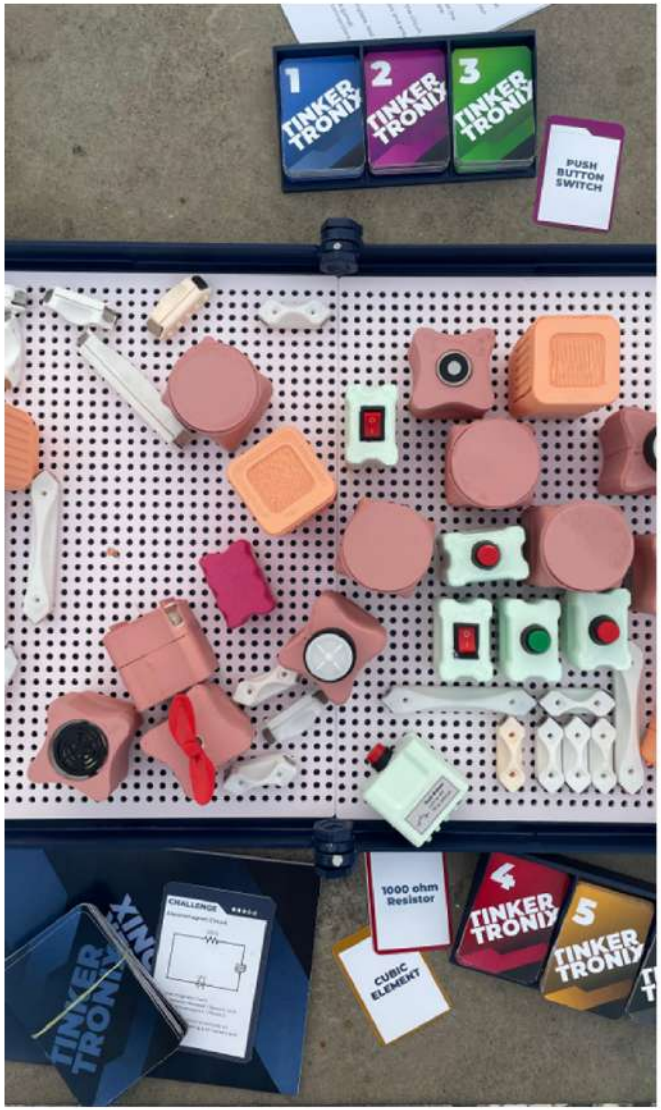
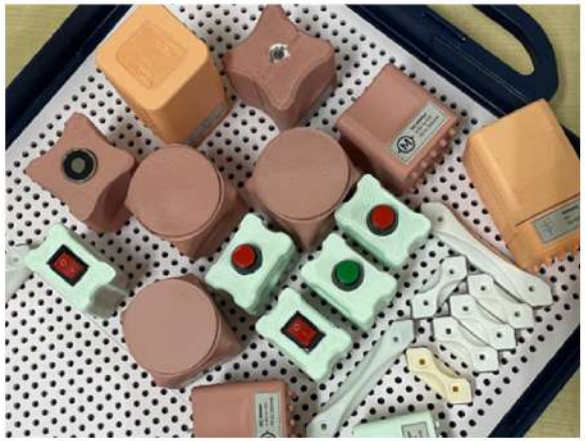
The Prototype

The Prototype





Mood board and Color pallet

Connecting element

Actuators

Battery pack

Resistors

Base plate

Case and other

Cost estimation

1.The total cost of whole tinker tronix kit would be around 2000 to 2500 INR.

2.The cost can be reduced mass manufacturing and economy of quantities.

3.Additionally tinkertronix can be made advanced using auxiliary components that users can buy depending on their specific needs.

4.Advanced versions of tinkertronix can include logic gates, complex servo and stepper motors and much more.

SR. no	Title of cost component	price
1	Plastic material	300 INR
2	All electronic components	1096 INR
3	Cards cost	210 INR
4	Dice and other elements	30 INR
5	Packaging	100 INR
6	Labour and overheads	200 INR
7	rulebook	20 INR
8	OTHER	100 INR
9	TOTAL	2056

Game testing

Game was tested with 3 different participants. The game was easier to understand to any new user. Yet the game slows down until some component cards are eliminated. Easier to understand the form of the product and corelate with actual components.

Participants found it difficult to connect different parts to board due to tolerance and 3d printing issues.

Insights From Testing

1. Not proper connections:
Issue: Weak connections between elements.
Solution: Use magnets to strengthen and secure components.

2. Overuse of strategy cards:
Issue: Overpowered strategy cards disrupt gameplay.
Solution: Adjust power levels to balance the game.

3. Rewriting the strategy:
Issue: Some strategy cards need updates.
Solution: Rewrite cards considering different probabilities.

4. Conditional pass or not to pass:
Issue: Lack of player choice in passing cards.
Solution: Allow players to decide whether to pass component cards.

5. Hassle of testing kit:
Issue: Complicated testing process.
Solution: Reconfigure the kit for external voltage and current testing.

What can be improved?

Magnetic Board and Elements
Issue: Current peg board system requires precise alignment.
Solution: Use a magnetic board for easier and quicker attachment of components.

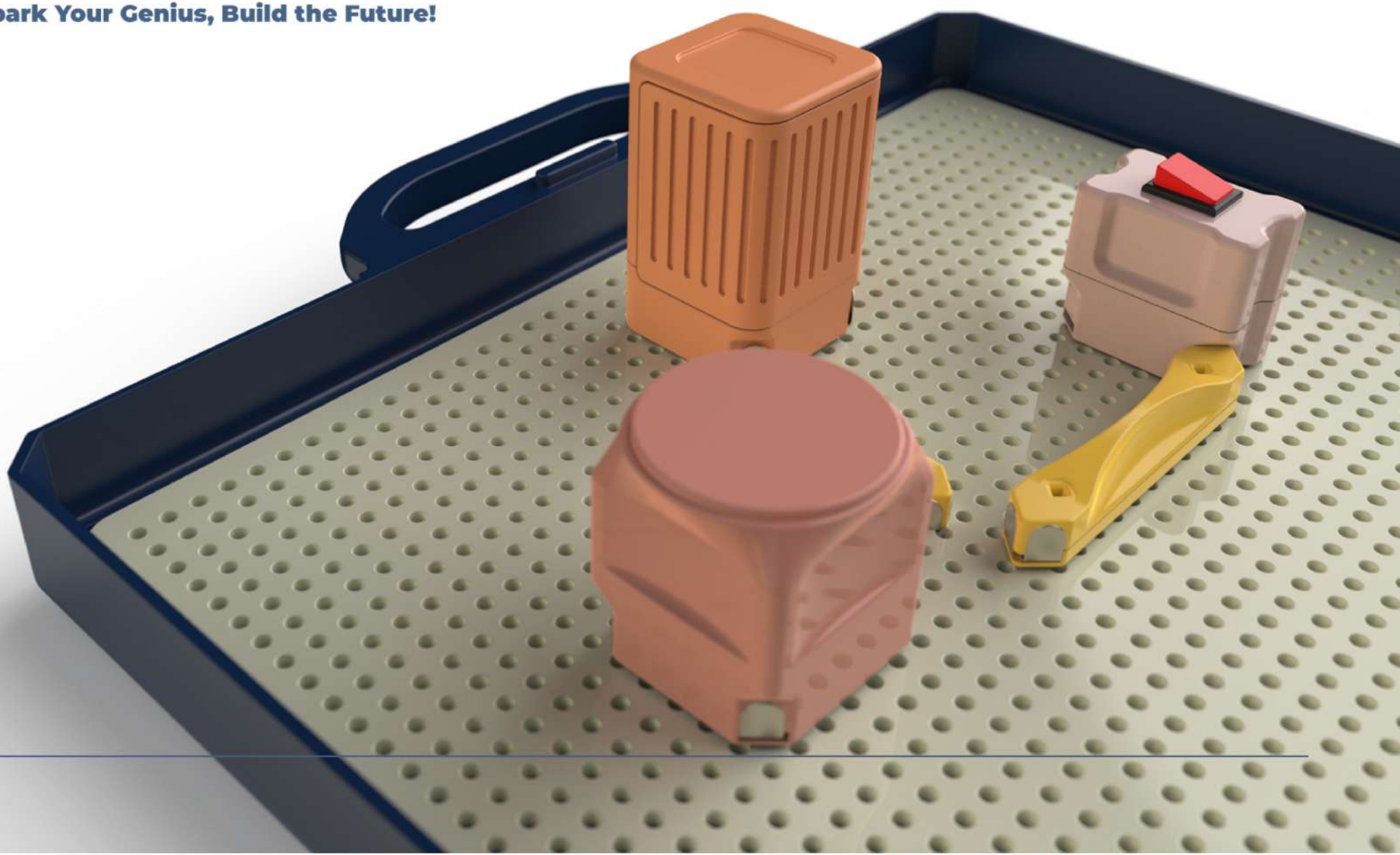
Fast-Paced Game
Issue: Some elements slow down gameplay.
Solution: Improve grouping or system of dice-drawn component cards.

Case Form
Issue: Current case design is primitive.
Solution: Enhance aesthetics to make it more appealing to kids.

More Complex Components
Opportunity: Introduce complex principles like gates, transistors, and capacitors as kids grow.
Benefit: Enhances learning and adds fun to the game.

TINKER TRONIX

Spark Your Genius, Build the Future!



THANK YOU