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Bamboo in toy design

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Abstract

The current time of environmental crisis demands the use of environmentally favorable materials for product development and production techniques. Bamboo is a strong contender amongst various eco-friendly materials to satisfy the prevalent eco-consciousness. Modern bamboo products for household utilitarian aspects, interior design, ornaments and storage purposes have evolved in the last decade to fill various market platforms. Amongst them, Bamboo Toys have taken form as toy cars, rocking horses, kitchen play-kits, bamboo blocks etc. These toys explore bamboo material by recreating products of other materials but, they are incapable of teaching the player about the nascent characteristics of bamboo such as build, color, texture, balance, floating capacity, water resistance, flexibility, tensile strength etc. Subconscious interactions with a material at a young age develops knowledge for future references. Innovative toys could impart knowledge through interactive play on the usability of the material bamboo for real life situations. Also, the toys could facilitate a decentralized system in the product making process in a small or medium industrial setup. This could improve the scalability of the project execution while involving local community participation. With the help of simple tools at micro level, quality products could be delivered through better packaging and improved selling prices to generate a better income for artisans. The domain could also invite explorations from the design and engineering community to collaborate with the industrial setup to deliver solutions for multiple play patterns, easy replaceability of elements, effective manufacturing techniques and waste management. As climate responsive design, this paper analyses the different possibilities of bamboo toy designs for young minds along with their feedbacks. It also examines the decentralized supply chains with monetary divisions at various production stages for execution in the Indian context, while simultaneously promoting the material for the future generation.

Keywords Bamboo; Toy Design; Eco-friendly Production; Market and Promotion

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1. Introduction

Toys play a pivotal role in a child's early years, influencing their physical, mental, and emotional development significantly. Interaction with a variety of toys not only nurtures essential skills such as problem-solving and motor coordination but also instills an appreciation for shapes and colors, fostering cognitive growth and nurturing creativity. Traditional toys hold a dual significance, serving as both developmental tools and cultural artifacts. They depict ancient myths and mirror the customs and beliefs of diverse communities. These timeless treasures attract consumers seeking to preserve their heritage. Also, the livelihoods of skilled craftsmen and artisans hinge upon the production of these toys.

1.1. Toy Business in India

In 2020, the Indian toy retail market was valued at approximately Rs. 16,000 crore (equivalent to US\$ 2.2 billion), constituting less than 1% of the global toy market. Presently, a substantial 85% of the country's toy demand is satisfied through imports, with the majority (80%) of these imports originating from China. The remaining imports come from various countries, including Sri Lanka, Malaysia, Germany, Hong Kong, and the United States. In stark contrast to the significant import volumes, India's toy exports amount to a mere Rs. 730 crore (approximately US\$ 100 million). This substantial trade deficit raises concerns, especially when considering India's potential to achieve self-reliance in an industry projected to grow at a rate of 10-15%, surpassing the global average of 5%. 90% of the Indian toy industry is unorganized with more than 4,000 micro, small and medium enterprises operating across the country (IBEF 2023).

1.2. Bamboo in Toy Business

Bamboo has been constituted as a new mainstream material for the upcoming Indian market (Surfaces Reporter, 2021). It has a lot of potential to be one of the new ventures of eco-friendly materials to be used in the near future. Bamboo's positive features like mechanical strength, easy processability and availability in many tropical and subtropical areas confer it attributes to become a renewable material for product design (Boran and Cavdar 2013). North-East Region (NER) of India dedicates itself to commercial bamboo production which constitutes 66% of the country's growing stock (National Bamboo Mission, India, 2017). This quick-growing, versatile, non-timber forest product weaves itself effortlessly into local livelihood generation through the mode of craftsmanship. The craft sector provides livelihood and employment to 20 million people of India (Vishwanath 2013) which constitutes 1.5% of the

country's population. With adaptation to the urban market, bamboo has immense potential for income generation and to be the breadwinning craft of the people of NER.



Figure 1. Existing Bamboo Toys in the Market.

Modern products with bamboo have evolved manifold in the last few years. Products such as lamps, cutting boards, ornaments, storage containers, speakers, cutleries, mirrors etc. have filled retail stores and online sale platforms. Out of the many categories of products, bamboo toys have also positioned themselves in various forms in the market.

Existing bamboo toys can be categorized into animal figures, balance toys, vehicle toys, building blocks, rattle toys, rocking horses and geometric shapes. The general observation was that the existing bamboo toys were simple recreations of toys made in other materials. Even though the toys were made of bamboo, they did not teach the players anything about the natural features of bamboo such as build, color, texture, balance, floating capacity, water resistance, flexibility, tensile strength etc.

1.3. Reasons to use Bamboo in Toy Design

Bamboo toys are gaining recognition in various parts of the world. Toys hold a pivotal role in the growth and development of children, making the choice of material significant.

1. Bamboo has gained an identity of an eco-friendly material for product development in the past few decades. It is a lesser known material in the latest trends of toy design, so making it visible to promote the material in mainstream market could improve sale-ability of bamboo products.
2. Current toys are made from synthetic materials and chemicals which have a harmful effect on children's health over elevated hours of interaction. Incorporating bamboo in toys would significantly reduce health hazards in children as they would be exposed to a natural material.
3. Toys made out of synthetic materials do not attempt to teach children about the characteristics of the material during play. The material is generally used due to the flexibility of developing forms during mass production. Also, manufacturing processes go through multiple trials to retain the strength of the material in the toy for prolonged use. Whereas regarding bamboo, toys could be designed to teach the players about the nascent characteristics of the material such as naturally built color and texture, floating capacity, water resistance, flexibility, and tensile strength. The cost effectiveness of the product also increases due to the inbuilt strength of the bamboo material, which naturally validates the product for strength and prolonged use, unlike synthetic materials.
4. As bamboo is a versatile material, it offers unique qualities that transform products and promote sustainability. Bamboo provides an environment for children to explore and comprehend the unique properties and attributes of the material.
5. Bamboo's compatibility with simple shapes like sticks, blocks, and rings foster skills related to placement and balance in children. Also, its natural texture and appearance engage children's sensory awareness, enriching their tactile experiences.
6. The utilization of bamboo as a material raises awareness of sustainability and eco-friendliness among children.
7. Bamboo stands out as a renewable resource due to its rapid growth, with diverse regional variations across Asia and other regions. These regional factors and environments also contribute towards making bamboo a remarkable material with distinct properties. The distinction of such properties could be easily directed towards play at an early age, which would build confidence in children for utilization of bamboo material in future prospects in their regions.
8. Further, bamboo can be expanded in higher education for making school projects through learning about biodiversity, botanical studies, and engineering aspects in terms of learning about its strength and durability.

There are multiple toys in the market made of various materials that have a range of benefits such as some helping to build their creativity or imagination or communication skills or problem-solving skills. Many toys develop gross motor skills in pre-schoolers to help them in their physical and emotional development. A few of the toys that promote development in pre-schoolers are Wheelbarrow toys, ride-on toys like kid's scooters, building blocks, etc. One more such game is Jenga which is a physical game that increases hand and eye coordination, it helps with problem-solving skills and critical thinking, and most importantly it develops patience as they have to wait without feeling anxious as they have to carefully test and remove the blocks and they have to think about their next move simultaneously.

In the present day, bamboo is being used to alter the material of the playing kit for example in Jenga, the blocks can be made of bamboo, which teaches the player nothing about the nascent characteristics of bamboo. As per the research, this is the extent to which bamboo has been predominantly used in our present-day market. Thus, the attempt of the research is to take a step forward by making toys of bamboo which will teach the player about the various characteristics of bamboo.

1.4. Child Development and its Stages

A child can be regarded as a human being in the early stages of their development, often referred to as childhood, which encompasses the period from birth until approximately the age of 12. This phase is marked by significant physical growth, characterized by a continuous increase in the child's height and weight. Moreover, it is a critical time for psychological development, during which behavioral changes occur, and the foundations of one's personality take shape. In the context of all species inhabiting the Earth, humans exhibit the slowest rates of growth and development. Human beings are notably characterized by a relatively gradual maturation process. For instance, while it takes a considerable amount of time for a child to learn to walk and run with stability, other species, like rats, reach full sexual maturity in as little as 15 days. This stark contrast underscores the unique pace of development in the human species (Berk 2012).

Jean Piaget's perspective states that children undergo developmental stages, with the emphasis placed on the sequential order of the stages rather than the specific age at which they occur. According to Piaget and Inhelder (1995), progressing to a new stage necessitates successfully traversing and surmounting the preceding ones. Piaget's Cognitive Theory articulates four distinctive developmental stages as follows:

1. *Sensorimotor Stage (0 months - 2 years)*: This initial stage, known as the sensorimotor stage, encompasses the first two years of life. During this period, children primarily interact with their environment through sensory experiences and motor actions.
2. *Preoperative Stage (2 - 7 years)*: The preoperative stage spans from ages 2 to 7 and is characterized by egocentric thinking. Children in this stage tend to view the world from their own perspective and struggle with understanding the viewpoints of others.
3. *Concrete Operations Stage (7 - 11 years)*: From ages 7 to 11, children enter the concrete operations stage. Here, mental organization becomes more integrated, enabling them to engage in logical thinking and problem-solving with concrete, tangible concepts.
4. *Formal Operations Stage (12 years and over)*: The final stage, formal operations, occurs at age 12 and beyond. It involves the development of abstract thinking abilities, allowing individuals to manipulate and reason about abstract concepts and hypothetical situations.

Piaget's model underscores that the progression through these stages is the key to cognitive development, irrespective of the specific age at which each stage unfolds.

1.5. Child Development and Toys

Children inherently possess active minds which are eager to learn and create within the context of their daily experiences. They exhibit a profound curiosity while engaging with their surroundings through play, observation, and interaction. They channel their energy and enthusiasm into their endeavours, employing all their senses in the process, often surprising their parents and caregivers with their responses. Every situation becomes a new opportunity for cognitive development. Toys, with their diverse shapes and colours, act as catalysts for a child's brain, promoting essential growth. Playthings like puzzles, building blocks, and educational games further enhance a child's thinking abilities, fostering a rich and dynamic learning environment.

Toys serve as a pivotal conduit through which children derive both enjoyment and acquire a diverse range of knowledge, fostering their mental and physical well-being, as well as enhancing their coordination skills. Children incorporate toys seamlessly into their daily lives, creating a dynamic environment that immerses them in imaginative narratives of their own weaving, while stimulating the creative faculties of the mind. Through play, they assimilate invaluable life skills, and also develop social and emotional connections, such as sharing, cooperation, and the mutual benefits of play. As a child matures, their cognitive comprehension of the world concurrently expands, supporting their self-assurance.

According to Castella 2019, children aged 3 to 6 exhibit the most distinct physical, cognitive, and social/emotional modes of learning:

1. Physical Development

- Improved gross motor skills with enhanced coordination.
- Enjoy activities like climbing, hopping, running, skipping, and performing stunts.
- Engage in tasks like throwing and catching balls, riding tricycles and bicycles, swimming, skating, hopscotch, and jump rope.
- Fine motor skills become more refined, allowing them to handle tasks such as proper pencil grip, working with clay, handwriting, manipulating smaller objects, dressing and undressing, using a keyboard and mouse, switching devices on and off, developing hand preferences, cutting with scissors, drawing recognizable pictures, and using utensils like forks and knives.

2. Cognitive Development

- Enjoy creative activities and exploration, with ongoing development of problem-solving skills using trial and error.
- Base their ideas on immediate sensory input.
- Tend to focus on a single solution to a problem but may experiment with multiple solutions.
- Engage in activities like coloring, writing, and learning, often unconcerned with rigid rules.

3. Social/Emotional Development

- Exhibit egocentric and concrete thinking.
- Gradually gain some understanding of another person's perspective.
- Participate in cooperative play, share, and take turns in interactive games.

Toy-Based Pedagogy can be an effective approach for students of all ages. Using toys provides learners with opportunities like exploring, imagining, observing, creating, expressing and, most importantly, engaging and playing. If mapped appropriately and strategically with concepts and subjects, the process from making toys to playing with them can also promote experiential learning (Kapoor 2022). Understanding these developmental stages and their associated characteristics is essential for designing toys and products that cater to the unique needs and interests of children in this age group.

1.6. Importance of Material in Toys

Materials play a pivotal role in the design and manufacturing of products, especially those intended for use by children. Children, in particular, interact with products in a myriad of unpredictable ways during playtime. They may bounce, throw, chew, and even sleep with their toys, making material selection a critical consideration. The safety, durability, functionality, and overall quality of toys hinge on the choice of materials. Material choices also greatly influence the visual aesthetics and appeal of toys. Colors, patterns, and textures contribute to making toys attractive and captivating for children. Notably, there is a growing emphasis on the use of environmentally friendly materials in toy production. By meticulously crafting toys with due caution and incorporating effective design principles, the play experience can be enhanced, fostering greater enjoyment and engagement.

The material, texture, and weight of toys have a significant impact on a child's sensory experience during play. Each toy offers distinct tactile sensations and sensory feedback, adding to the overall enjoyment of the playtime. Variations in texture, weight, and even temperature of materials can profoundly influence a child's sensory engagement with a toy, contributing to a more enriching and immersive play experience.

2. Aim and Objectives

The aim of this research project on bamboo toys is to impart knowledge on the material bamboo to children of Preoperative Stage aged 3-6 years through interactive and immersive play.

The objectives are as follows:

- To incorporate the material bamboo for toy design
- To implement user study of the toys and receive feedback on the material and design
- To propose suggestions for improvements on bamboo toys for effectiveness

3. Methodology

Fernandes and Coelho, 2013 have put forward a 10 step Methodology for the Design of Toys that promote awareness of Environmental Sustainability. The steps include the following:

1. Review the stages of physical, cognitive, sensorimotor, social and emotional development of children to meet real needs rather than needs related to passing fashion or constructed by markets.

2. Given the context of the design project being developed, carry out exploration activities that may contribute to the development of the child in one or more of the spheres covered above.
3. Generate concepts for one or more activities that can underpin the creation of toys or recreational objects, directing creativity to issues that foster awareness of environmental sustainability in an educational manner.
4. Evaluate the toy or playful object concepts triggered in the previous stage against a set of requirements generally applicable to toys or playful objects such as low toxicity and safety against injury.
5. Set a specification of the concept selected in order to guide the design process of the toy or playful object. At this stage, market objectives should be considered including cost, packaging, distribution and consideration may also be given to objectives of a particular nature, including sustainability.
6. Review the existing product market, including environmental and social features.
7. Developing a picture of the profile outlined by the environmental impact of the new product.
8. Proceed to the development of the detailed concept and produce prototypes enabling testing under controlled conditions of safety, initially with adults and ensuring no hazard is presented by the prototypes when seeking to involve children in their use.
9. In this process the results of usability testing can motivate changes to the product description and a new iteration of design refinement and testing.
10. Development of production processes and of release, distribution and marketing documentation.

The steps 1, 2, 3, 4, 6, 8 and 9 have been followed in this research. The details of the steps have been delivered through target age group research, bamboo toy design ideations, manufacturing processes and field observations. Ethnographic field observations were carried out as per Woods 1986, with the collection of field notes that include observations and reflections of what was observed. Given the academic nature of the research project, steps 5, 7 and 10 of the methodology could not be followed.

4. Bamboo Toy Designs

The bamboo toy designs were developed for the age group of 3-6 years since they exhibit the most distinct physical, cognitive, and social/emotional modes of learning. The intent of designing the toys was to teach the players about the nascent characteristics of bamboo such as

build, color, texture, balance, floating capacity, water resistance, flexibility, tensile strength etc. Four different kinds of bamboo toys were developed and prototyped for user testing. The details of the designs and the ways to play have been discussed further.

4.1. Toy #1: Bamboo Balancing Toy (BB Toy)

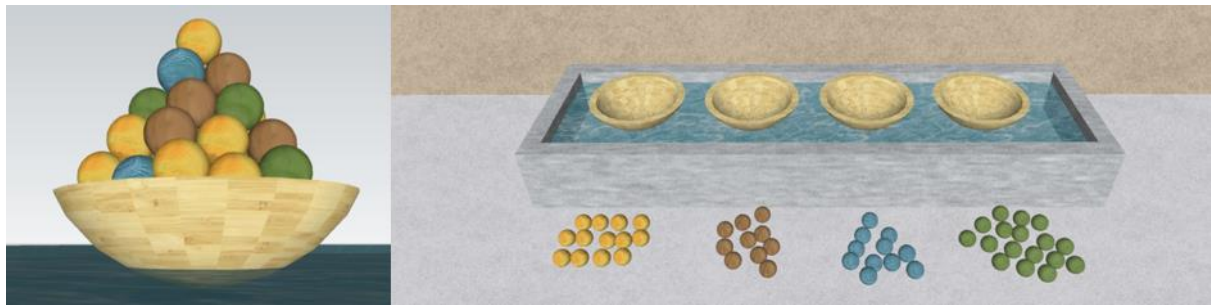


Figure 2. Bamboo Balancing Toy (BB Toy) and items required to play

Items Required to Play -

- A large vessel to hold water
- Bamboo bowl - 2 no's minimum
- Bamboo balls - 20 mm in dia. - naturally dyed with different colours

No. of Players - Minimum two number of players required in order to decide the winner.

Age Group - 3-5 Years

Characteristics of Bamboo Emphasised in the Game -

- Floating capacity of bamboo
- Tight weight character of bamboo
- Texture of the material

How to Play -

- Take a large vessel of water.
- Place the bamboo bowls in the water such that it floats.
- In order to win, the players have to arrange similar coloured balls in the respective bowls such a way that the bowl doesn't topple or drown.
- The player who can put maximum number of balls in the bowl without getting the bowl topple or drown wins the game.

Tools Used -

- **BAMBOO BOWL MAKING:** Consists of extracting the node of a bamboo with a larger diameter and shaping it into a bowl. Machines used are Bamboo knot removing machine (external), Cutting machine, Lathe machine and Sanding machine.
- **BAMBOO BALL MAKING:** Consists of both lathe and drill press to make bamboo balls of even sizes.
- **NATURAL DYEING OF BAMBOO:** Yellow - Turmeric, Blue - Indigo, Brown - Tea Powder, Green - Mango Leaves, Maroon – Pomegranate

Prototypes and User Testing –



Figure 3. Prototype of BB Toy and user testing with 3-5 year children in Bhopal, India.

4.2. Toy #2: Ring-A-Ring

Items Required to Play -

- Bamboo stand – As shown in the image, it's a 600 mm tall bamboo stand with various colour coded side branches representing strength, Weakness, Opportunities and threats
- 75 mm dia. Bamboo rings

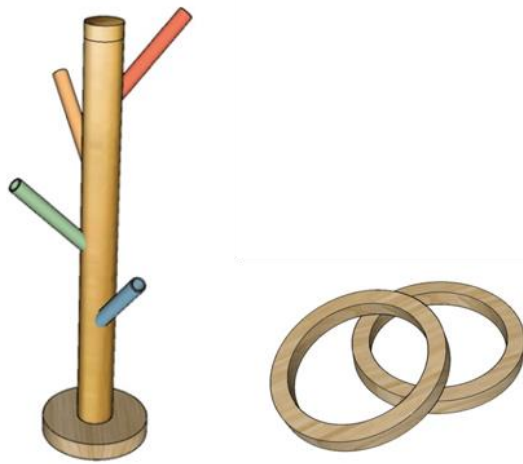


Figure 4. Ring-A-Ring and items required to play

No. of Players - One player can play at a time.

Age Group - 3-5 Years

Characteristics of Bamboo Emphasised in the Game -

- Hollow section of bamboo culms
- Stiffness of bamboo ring
- Texture of the material
- Light weight of bamboo

How to Play -

- Place the stand on a stable surface.
- Throw the coloured rings into the members of the stand such that the rings enter the stand.
- After the player has successfully put a ring in the stand, the player has to say something about the bamboo characteristic depending on the colour of the branch.

Tools Used -

- **BAMBOO STAND MAKING:** Consists of extracting the bamboo pole with two nodes at either end of a bamboo with a diameter of 50 mm using External knot removing, bamboo cutting machine and then drilling 4 holes of 10 mm size in various heights of culm using drilling machine and then fixing bamboo sticks in those holes.
- **BAMBOO RING MAKING:** Cutting a bamboo culm of 100 mm dia. into rings of 10 mm width using bamboo cutting machine.
- **NATURAL DYEING OF BAMBOO:** Yellow - Turmeric, Blue - Indigo, Brown - Tea Powder, Green - Mango Leaves, Maroon – Pomegranate



Figure 5. Prototype of Ring-A-Ring and user testing with 3-5 year children in Bhopal, India

4.3. Toy #3: StrawBall

Items Required to Play -

- 20 mm Dia. Bamboo culm without nodes – 250 mm in length
- 20 mm Dia. ball
- Bamboo Board sized 600 x 900 mm – with two holes on opposite sides – As shown in the image. The board can be folded from centre to act as a box to keep the other playing kits.



Figure 6. Straw Ball and items required to play

No. of Players - Two players can play at a time.

Age Group - 3-5 Years

Characteristics of Bamboo Emphasised in the Game -

- Hollow section of bamboo culms
- Cylindrical shape of bamboo culms
- Texture of the material
- Light weight of bamboo

How to Play -

- Place the bamboo board on a stable surface with the balls placed on the board.
- Assign one bamboo straw to each player.
- Both the players have to blow air through the bamboo straw in order to move or roll the ball towards the opposite goal.
- The player who scores more goal within a fixed time frame wins the game.

Tools Used -

- **BAMBOO STAND MAKING:** Consists of extracting the bamboo pole with two nodes at either end of a bamboo with a diameter of 20 mm using External knot removing, Bamboo cutting machine and polishing the circular edges using Sanding machine and File.
- **BAMBOO BALL MAKING:** Consists of both lathe and drill press to make bamboo balls of even sizes.
- **BAMBOO BOARD MAKING:** Engineered bamboo wood can be used to make the playing board or we can just provide a set of goal posts of size (100x75) mm made of bamboo and they can play in any plain floor or table top.
- **NATURAL DYEING OF BAMBOO:** Yellow - Turmeric, Blue - Indigo, Brown - Tea Powder, Green - Mango Leaves, Maroon – Pomegranate

Prototypes and User Testing –



Figure 7. Prototype of StrawBall and user testing with 3-5 year children in Bhopal, India.

4.4. Toy #4: BamRoll

Items Required to Play -

- 50 mm Dia. Bamboo culm with nodes on both the ends– 300 mm in length
- 25 mm Dia. Bamboo ball
- Thread – one end will be connected to the bamboo culm and the other to the bamboo ball.

No. of Players - Two players can play at a time.

Age Group - 3-5 Years

Characteristics of Bamboo Emphasised in the Game -

- Cylindrical shape of bamboo culms
- Stiffness of bamboo between two nodes
- Texture of the material
- Light weight of bamboo

How to Play -

- Both the players must stand behind a single line with the bamboo roller in hand.
- The Ball at the end should be placed far away, stretching the thread, equidistant from the players.
- The player who can roll the thread fast around the bamboo roller and simultaneously bring the ball closer to the roller wins the game.



Figure 8. BamRoll and items required to play

Tools Used -

- **BAMBOO ROLLER MAKING:** Consists of extracting the Bamboo pole with two nodes at either end of a bamboo with a diameter of 50 mm using External knot removing, bamboo cutting machine and sanding the middle portion of the culm in order to hold the thread in place using Lathe machine, Sanding machine and File.
- **BAMBOO BALL MAKING:** Consists of both lathe and drill press to make bamboo

balls of even sizes.

- NATURAL DYEING OF BAMBOO: Yellow - Turmeric, Blue - Indigo, Brown - Tea Powder, Green - Mango Leaves, Maroon – Pomegranate

Prototypes and User Testing –



Figure 9. Prototype of BamRoll and user testing with 3-5 year children in Bhopal, India.

5. Manufacturing Process of Toys

Simple workshop tools and machines were used to make the prototypes of the bamboo toys. The tools used for making the prototypes with pictorial descriptions are mentioned below.

5.1. BAMBOO BOWL MAKING: Consists of Cutting and Sanding tools used for developing bowls with removed exterior skin.



Figure 10. Bamboo Bowl Making Process

5.2. BAMBOO BALL MAKING: Consists of both Lathe and Drill press machines to make bamboo balls of even sizes.

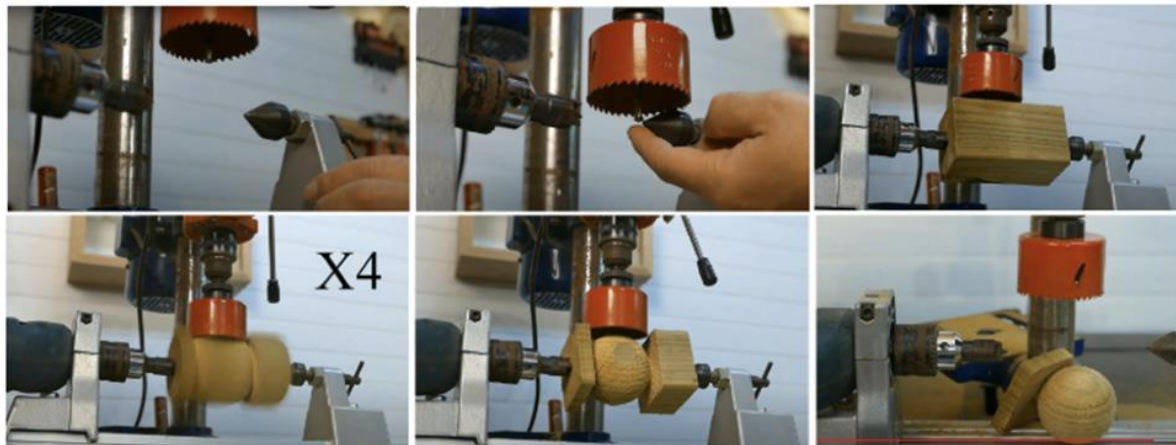


Figure 11. Bamboo Ball Making Process

5.3. BAMBOO STAND, RING, STRAW AND ROLLER MAKING: Consists of External node removing machine, Bamboo cutting machine, Drilling machine and Sanding Machine to make the elements.



Figure 12. Bamboo Stand, Ring, Straw and Roller Making Process

5.4. NATURAL DYEING OF BAMBOO: Yellow - Turmeric, Blue - Indigo, Brown - Tea Powder, Green - Indigo + Turmeric



Figure 13. Natural Dyeing of Bamboo process.

6. User Study and Observations

The user study was conducted at Holy Family Convent Sr. Sec. School at Bhopal, Madhya Pradesh. There were 30 students aged 3-5 years. The field observations were carried out as per Woods 1986, with the collection of field notes that include observations and reflections of what was observed. The observations were made on the overall play performance of the group as well as based on age. The observations were divided into 2 age groups - 3 Yrs and 5 Yrs, to better understand the cognitive ability of the students.

Table 1. Field Observations with 3-5Yr children with BB Toy.

BAMBOO TOY - BB Toy		
Description of activities	Insights for 3Yr old	Insights for 5Yr old
Introduction to the toy	The students were fascinated by the water, bamboo and marbles, as they had never seen this combination of materials before. Everybody was involved in the game.	
Understanding how to play	Initial instruction was required. The play was intuitive and they learnt easily from previous games.	
Play participation	They dropped the marbles into the bowl.	They threw and aimed the marbles from a distance at the bowls. Better comprehension of rules.
Play response	The secondary crowd was very involved with the gameplay. Everybody was cheering the participants.	More differentiable colours required with high contrast to remove confusion in play.
Interaction with the material	After the first round of play, everybody chose their own coloured bowls. While play, some of them forgot which bowl was theirs. For the conduction of play, different coloured marbles would be helpful for sorting and assigning.	
Response to the material	The texture and feel of marbles, bamboo and water spiked their interest.	

Table 2. Field Observations with 3-5Yr children with Ring-A-Ring.

BAMBOO TOY - Ring-A-Ring		
Description of activities	Insights for 3Yr old	Insights for 5Yr old
Introduction to the toy	More distinguishable colours needed. They made their own rules to win the game.	Placement of the student and the person determines the advantage in the game. Requires redesign of placement of branches.
Understanding how to play	High difficulty. The form of the designed elements was visually explanatory.	Gameplay wise, more instructions were needed to determine winner. A demonstration was necessary in the beginning.
Play participation	Some children were active, some needed further instruction.	There was more understanding of the game in this age group. They were smarter and needed better rules in the gameplay.
Play response	They tried to put all the rings at once which was against the instruction	Eager to win the game, mentally competitive.
Interaction with the material	The interaction was very intuitive. More colours were needed to make it more distinguishable. Smoother rings were needed to avoid hazard. The action of throwing the ring into the stand needed proper teaching.	
Response to the material	The response was very intuitive with the material. The texture and weight were comfortable for play.	

Table 3. Field Observations with 3-5Yr children with StrawBall.

BAMBOO TOY - StrawBall		
Description of activities	Insights for 3Yr old	Insights for 5Yr old
Introduction to the toy	Students were intrigued by the straw and intuitively picked it up to blow through it. Holding the straw gave them authority to play.	
Understanding how to play	Confused about which is their goalpost. They did not follow much rules.	Understood better about which is their goalpost. They understood rules better.
Play participation	Excited play. Two or four heads together were blowing hard through the straws to move the ball. Placed hand on board. Moved the balls with the straw while blowing.	Intuitive play performance. Played better than 3Yr olds. The straws would require a bigger dia. for blow effect and sanitation.
Play response	Need feedback about goals. They picked up ball from the goal to play again. Satisfaction of blowing noticed.	They picked up the balls which they put in the goals. That determined who won.
Interaction with the material	Sanitation of the straw needs to be taken care of. Blow dynamics need to be checked. Surface of the board was velvety which allowed smooth movement of the bamboo ball.	
Response to the material	Easy on the hand sizes and weight of the straw. Colours added interest to the game.	

Table 4. Field Observations with 3-5Yr children with BamRoll.

BAMBOO TOY - BamRoll		
Description of activities	Insights for 3Yr old	Insights for 5Yr old
Introduction to the toy	The yellow colour of the roller grabbed attention. The weight of the toy and the strings made them curious.	
Understanding how to play	The play was easy to comprehend. Once the demonstration of how to play was introduced, they picked up the game very quickly. They were keen to play as they had never played something like it.	
Play participation	Irrespective of age, few understood the technique of pulling in the ball through the thread faster.	
Play response	Since they were playing in a pair, few were constantly competing and few were consumed in rolling.	
Interaction with the material	The interaction was easy and excited. The material facilitated rolling in the palm of their hands. It was not heavy because of the size.	
Response to the material	The material was earthy and the children were acquainted with it very quickly.	

7. Inferences and Discussion

The main intention of the bamboo toys was to deliver information of the material through play. Similar toys could be developed based on the same principle. Few observations were made regarding the developed toys which could initiate the incorporation of design and material interventions towards the products:

- Distinguishable and prompt colours are much required to enhance the attention and playability of the toys. Improved dyeing and colouring techniques could be incorporated for the designs.
- Sanitation is an important concern for the game StrawBall, since it involves the technique

of air blowing into play.

- For the BamRoll toy, the play was universal for 3Yr and 5Yr old students. The age did not matter in this game.
- BB Toys could be played in two different ways depending on age group. One could be about drowning of the bowl in water for younger children and the other could be about aim and play in the dynamics of water for older children.
- Ring-A-Ring and StrawBall could also be introduced to an older group of users due to its intuitive play and manoeuvrable difficulty levels.
- Delivery of instructions should be taken care of by developing and using play manuals.
- The manufacturing process of the toys was executed using simple tools which could be easily replicated for mass manufacturing in the craftsmanship sector.
- Packaging to intrigue parents and teachers of the children must be incorporated since even though the toys are for children, they are bought by the elders.

Innovative toys could impart knowledge through interactive and immersive play on the usability of the material bamboo for real life situations. Also, the toys could facilitate a decentralized system in the product making process in a small or medium industrial setup. This could improve the scalability of the project execution while involving local community participation. With the help of simple tools at micro level, quality products could be delivered through better packaging and improved selling prices to generate a better income for artisans. The domain could also invite explorations from the design and engineering community to collaborate with the industrial setup to deliver solutions for multiple play patterns, easy replaceability of elements, effective manufacturing techniques and waste management.

8. Way Forward

The way forward for the designed bamboo toys would be addressing the colour, hygiene and finish of the toys while developing intriguing packaging and incorporating business strategies to attract the attention of the market and consumers towards sustainability and eco-friendliness. Since a lot of emphasis is already laid towards learning while doing, bamboo toys can be well placed in the school education domain as well as games for adults. Subconscious interactions with a material at a young age could develop knowledge for future references. Innovative toys could impart knowledge through interactive play on the usability of the material bamboo for real life situations.

Conclusion

Utilizing bamboo as an environmentally conscious material can serve as a catalyst for raising awareness about sustainability from an early age. By introducing this knowledge through bamboo-based toys, the prospects for its widespread utilization can be enhanced to foster a deeper understanding of its unique characteristics, paving the way for a climate-responsible future. In this context, various government initiatives, coupled with an increasing awareness of traditional toys and a nationwide emphasis on supporting local handicrafts, are propelling India's traditional toy industry towards unparalleled growth. This industry is experiencing rapid transformation driven by a multitude of technological innovations and is poised to become a significant contributor to the nation's economy in the years ahead. The burgeoning traditional toy sector represents a significant stride toward realizing the vision of a self-reliant India.

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Author Declaration and Conflict of Interest

It is hereby confirmed that the manuscript has been read and approved by all the named authors and there is no conflict of interest. All regulations of our institution/institute/company including intellectual property rights have been followed and there are no impediments to publication.

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