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UNDERSTANDING TODDLER PLAY BEHAVIOUR AND DEVELOPMENTAL GAINS IN MONTESSORI TOY INTERACTION

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ABSTRACT

The project examines the developmental needs of toddlers aged 1 to 4 years, with a focus on fine motor skill development through Montessori-inspired toys. The aim is to design a multifunctional product that supports children's growth while aligning with the values of parents and caregivers who seek safe, educational, and screen-free play experiences. To deepen understanding of the topic, several literature reviews were conducted covering child development, Montessori principles, and toy design. Data were collected through surveys, video analysis, and observational studies, specifically looking at behaviour and toy interaction among toddlers in Malaysia. These findings revealed user preferences and developmental gaps, which were addressed through the design of a compact and sustainable toy using PLA material. Ultimately, the project presents a multifunctional toy design that promotes creativity, motor skills, and ethical design practices, thereby supporting the development of early childhood.

Keywords: Toddler, Montessori Toy, Fine Motor Skills, Malaysia
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INTRODUCTION

The development of fine motor skills during early childhood represents a critical foundation for cognitive growth, learning abilities, and overall well-being. Within this domain, the concept of Learning Through Play (LTP) emerges as a pivotal approach, offering children opportunities to strengthen motor coordination through interactive and hands-on activities. Central to this practice are Montessori toys, which serve not only as educational tools but also as structured platforms for independent exploration and skill refinement. Despite their proven potential, the integration of Montessori toys in Malaysia faces challenges. Limited parental awareness of the significance of fine motor development, combined with the dominance of pretend play toys in the market, restricts children's access to resources that balance entertainment with developmental benefits. Moreover, Montessori and STEM-based toys often come at higher costs, thereby reducing their accessibility to families across varied socioeconomic backgrounds. This study seeks to investigate the role of Montessori-based educational toys in enhancing toddlers' fine motor skills. It explores behavioural patterns during play, identifies design features that facilitate effective engagement, and highlights the broader implications of toy market imbalances.

By situating the research within both developmental and socio-economic contexts, this work contributes to the discourse on purposeful play as a mechanism for early childhood development. In doing so, it aligns with global educational objectives while promoting inclusive, health-focused, and sustainable learning practices.

SHAPESCAPE

Figure 1: SHAPESCAPE Product 3D view

The final prototype of ShapeScape is presented early to provide a clear understanding of the design outcome. The toy integrates shape sorting and modular stacking features to support toddlers' fine motor skill development through interactive play.

LITERATURE STUDY

The Montessori philosophy, developed in the early twentieth century, emphasises child-centred and self-directed learning supported by structured materials and guided facilitation (Rosati, 2021; Meinke, 2019). Its holistic approach integrates moral, emotional, and cognitive development, with evidence linking Montessori practices such as tactile learning and peer collaboration to positive developmental outcomes (Culclasure et al., 2019; Darling-Hammond et al., 2019).

Unlike teacher-centred models, Montessori education encourages autonomy, creativity, and intrinsic motivation. Learning materials such as sensorial blocks and practical life tools provide structured opportunities for independence, fine motor control, and cognitive growth (Marshall, 2017; Mead, n.d.).

During the toddler years, between the ages of one and three, children experience rapid progress in language, autonomy, and motor skills. This development is strongly supported by unstructured play and parental involvement, which foster creativity, resilience, and emotional growth (Colson & Dworkin, 1997; Nidirect, 2018). Play is widely recognised as fundamental to early childhood as it supports cognitive, social, and emotional growth, while also nurturing problem-solving, collaboration, and creativity (Sutton-Smith, 1997; Yogman et al., 2018).

Fine motor skills, defined as the precise coordination of hand and finger movements, are essential for daily functioning and academic readiness. These abilities develop significantly during toddlerhood through activities such as stacking, drawing, and manipulating small objects (NHS Border, n.d.; Cleveland Clinic, 2023). Studies indicate that toy-based interactions at home and in educational settings enhance fine motor coordination, with parents and teachers playing a central role in sustaining developmental progress (Nik Roseli et al., 2023; Tucker, 2019). At the same time, delays in fine motor development may result from medical or neurological conditions, requiring interventions such as occupational therapy alongside play-based activities to strengthen children's abilities (Mandaya, 2025).

Overall, the literature highlights the importance of Montessori education, play, and toy design in fostering toddlers' fine motor development, while also emphasising accessibility and parental awareness as key factors in ensuring consistent developmental progress.

METHODOLOGY

This study employed a mixed-method approach combining quantitative and qualitative data collection. A questionnaire survey was distributed to parents to gather demographic information, assess awareness of fine motor development, and identify preferences and expectations regarding educational toys. The survey responses provided valuable insights into parental perspectives on toy selection and developmental priorities.

Complementing the survey, observational research was conducted in shopping malls in Gombak and Subang Jaya to compare the availability of Montessori-based toys with pretend play toys. This was undertaken to evaluate the imbalance in the local toy market. Additionally, video analysis of toddlers' play behaviour was carried out to examine their engagement with Montessori toys, focusing on hand-eye coordination, grip strength, and finger dexterity through a structured observation checklist.

The research instruments, including the survey and observation checklist, were developed based on relevant literature and established frameworks. These tools ensured that the data collected aligned with the study's objectives, particularly in identifying key design features of Montessori toys that enhance fine motor skill development.

SUMMARY OF QUESTIONNAIRE FINDINGS

The questionnaire findings offer valuable insights into current preferences, concerns, and expectations regarding toddler toys, particularly those designed to promote fine motor skill development. Key points from the analysis include:

- **Demographics**: The majority of respondents were female (56.3%), aged between 30 and 39 years, primarily consisting of parents, followed by guardians and educators, providing varied caregiving perspectives.
- **Child Development**: Most respondents reported having children aged 4 years old (62.5%), a critical stage for fine motor skill growth. Dressing up and brushing teeth were identified as everyday daily struggles.
- **Playtime Preferences**: Pretend play toys (65.6%) and digital toys (62.5%) were the most popular types of toys. Educational toys were used by children only occasionally, highlighting the potential for improvement in this area.
- **Play Challenges**: Shape sorter puzzles (72%) and stacking blocks (24%) were perceived as the most difficult toys. Some children struggled with connecting pieces or fastening small items.
- **Toy Avoidance & Reactions**: Most children did not avoid difficult toys (52%), but 40% would avoid them sometimes. When facing difficulty, 58% asked for help, while 40% kept trying.
- **Material Preference**: Eco-friendly materials (43.8%) and plastic (43.8%) were equally preferred, while wood was less favoured.
- **Accessibility**: Although 59.4% found Montessori toys accessible, 40.6% still experienced difficulty in sourcing them affordably or conveniently.
- **Fine Motor Importance**: Nearly all respondents rated the importance of fine motor skills development in toys as high (Scale 4 or 5), confirming the relevance of toys that target this specific growth area.
- **Suggestions**: Valuable ideas were shared, including adding lights or sound responses, creating child-friendly household role-play toys, and focusing on safe materials and storage solutions.

Overall, the data confirms the strong demand for a multifunctional Montessori toy that is engaging, accessible, and tailored to support fine motor skills in young children.

The findings indicate that toddlers face challenges in fine motor activities such as gripping, sorting, and coordinating hand movements. Additionally, the preference for engaging and interactive toys highlights the need for designs that balance learning and play. Therefore, the proposed design integrates simplified geometric forms, ergonomic sizing, and modular interaction features to directly address these developmental needs while maintaining engagement.

SAMPLE OF QUESTIONNAIRE FINDINGS

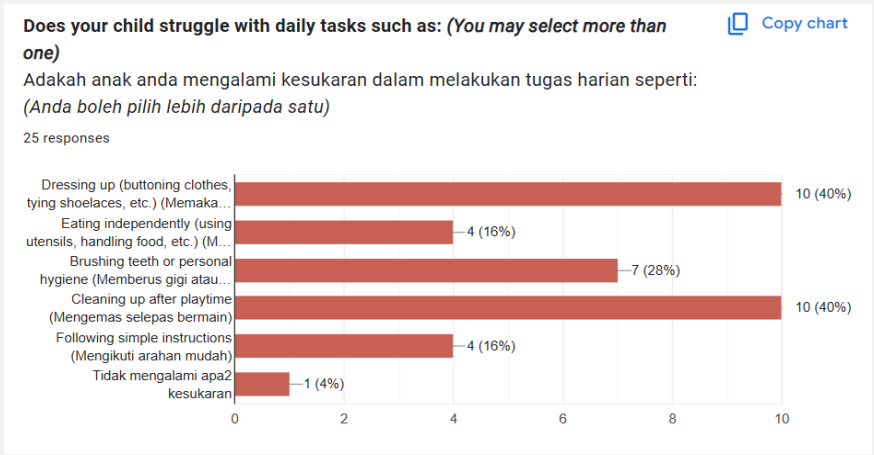

Figure 2: Child's Daily Task Struggle Bar Chart

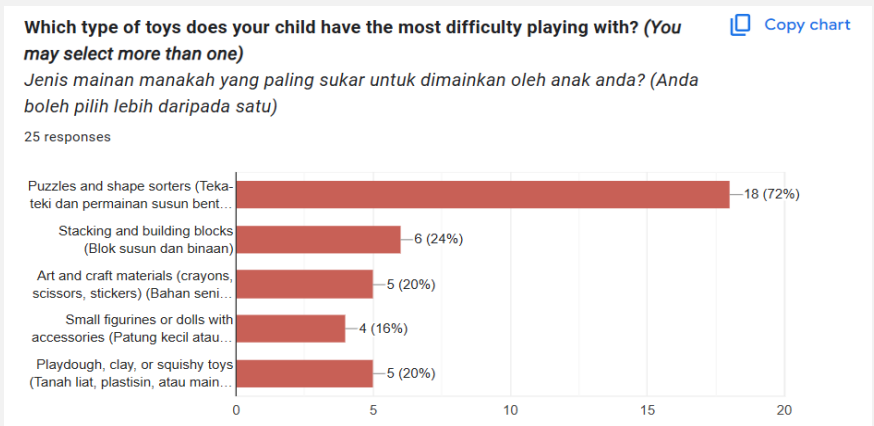

Figure 3: Child's Difficult Toys Bar Chart

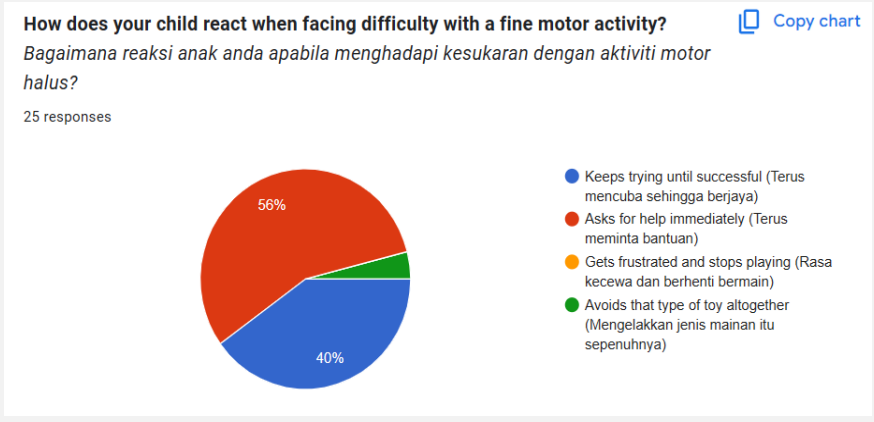

Figure 4: Child's Reaction to Fine Motor Activity Pie Chart

PRODUCT LINEUP

This section presents an analysis of 80 Montessori-inspired toys across four core categories of fine motor development:

- Grip Strength & Dexterity Improvement
- Hand-Eye Coordination Improvement
- Finger Manipulation & Precision Improvement
- Bilateral Coordination Improvement

Figure 5:Product Lineup Table

OVERALL LINEUP FINDINGS

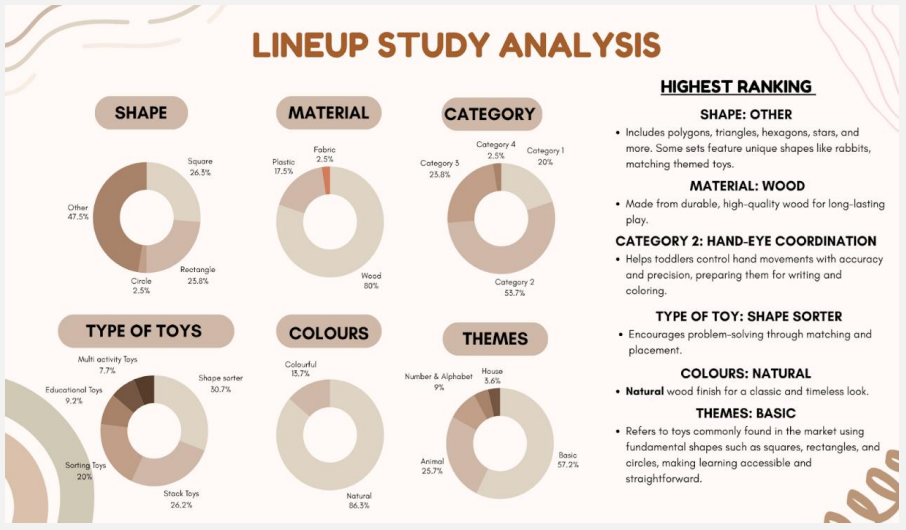

Figure 6: Lineup Study Analysis

Among all categories, the highest overall developmental focus was observed in the Hand-Eye Coordination Improvement category. This category emphasises activities that help toddlers develop accuracy in their hand movements, which is essential for early writing, drawing, and self-help tasks.

- **Shape**: The most frequent shape classification fell under "Other", which encompasses a variety of forms beyond typical geometry, including stars, polygons, triangles, hexagons, and creative shapes such as rabbits or themed figures. These enhance visual interest and shape-matching skills.
- **Material**: Wood was the most preferred material due to its high durability and alignment with Montessori philosophies. Its tactile and eco-conscious properties make it a favoured choice in quality educational toys.
- **Type of Toy**: The most represented toy type across the dataset was the shape sorter, known for its effectiveness in promoting problem-solving and logical reasoning.
- **Colour Palettes**: The use of natural wood finishes was prevalent in the broader study, reflecting a minimalist and calming aesthetic that aligns with Montessori design values.
- **Theme**: Basic shapes, such as squares, rectangles, and circles, were the most popular themes, making the toys intuitive and suitable for early learners.

SUMMARY LINEUP FINDINGS

The analysis of the product lineup for hand-eye coordination toys highlights the importance of incorporating basic shapes such as squares and rectangles, using durable wooden materials, and featuring visually engaging, colourful finishes. These elements were found to be the most prevalent and preferred across the evaluated products. This suggests that educational toys targeting hand-eye coordination should adopt these features to enhance both developmental effectiveness and child engagement, providing a valuable reference for future Montessori-inspired toy design.

PHYSICAL RETAIL OBSERVATION FINDINGS

Table 1 summarises the findings from physical observation conducted at five retail locations: AEON BiG Wangsa Maju, TF Value-Mart Batu Caves, Mydin Subang Jaya Hypermarket, Toys "R" Us, and Eco Shop @ Selayang Warta Lama. The aim was to evaluate the availability and accessibility of fine motor skill development toys, particularly those aligned with Montessori principles.

Table 1 : Physical Observation Findings at Selected Retail Store

No	Toy Store / Mall	Montessori Toys Available?	Pretend Play Toys?	Type of Montessori Toys Seen
1	AEON BiG | Wangsa Maju	No	Yes	-
2	TF Value-Mart Batu Caves	Yes	Yes	Building block
3	Mydin Subang Jaya Hypermarket	No	Yes	-
4	Toys "R" Us Suria KLCC	Yes	Yes	Shape sorter, Building block, etc.
5	Eco-Shop @ Selayang Warta Lama	Yes	Yes	Building block

PRODUCT AVAILABILITY

All five locations consistently stocked pretend play toys, highlighting their popularity and demand in the Malaysian toy market. However, the availability of Montessori-inspired toys varied significantly by store type.

Figure 7:AEON Big Wangsa Maju Toys Observation

Figure 8:Mydin Subang Jaya Hypermarket Observation

AEON BiG Wangsa Maju and Mydin Subang Jaya Hypermarket did not offer Montessori toys, despite being large hypermarkets with extensive toy sections. This suggests that such stores prioritise general or mass-market toys rather than educational or skill-targeted options.

Figure 9:Toys "R" Us Observation

In contrast, Toys "R" Us offered a wider range of toys supporting fine motor development, including shape sorters, building blocks, and stacking toys, some of which align with Montessori principles.

Figure 10:TF Value Mart Observation

Figure 11:Eco Shop Observation

TF Value Mart and Eco Shop, although budget-oriented, also carried basic Montessori-style toys such as simple wooden puzzles, shape sorters, and block sets, indicating some accessibility even at lower price points.

CATEGORISATION & DISPLAY

None of the stores had a dedicated section for Montessori or fine motor skill development toys. Stores typically organise products by toy type or age group, rather than by developmental function. This makes it difficult for parents to identify toys that target specific skills, such as grip strength or bilateral coordination.

SUMMARY OF OBSERVATION

The physical retail study reveals that Montessori toys are not widely available in mainstream retail spaces, particularly in large hypermarkets. While educational toys are present in specialised stores like Toys "R" Us and to some extent in discount stores like Eco Shop, their presentation lacks precise developmental categorisation. This underscores a gap in the local market for clearly labelled, skill-specific educational toys that are both affordable and accessible to all income levels.

VIDEO ANALYSIS

Table 2 and 3 presents the findings obtained from an observational checklist used in the video analysis of toddler play sessions involving Montessori-inspired toys. The analysis focused on behavioral patterns, engagement duration, motor skills, and social-emotional responses to explore developmental behaviors during play.

OBSERVATION CHECKLIST FOR VIDEO ANALYSIS PART 1

Table 2 : Observation Checklist for Video Analysis

KIDS	Category 1: Behavioural Patterns				
	Insert the shape into the correct hole.	Rotates/manipulates the block.	Stacks blocks	Seeks help from an adult	Imitates adult/peer actions
1	X	X	X	/	X
2	/	X	X	/	/
3	/	/	/	/	/
4	/	X	/	X	/
5	/	X	/	/	/
6	/	/	/	/	/
7	X	/	/	/	/
8	X	/	X	/	/
9	X	/	X	/	/
10	X	X	X	X	X

KIDS	Category 2: Engagement Duration		
	Approximate total play duration (e.g., 5 min, 12 min)	Focused throughout or easily distracted?	Return to the toy after a distraction?
1	3	X	/
2	1- 2	X	X
3	4	/	/
4	2	X	X
5	4	X	/
6	3	X	/
7	3	X	/
8	2	X	/
9	4	X	X
10	3	/	/

OBSERVATION CHECKLIST FOR VIDEO ANALYSIS PART 2

Table 3 : Observation Checklist for Video Analysis

KIDS	Category 3: Motor Skill Indicators (Fine Motor, Dexterity, Coordination)				
	Grasping blocks with a pincer grip / a whole hand	Transferring a block from one hand to another	Placing shapes into holes accurately	Stacking with coordination	Eye-hand coordination
1	X	X	X	X	X
2	/	/	/	X	X
3	/	X	/	/	/
4	/	/	X	/	/
5	/	/	/	/	/
6	/	/	/	/	/
7	/	/	/	/	/
8	/	/	X	/	/
9	/	/	X	X	/
10	/	/	X	X	X
KIDS	Category 4: Emotional and Social Responses				
	Smile / Laugh during play.	Shows frustration	Displays excitement	Attempt to communicate	Shows independence
1	/	/	/	X	/
2	/	X	X	X	X
3	/	X	/	X	X
4	/	/	X	X	X
5	/	/	/	X	X
6	/	/	/	/	/
7	/	X	X	X	X
8	/	X	/	X	/
9	/	X	/	/	/
10	/	/	/	X	X

DESIGN STATEMENT

ShapeScape is a Montessori-inspired toy that reimagines the classic shape sorter, utilising unique, architecture-based forms such as Roman arches. Made from safe, biodegradable PLA, ShapeScape supports sustainability and child safety. It also encourages interaction between children and caregivers, helping to develop communication and hand-eye coordination in a fun and meaningful way. Designed to boost creativity and fine motor skills, it offers a more engaging and visually appealing play experience. Its toddler-friendly size ensures an easy grip for independent play and problem-solving.

Unlike conventional Montessori toys, ShapeScape incorporates architecture-inspired forms such as arches and geometric structures, introducing an additional layer of spatial understanding alongside fine motor skill development.

PROBLEM STATEMENT

In recent years, there has been increasing concern about the developmental health of young children, especially in the area of fine motor skills. Factors like increased screen time, fewer outdoor activities, and a shift towards convenience in parenting have contributed to this problem. Additionally, the decline in reading for leisure among children has reduced their involvement in hands-on activities that support fine motor development. These lifestyle changes are creating developmental gaps during the vital early years, particularly in hand-eye coordination, grip strength, and finger dexterity. If left unaddressed, these issues could affect children's preparedness for school tasks and everyday life skills. Therefore, it is crucial to explore solutions that can support fine motor skill development in a more engaging and accessible manner.

DESIGN AIM

To design a multifunctional, ergonomic Montessori-inspired toy that combines shape sorting and block-building features to support toddlers' fine motor skill development.

DESIGN OBJECTIVES

- To develop a modular toy that integrates shape sorting and building activities suitable for children aged 1 to 4 years old.
- To ensure ergonomic sizing and tactile features that cater to toddlers with delayed motor skill development.
- To support both independent play and two-way communication between toddlers and parents through interactive design features.

TARGET USER

The main users of the proposed product are toddlers aged 1 to 4 years, who are in a vital stage of developing fine motor skills, hand-eye coordination, and cognitive abilities through active play. At this stage, children gain the most benefit from tactile, screen-free, and interactive activities that promote their physical and mental development.

Secondary users are parents and caregivers who increasingly seek educational, engaging toys that foster creativity, motor skills, and meaningful interaction without relying on digital devices. These users prioritise safe, developmentally suitable, and purposeful products that adhere to Montessori principles and provide alternatives to passive screen time.

DESIGN PROCESS

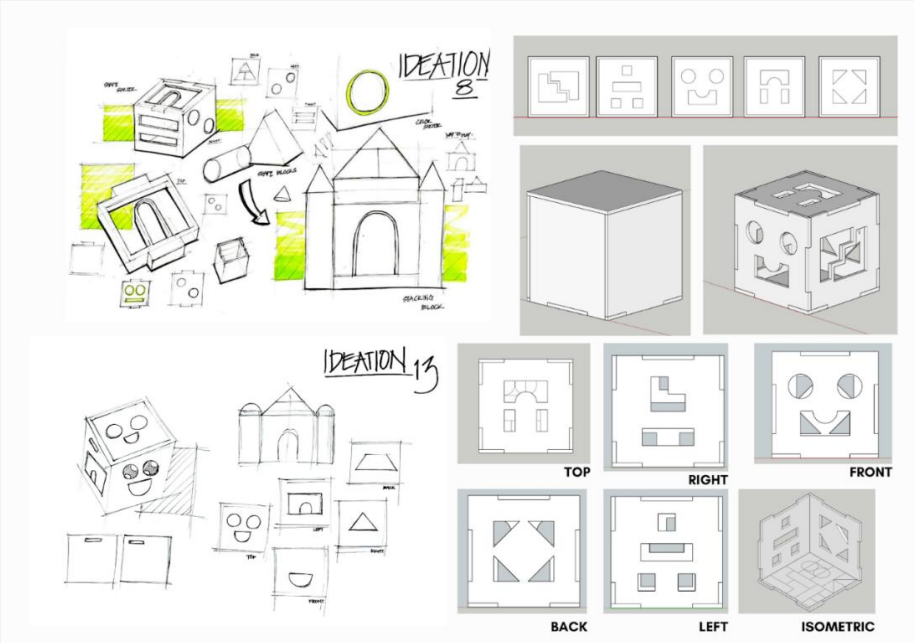

Figure 12: Compilation of Ideation

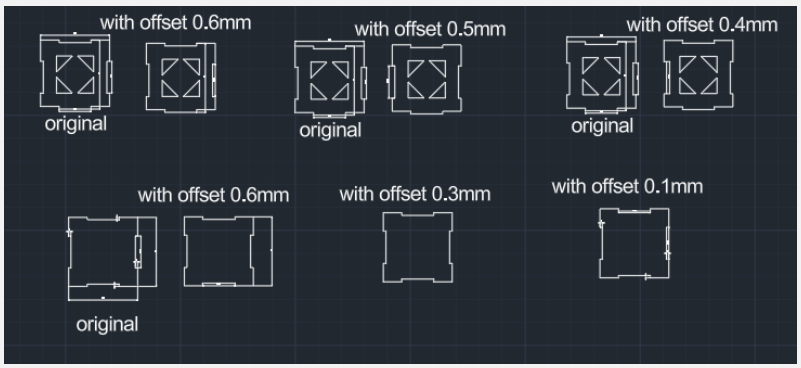

Figure 13: Model Process

Figure 14: Offset testing in AutoCAD

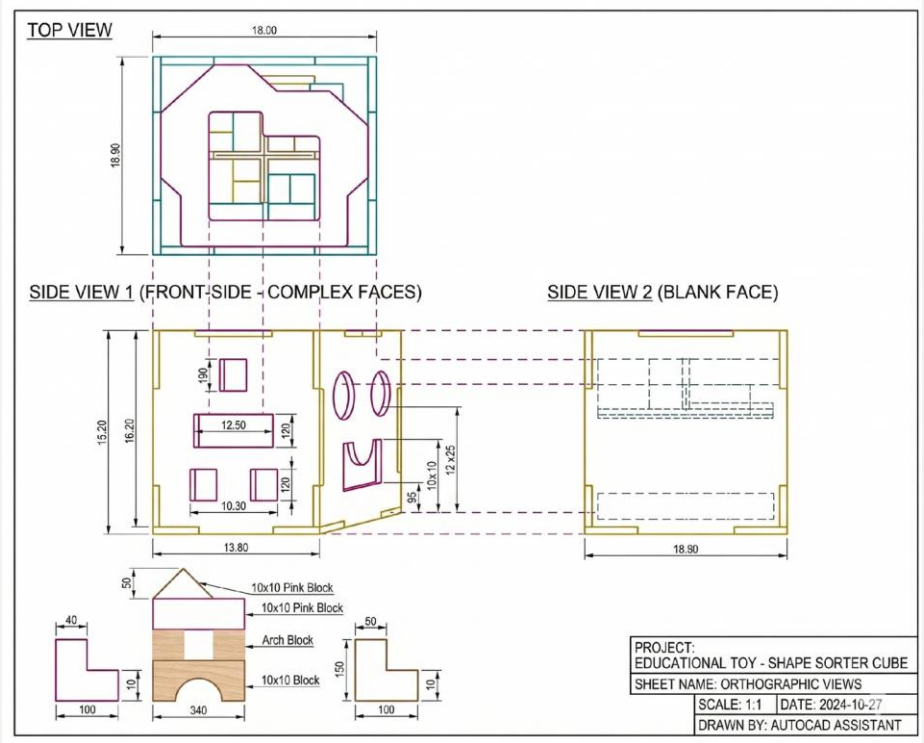

Figure 15: Technical Drawing

The final working prototype was produced using 3D printing with PLA filament, allowing a hands-on understanding of the toy's size, structure, and functionality. The model demonstrates how toddlers interact with the product — inserting shapes and stacking blocks — effectively promoting the development of fine motor skills. Photos of the final model showcase both its aesthetic and functional aspects, affirming its suitability for use in early childhood.

Figure 16: Colour Variant for ShapScape

The range of eco-friendly wooden ShapeScape, proposed in four curated color variants: the soft and sweet "Pastel Petals" (pink), the serene "Calm Coast" (blue), the grounded "Natural Elements" (green), and the warm "Sunlit Sands" (mustard). Each set is crafted from sustainable wood, designed to spark joy and develop essential cognitive skills through play. Perfect for nursery or playroom, these beautiful cubes are as pleasing to the eye as they are to the touch.

CONCLUSION

This research examined the developmental needs of toddlers with an emphasis on enhancing fine motor skills through Montessori-inspired toys. Parental feedback highlighted the importance of hand-eye coordination, finger dexterity, and bilateral coordination, while observational and video analyses confirmed that toddlers benefit most from simple, interactive toys that provide visual and tactile feedback.

Market observations showed that although educational toys are available, multifunctional designs that combine multiple developmental benefits remain limited. Parents also stressed the need for durability, safe materials, engaging features, and visual appeal. These insights guided the final design proposal, which demonstrates how Montessori-inspired multifunctional toys can effectively support fine motor development while promoting sustainable and ethical design practices.

This study contributes to the field of design by demonstrating how research-driven product development can support early childhood development. Future improvements may explore interactive features such as sensory feedback and expanded modular systems to enhance learning engagement.

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