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Proposed Design of Toy to Optimize the Brain Development of Children Aged 3-5 Years Old

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ABSTRACT

Children and games are inseparable, especially during their childhood which is known as the golden age. This is the phase when they experience a very fast and significant brain growth and development under the influence of several factors such as the sensory, motor, and cognitive aspects. Therefore, this study aims to design a safe toy without hazardous materials to maximize the brain development of children aged 3 to 5 years in the sensory, motor, and cognitive aspects. The design was based on the Nigel Cross principle normally used to analyze the consumer needs and this led to the production of three different toys which include the hand puppet, board game, and puzzle. The toys' specifications and features were obtained from questionnaires distributed online and data analysis. The materials used include velboa fabric for hand puppets while Polylactic Acid (PLA) was used for both the board game and puzzles and they were selected based on the evaluations conducted by 3 competent production stakeholders. In conclusion, it was discovered that the design was able to provide solutions and breakthroughs needed to maximize the brains of children in their golden age.

INTRODUCTION

All organisms including human beings certainly undergo two continuous processes which include growth and development, physically and in several other aspects such as the brain. It has been discovered that the human brain is one of the most important organs which functions as the center of intelligence as well as the control center of all human body systems (Munawaroh & Haryanto, 2005). Wahyuni & Wukiratun, (2017) found that the human brain's growth and development commences from the womb while the growth of its tissue is influenced by external stimuli. The lack of this stimulation often results in cognitive or intellectual disability and the shrinkage of a child's brain compared to normal children. Dito (2014) also found that every human is born with more than 100 billion neurons and synapses and this significantly affects the cell structure formation of their brain. Hasan (2011) explained

that 5 years old children have 80% perfect brain growth and this implies those within this age range naturally have very rapid and significant brain growth and development. This is the reason Septiani et al. (2016) described this phase as the "golden age" influenced by several factors including sensory, motor, and cognitive abilities.

Sensory ability is the aspect of children's growth that is observed from their motor activities and simple perceptions, while motor ability is the process of children's growth and movement through coordinated nerve and muscle activity (Chandra Ananditha et al., 2017). Cognitive ability is the process of interaction that occurs between children and their perception of an object or natural event in an environment (Purnamasari & Nuhayati, 2018). Therefore, Nilawati Astini et al., (2017) concluded that these three abilities are very important in the process of growth and development of a child's brain.

Ifrianti (2015) explained that the best approach to hone and familiarize children with these three abilities includes the use of games and toys. Dito (2014) found that associations with playing always arise when thinking about children, the reason being that children and games are inseparable, but unfortunately, several toys produced are for their entertainment, not for brain development. Wijaya (2013) discovered that there are currently very few games made with eco-friendly materials, therefore, educational games need to be designed with different activities to ensure they are attractive and understandable to the children in order to achieve better results (Huang et al., 2018).

Presently, the study of children's toys is only focused on Indonesia due to the anthropometric principles of the country. The use of an ergonomic approach with anthropometric principles for the children involves all three abilities - motor, sensory, and cognitive. Meanwhile, the reaction to the novelty of this study is still relatively small, therefore there is a need to design a toy for children aged 1 to 5 years to maximize their growth potential and brain development in the golden phase.

RESEARCH METHOD

The systematic stage of designing a product is developed based on the Nigel Cross principle which consists of clarifying objectives, establishing functions, setting requirements, determining characteristics, generating alternatives, evaluating alternatives, and improving details (Ginting & Khatami, 2019). It is important to note that this study uses the first six but neglects the last stage.

1. Clarifying Objectives
   This stage aims to explain the purpose of designing toys for the children by using the Objectives Tree Method (Rahmat et al., 2015), presented in a diagrammatic form of hierarchical goals and sub-objectives patterns, as well as the way these goals relate to one another.
2. Establishing Function
   The second stage aims to develop the necessary functions and limits of the product design system by using the input-output system functional analysis method according to the Black Box principle (Ginting & Khatami, 2019). This functional analysis method considers the essential functions of the toy and ensures that the design is satisfactory, regardless of the physical components used.
3. Setting Requirements
   This third stage aims to obtain accurate demands of consumers and a construction that is based on the designer's expectation from a specified design solution, by using the Performance Specification Method (Rahmat et al., 2015). This method combines the data from questionnaires distributed online, which is intended for Indonesian parents having children within the age of 5 years to investigate their demand as potential customers.
4. Determining Characteristic
   This stage aims to determine the target specifications and characteristics to be achieved from the design of this tool by using the House of Quality Method with a questionnaire directed to parents that have children within 5 years of age. The questionnaire is used to obtain the toy's specifications or attributes to be designed as well as the importance of each specification, compared to the competing products in terms of product specifications and requirements that were conducted in the previous stage.

5. Generating Alternative
   This stage aims to provide possible new alternatives to solve the problem and obtain the best among the alternatives by using the Morphological Chart Method (Ginting & Khatami, 2019). These alternatives are provided in the form of constituent materials that are useful for this study.
6. Evaluating Alternative
   This stage entails the conceptual assessment of the tool using the selection method developed by Stuart Pugh.

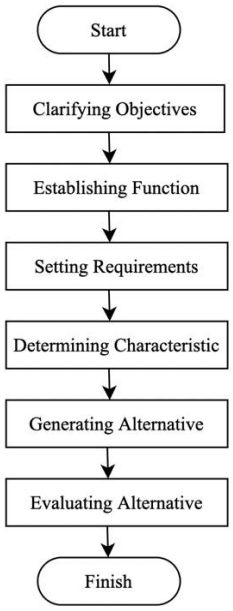

Figure 1. Nigel Cross Stage Flowchart

RESULTS AND DISCUSSION

The results were obtained from each of the six stages of the Nigel Cross principle as well as the questionnaire previously tested for adequacy through validity and reliability tests.

1. Clarifying Objectives

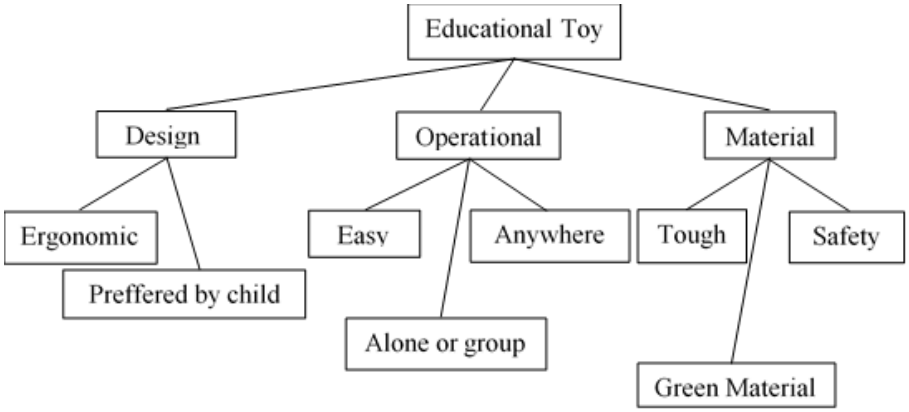

Figure 2. Objective Tree

2. Establishing Function
   Input: Green toys and safety materials, tools such as gauges, scissors, and glue, as well as machines such as 3D printing, 2D printing, and sewing machines.
   Black box: Measuring the main material with tape, cutting with a butt, assembling, accessories, and finishing. Output: Tools in the form of toys for children aged 3 to 5 years.

3. Setting Requirements

   Expectations: Toys as a learning medium, made of harmless materials, have special features and learning abilities, able to train sensory, motor, cognitive abilities, and all three skills at the same time, flexible to be played with alone or with a group, anywhere, has the appropriate dimensions with the intended child's age, and non-digital toys.

   Demand: Toys that are durable and not easily damaged, easy to carry, multifunctional and not tedious, as well as toys of various shapes and colors.

   These points are grouped into 8 main categories, which include safety materials, multifunctional learning, sensory abilities, motor abilities, cognitive abilities, flexibility, ergonomics, and durability.

4. Determining Characteristic

   The proposed toy has 5 important characteristics which are as follows:

   a. Toys as a medium for storytelling activities.

   b. Toys as a medium for storytelling activities that are not only playable by friends/supervisors/parents but also by the children.

   c. Toys with multiple backgrounds, equipped with pictures and illustrations.

   d. Toys with simple challenges around basic things such as five senses, simple puzzles, numbers, and letters which are possible to be adapted to the children's abilities.

   e. Toys arrange to form something from small pieces of toy parts (puzzles) in order to support cognitive and motor learning in children's games.

   Based on these requirements and characteristics, the kindergarten anthropometry body parts, namely front handle length, elbow length, shoulder width, and palm length (Herawati & Pawitra, 2013) were used to form an anthropometrically designed toy as see in figure 3.

Figure 3. Designed Toy

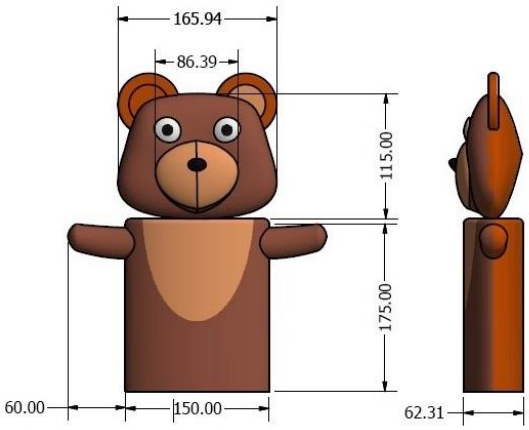

Figure 4. Hand Puppet Dimension in mm

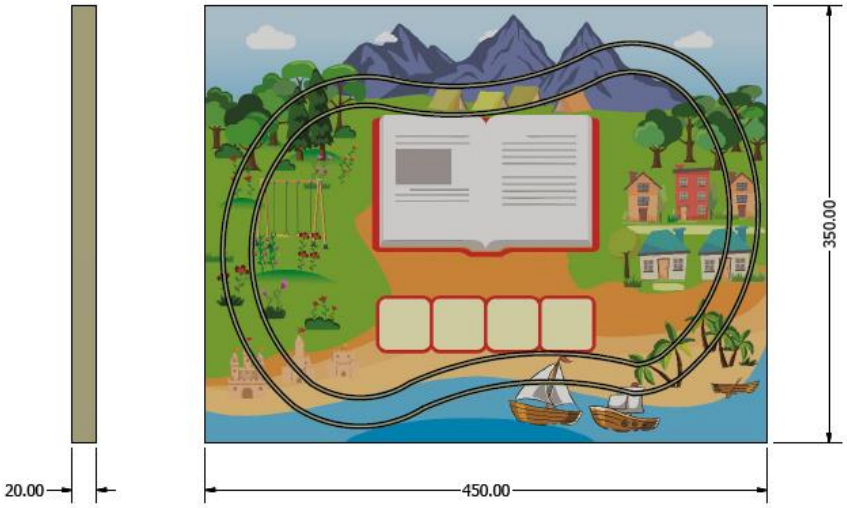

Figure 5. Board Game Dimension in mm

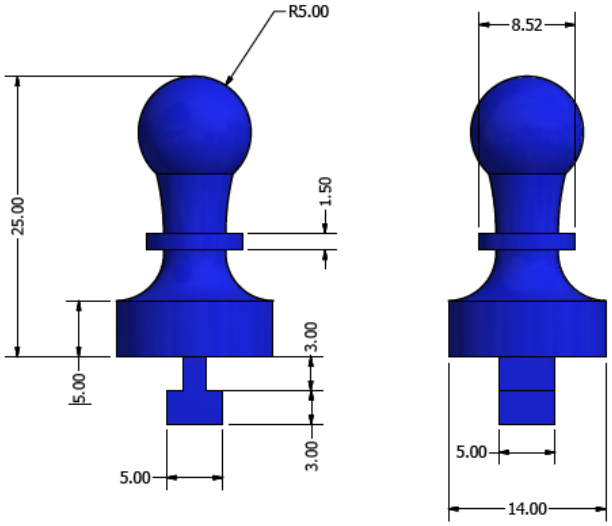

Figure 6. Pawn of Game Dimension in mm

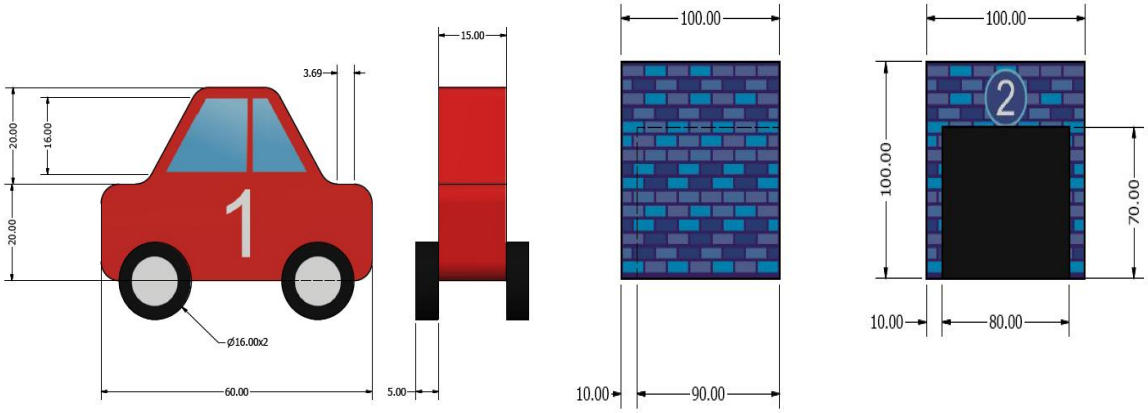

Figure 7. Car and Garage Puzzle Dimension

Then, the toy design is compared with competitors' products to determine its position in potential customers' perspectives using House of Quality methods as shown in figure 8. Figure 9 shows the two competitors' products.

	Requirement / Technical Characteristics		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
			Non-digital	Suitable material for children	Sensory abilities, motor, cognitive at once	Challenges that can be adjusted according to the child's abilities	Many shapes and full color	Hand puppet	*Board game*	Puzzle	Alone or group	Anytime and anywhere	Length of the grip of the hand forward	Length of the elbow	Width of the shoulder	Length of the palm	Width of the palm	Durable
		Importance Rate																
1	Safety materials	7,47	67,23	67,23														
2	Multifunctional learning	7,58			68,22	68,22	68,22	22,74	22,74	22,74								
3	Sensory abilities	7,31				21,93	21,93	65,79	65,79	65,79								
4	Motor abilities	7,39				22,17		66,51	66,51	66,51								
5	Cognitive abilities	7,78				23,34		70,02	70,02	70,02								
6	Flexible	8,09									72,81	72,81						
7	Ergonomic	7,86											70,74	70,74	70,74	70,74	70,74	
8	Durable	7,82		7,82														70,38
Total			67,23	75,05	68,22	135,66	90,15	225,06	225,06	225,06	72,81	72,81	70,74	70,74	70,74	70,74	70,74	70,38

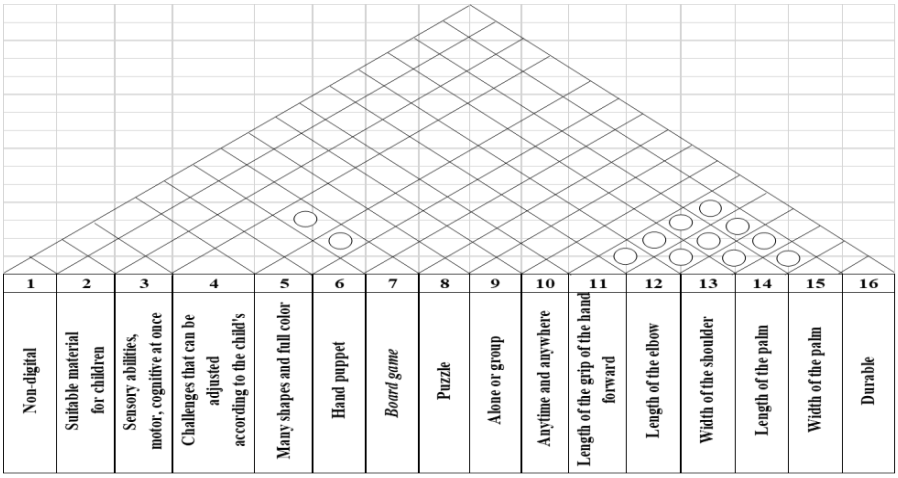

Figure 8. House of Quality (HoQ)

Figure 9. Competitors' products

Table 1. Score of requirements

No	Requirements	Importance Rate	Sales Point	Goals	Improvement Ratio	Weight Line	Normalized Weights
1	Safety materials	4.28	1.50	4.50	1.05	6.75	0.15
2	Multifunctional learning	4.28	1.50	4.50	1.01	6.75	0.15
3	Sensory abilities	4.28	1.00	4.50	1.06	4.50	0.10
4	Motor abilities	4.28	1.20	4.50	1.07	5.40	0.12
5	Cognitive abilities	4.28	1.50	4.50	1.02	6.75	0.15
6	Flexible	4.28	1.00	4.50	1.06	4.50	0.10
7	Ergonomic	4.28	1.50	4.50	1.06	6.75	0.15
8	Durable	4.28	1.00	4.50	1.06	4.50	0.10

5. Generating Alternative
   There are 3 alternative materials obtained from the calculation and data processing in the previous stages and they are stated as follows:
   a. Alternative 1
      The flannel cloth was used for the hand puppet while Polylactic Acid (PLA) was applied for both the board and puzzle games. This alternative utilized medium-quality and general materials that are easy to find for the hand puppets while those considered best suited for the board games and puzzles were selected to ensure durability and affordability.
   b. Alternative 2
      Velboa fabric was used for hand puppets, while PLA is used for board games and puzzles. This alternative prioritizes the best materials at a relatively high price for each option, resulting in products of good quality and long usage time.
   c. Alternative 3
      Rag is used for the hand puppets while the yellow board was used for board games and puzzles. This combination prioritizes economic value by ensuring the product has the cheapest price compared to other alternatives.
6. Evaluating Alternative
   The highest alternative score was obtained from 3 competent stakeholders, and they chose alternative 2 which entail the use of velboa fabric for hand puppet as well as Polylactic Acid (PLA) for board game and puzzles. The advantage of this alternative is that the velboa fabric used for hand puppets has a very smooth and soft texture, making it suitable as a raw material for dolls. Meanwhile, PLA is used for board games and puzzles because it is durable and eco-environmentally friendly.

   The simulation was conducted using AODV, DSDV, and AODVEO, through the Network Simulator 2.35. In this condition, only the best five of the seven runs (seven seeds) were selected and averaged, with the spacing (d) and time (t) being 50 m and 500 s, respectively. Moreover, the transport agent and traffic type applied were the Transmission Control Protocol (TCP) and Constant Bit Rate (CBR), respectively. The size of the executed packet was also 512 bytes, with the transfer rate being two packets/secs, as shown in Table 2.

CONCLUSIONS

The toy produced based on the requirements, specifications, features, and materials in alternative 2 was able to maximize the brain development of children aged 3 to 5 years, thereby, making it to be acceptable to the customers. This is also supported by the fact that all requirements, specifications, features, and designs are based on the responses provided by prospective customers through questionnaires.

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