Design of Baby Walking Assistant (AB3) by Using Axiomatic Design Method

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Abstract

Statistical data from National Population and Family Planning Board (BKKBN) illustrated that the numbers of Indonesian population in 2014 has increased 1,40% from approximately 240 million persons, with 10.000 childbirths/day. Hence, with the huge number of childbirths, a walking tool is required to train babys walking ability. It called as Alat Bantu Berjalan Bayi (AB3)/baby walking assistant. AB3 is designed by using axiomatic design method. The criteria of the design based on customers preferences are simple, safe, strong and stylish. Therefore, the design parameters for AB3 by using axiomatic design method are determined as AB3s appearance design (DP1), comfortable design (DP2), pure cotton material (DP3) and half rounded design model (DP4). Validation that conducted by using Stuart-Maxwell test of Marginal Homogeneity reveals that value of alpha $> 0,05$ indicates that the proposed design has fulfilled customers preferences.

Keywords : *Baby Walking Assistant, Axiomateic Design Method, BKKBN*

1 INTRODUCTION

The increasing numbers of population become the important issue to be discussed by every country. Hence, the figures are kept being monitored. The increasing population is the indicator of countrys welfare. Since a country is indicated as prosperous country if the number of its gross regional domestic product (PDRB) is less than 1% from the total amount of population [1]. Statistical data from National Population and Family Planning Board (BKKBN) illustrated that the numbers of Indonesian population in 2014 has increased 1,40% from approximately 240 million persons, with 10.000 childbirths/day [2]. The result of study shows that toddlers growth has its own pattern with certain way and speed. Therefore, all toddlers will not accomplish the identical growth point in the same age [3]. Toddlers growth is defined as gross motor skill to maintain the body development that coordinates body movements to sustain body stability. It is parents responsibility to stimulate the growth of childs gross motor skill. According to [4], toddlers age is commonly declared as an ideal time to observe motor skill due to following circumstances: 1) Childs flexible body, 2) Toddlers

still have limited skill, 3) Child is braver to try something new, 4) child love adventures, and 5) Child has more time to study motor skills

Inappropriate motor skills development that is caused by improper tool could cause obstructed motor skills and physical development or else the growth will run unexpectedly. The result of research reveals that the walking progress leads to incorrect development is caused by the existing baby walking assistant that less consider in strengthening the thigh and pelvic muscle that mostly used for walk practicing [5]. In terms of developing motor skills, a child has to be motivated to conduct the movements since motor skills could be formed from compilation of several factors, such as: nerve development, bodys physical characteristic and its possible movement, walking skill control, which needs active efforts from the child to coordinate several components of designated skills. Hence, to train motor skills components and other parts that support babys walking development, a design on appropriate walking tool is required. Product design consists of two words, which are design and product. According to Indonesian dictionary, design means frame of form or plan. Product design should be fashionable, that turns to be the most important part on communitys life style [6].

The process of product design is highly related to configuration, composition, meaning, value and purposes of manmade phenomenon [7]. The nature of products not only efficient in the context of function and economic mechanism, but also should consider on factors of moral, social and its impact to environment [8, 9]. Others that should be fulfilled are global equality, fair trade, social justice and responsibility. They interact each other to form strong bound among products and surroundings [1, 10]. Observation on baby walking assistant will cover material usage, protection strap and baby security system. It will employ product design method and axiomatic design. Axiomatic is product designing method based on functional requirements and maintaining its two basic principles, which are functional freedom and information content minimization [11]. Besides, Axiomatic design helps researcher to carry out designing activity based on the process of logical thinking, rational and tools [12] to expand scientific procedures, general, modified and systematic in design [13]. Axiomatic process are : 1) understanding the customers need, 2) Defining the problem to be solved, 3) Making and selecting a solution, 4) Analyzing and optimizing the solution, 5) Assessing effect of the design towards customer [1]. Basic concepts of Axiomatic Design are Customer Attribute, Functional Requirement, Design Parameter and Process Variable [12].

Ordinal scale non parametric analysis is used to classify measured variables to avoid mistakes in determining data analysis and further research step [14, 15]. Measurement scale justification employs validity and reliability test analysis. Validity test is an instrument to calculate instruments validity by using Spearmans Rank Correlation Method, while Spearmans Rank is an equation from person product moment, which is used to calculate instruments validity. An instrument is indicated as valid if it had correlation coefficient (r) bigger or equal with 0,3 14, 16]. Reliability test is applied to obtain level of accuracy by using Cronbachs alpha method under scale of 0-1. Development process on product design uses principles of multiple effect design. Prior to previous introduction, researcher tries to create prototype of Alat Bantu Berjalan Bayi (AB3)/Baby walking Assistant that appropriates with concept of childs development and customers preferences by applying concept and method of Axiomatic Design.

2 RESEARCH METHODHOLOGY

2.1 Object of Research

Object of this research is the design of Alat Bantu Berjalan Bayi (AB3)/Baby Walking Assistant. The respondents are women with age ranged from 20-30 years old that have children with age ranged from 1-2 years old as the users of AB3. Questionnaires were distributed to random several places. The amounts of respondent were 30 persons. The design of AB3 is constructed by using software inventor fushion 13.2 as one of the supporting tool, while for three dimension and rough sketching, sketch-up pro 9 is also employed. Process of designing on customers requirement applies axiomatic design method. This research was conducted in manufacturing system laboratory, department of Industrial Engineering, Universitas Islam Indonesia.

2.2 Data Collection Process

The research is conducted by removing samples out of population. It is assumed that the population is infinite by using accidental sampling. Data collection techniques are explained as follows: 1) Observation. By conducting direct observation on AB3 users, 2) Interview and Questionnaire. By performing interview and spreading the questionnaire to AB3s users. Interviews samples are taken from 30 respondents that use baby walking assistant with age ranged from 20-30 years old, and 3) Study Literature. This technique involves study literature, books, journals, magazine and other supporting data.

2.3 Process of Design

The steps of design and Axiomatic Design are clarified as follows : 1) Identification on customers requirement. Costumers preferences on the design of AB3 are identified by distributing the open questionnaire. After the data are processed, costumer attributes will be recognized and will be used as basic of further process, 2) Mapping process, from costumer attributes (CAs) to the level of functional requirement and from functional requirement (FRs) mapped to design of parameters (DPs), 3) Design Matrix FR/DP for each level. On this step, Design matrix (DM) is made to adjust the design. Later, to be fitted in the independence axiom on attributes for each level, 4) Questionnaire Improvement. It is carried out under several stages to obtain questions attributes, which are valid and reliable, 5) Determining Functional Requirement. This stage determines functional requirement from customer attribute, in form of functional statement that could fulfill customer attribute, 6) Determining Design Parameters. By defining solution to accomplish current functions, 7) Prototyping. This stage is defined as process to transfer the design parameters at leaf level into a virtual prototype, 8) Design validation. Validation test is performed to evaluate whether the proposed design has met the customers preferences or has not. Validation test in this research employs Stuart-Maxwell test of Marginal Homogeneity.

2.4 Validity and Reliability Method

Data measurement is an effort to relate the concept with reality. Questionnaire is used as an instrument for data collecting. It is composed theoretically in form of Likert scale. Score 5 is categorized as very important, score 4 is categorized as important, score 3 is categorized

as fair/neutral, score 2 is categorized as not important and score 1 is categorized as very not important. Before distributing, the questionnaire should be assessed by using validity and reliability test. Validity test employs Spearmans Rank Correlation Method, while reliability test involves Cronbachs Alpha with scale 0-1 to compare coefficient of reliability.

3   RESULTS AND DISCUSSIONS

3.1   Result on Respondents Needs

The respondents are women with age ranged from 20 30 years old that have children with age ranged from 1-2 as users of AB3. The result on identification of costumers needs toward AB3 accumulates 15 attributes (table 1).

Table 1: Costumers Needs.

No	Customers Needs	No	Customers Needs
1	Attractive	9	Comfortable
2	Elegant	10	Unique
3	Durable	11	Soft surface
4	Big Capacity	12	Easy to maintain
5	Cheap	13	Strong material
6	Simple	14	Modern shape
7	Has more than one safety items	15	Interesting Color
8	Environment friendly		

3.2   Respondents Validation Test

Attributes are considered as valid if the value of Corrected Item-Total Correlation more than or equal with 0,3. It can be notified, there are 4 valid attributes while others are indicated as invalid. The result of the validation test is illustrated by table 2. Valid attributes will become customer attribute (CA) in AB3 designing.

Table 2: Result of validation test on Customers Needs

No	Customers Needs	Corrected Item-Total Correlation	Desc.
1	Simple	0.423	Valid
2	Design on safety items	0.512	Valid
3	Strong material	0.579	Valid
4	Latest design	0.459	Valid

3.3   Respondents Reliability Test

Result on reliability test (to identify accuracy level) by using SPPS yielded that the Cronbach's Alpha value for attributes is 0,721. This value is considered as acceptable. All

four attributes are consistent instruments in data collection. It declared as accurate and could be treated as input data for this research. Reliability value is presented in table 3.

Table 3: Reliability Test

Cronbach's Alpha	N of Items
0.721	4

3.4   Designing Process for Axiomatic Design

3.4.1   Customer Attribute (CA)

Table 4: Result of validation test on Customers Needs.

No	Customers Needs	Code	Description
1	Simple	CA1	Design of shape is not complicated
2	Design on safety items	CA2	Has more than one safety items, baby will be in safe position while learning to walk
3	Strong material	CA3	AB3 uses strong material, not easy to rip or broken off when being used
4	Latest design	CA4	AB3 is designed with high level of uniqueness and fine design, especially for baby supporting design

3.4.2   Customer Attribute (CA), Functional Requirement (FR) and Functional Requirement (FR), Design of Parameter (DP)

Once Customer Attribute (CA) is identified, then CA is mapped to certain function (FR) that will be later answered by Design of Parameter (DP) as the solution. In this research, the decision for design of parameters will be determined by surveys to respondents. Next step in Axiomatic design is zigzagging through decomposition process. Design of Parameter is defined according to functional requirement in the same level and FR in the lower level is defined based on upper level of DP. Decomposition process continues until leaf level is achieved.

3.5   Design of FR and DP Matrix

This matrix design for each level of FR/DP is conducted to ensure that the design has fulfilled the requirement of Independence Axiom. Table 6 shows that DP1 and DP2 fulfill more than one FR. The correlation below diagonal line will refer to triangular or decouple design. In Axiomatic design, this is acceptable. It means that FR is independent and DP is placed on the appropriate order. Therefore, the process can be continued. Afterward, matrix design in every level should be analyzed to determine whether the design concept consistent to independence axiom.

Table 5: Mapping CA to FR and FR to DP

Code	Customer Attribute	Code	Functional Requirement	Code	Design Parameter
CA1	Simple	FR1	Reducing design on AB3	DP1	Appearance design of AB3
		FR11	Reducing colors on AB3	DP11	3 combination of color Ferrari red, black and green
		FR12	Has simple shape	DP12	Unicom shape
		FR13	Reducing extra compartment on AB3	DP13	Space for babys walking
CA2	Design of Safety	FR2	Minimizing the negative effect	DP2	Comfortable design
		FR21	Designing strong AB3	DP21	Could afford heavy load
		FR211	Material combining	DP211	Type of internal and external material
		FR2111	External Part	DP2111	Cotton 70% and cloths foam 30%
		FR2112	Internal Part	DP2112	100% cloth's foam
		FR212	Avoiding fabric perforated on AB3	DP212	Nylon stitch 250
		FR2121	Applying the highest quality of yarn	DP2121	Nylon yarn 250
		FR2122	Performing strong stitching pattern	DP2122	Stitching pattern with double line
		FR22	Designing inclined connection side	DP22	Design of pattern half round
		FR23	Designing harmless handle	DP223	Half round handle made from foam
		FR231	Easy grip	DP231	Half round
		FR232	Gentle grip	DP232	Handle is covered with cotton
		FR24	Applying strong height lock	DP24	Lock with plastic slip model
		FR241	Type of Slip	DP241	Slip Lock
		FR242	Locking position	DP242	Upper left and right side corner and in the central of AB3
CA3	Strong Material	FR3	Minimization of material allergic on baby during utilization	DP3	Pure cotton as material
		FR31	Utilization of material that hard to be ripped or broken	DP31	Cotton and fabric foam for internal part
		FR311	Utilization of material with high level of tension	DP311	Poly cotton
CA4	Latest Design	FR4	Designing AB3 to be different from other existing products	DP4	Half round design
		FR41	Accommodating variation of accessories	DP41	Doll accessories
		FR42	Providing flexible dimension on AB3s body	DP42	Designed from small to bigger size
		FR421	Having smaller size for internal compartment	DP421	Internal circle is measured as 35 cm X 35 cm and length of string as 120 cm
		FR422	Having bigger size for external side	DP422	Internal circle is measured as 45 cm X 45 cm and length of upper string as 120 cm
		FR43	Minimalist pattern design	DP43	D pattern

Table 6: Design of Matrix level 1

	DP1	DP2	DP3	DP4
FR1	X	O	O	O
FR2	O	X	O	O
FR3	O	O	X	O
FR4	X	O	O	X

Table 7: Design of Matrix level 2.

	DP11	DP12	DP13	DP21	DP22	DP23	DP24	DP31	DP41	DP42
FR11	X	O	O	O	O	O	O	O	O	O
FR12	O	X	O	O	O	O	O	O	O	O
FR13	O	O	X	O	O	O	O	O	O	O
FR21	O	O	O	X	O	O	O	O	O	O
FR22	O	O	O	O	X	O	O	O	O	O
FR23	O	O	O	O	O	X	O	O	O	O
FR24	O	O	O	X	O	O	X	O	O	O
FR31	O	O	O	X	O	O	O	X	O	O
FR41	O	O	O	O	O	O	O	O	X	O
FR42	O	X	O	O	O	O	O	O	O	X

In this level 2, matrix design refers to decouple design in which DP12 not only has fulfilled the necessities of FR12 but also could accommodate FR42. It can be translated that matrix level 2 is acceptable.

Table 8 represents design of matrix level 3. It shows matrix of decouple design which indicates that the design is acceptable. Last matrix of design will be design of matrix level 4 FR/DP.

Table 8: Design of Matrix level 3.

	DP11	DP12	DP13	DP21	DP22	DP23	DP24	DP31	DP41	DP42
FR11	X	O	O	O	O	O	O	O	O	O
FR12	X	X	O	O	O	O	O	O	O	O
FR13	O	O	X	O	O	O	O	O	O	O
FR21	O	O	O	X	O	O	O	O	O	O
FR22	O	O	O	O	X	O	O	O	O	O
FR23	O	O	O	O	O	X	O	O	O	O
FR24	O	O	O	O	O	O	X	O	O	O
FR31	X	O	O	O	O	O	O	X	O	O
FR41	O	O	O	O	O	O	X	O	X	O
FR42	O	O	O	O	O	O	X	O	O	X

Design matrix level 4 refers to Diagonal Matrix, hence, this design is also acceptable.

3.6 Validation on Design and Planning

Final step of the research is validation based on parameters design from axiomatic design. Validation test employs Stuart-Maxwell test of Marginal Homogeneity that shows all alpha value on design variables are calculated more than 0,05. This indicates that proposed design has accommodated customers preferences.

Table 9: Design of Matrix level 4

	DP2111	DP2112	DP2121	DP2122
FR2111	X	O	O	O
FR2112	O	X	O	O
FR2121	O	O	X	O
FR2122	O	O	O	X

Table 10: Alpha value for AB3

Customer Attribute	Alpha
Simple	0, 267
Design of Safety	0,289
Strong material	0,342
Latest Design	0,431

4 CONCLUSSIONS AND RECOMMENDATIONS

Based on research, it could be concluded that the design criteria of AB3 that preferred by customer are: simple model, design of safety, strong material and latest design. Furthermore, based on axiomatic design method, appearance design (DP1), comfortable design (DP2), pure cotton material (DP3), and half rounded design model (DP4) are set as parameters of design that could fulfill customers preferences. Result of validation test using Stuart-Maxwell test of Marginal Homogeneity shows that all alpha value on design variables are calculated more than 0,05. This indicates that proposed design has accommodated customers preferences.

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