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Product Design of Trolly Wheelchair for Disabled People Using Ergonomic Function Deployment Method

Nurfajriah[1a]◆, Mohammad Rachman Waluyo[1b], Halim Mahfud[1c], Fajar Rahayu Ikhwannul Mariati[2d], Dwie Achmad Basyar[1e], Renesha Fitri Asila[1f], Dinda Meimana[1g]

Abstract. *Disability is a problem with the body-function or body-structure, activity limitations, such as individual's difficulty in carrying out actions in life situations. One example of physical disability is a foot disability or an injury on foot that prevents people's ability in doing activities, where disabled people will find it hard to move from one place to another. Not only needing assistive devices, disabled people who use wheelchairs also need special facilities to do their activities. One of the activities is to shop. In Indonesia there are still no facilities that make disabled people with wheelchairs to shop at supermarkets in ease. Therefore, an innovation is indeed needed to make an integrated, automated, and special trolleys so it can facilitate and increase awareness of the importance of special facilities for disabled people in Indonesia. The EFD (Ergonomic Function Deployment) method is used to design the trolley according to the respondent's wishes. EFD is a development of QFD by adding a new relationship between consumer needs and the ergonomic aspects of the product. The product attributes that is used are derived from the ergonomics aspect which is known as ENASE (Effective, Comfortable, Safe, Healthy and Efficient). The prioritized variables of product design are trolleys for disabled people that run automatically, have an additional trolley basket (opening an additional trolley), have a soft back and seat, and have a strong locking system so that it makes it easier for users with a weight of 0.06048. The priority of consumer needs (Customer Needs) from the results of the HOE design are 3,4,7,8,9.10,11,14,5,6,12,13,16,18,19,1,15,2, and 17 and the Priority of Technical Requirements from the results of the HOE design are C, A, B, E and D*

Keywords: *disability, Ergonomic Function Deployment (EFD), anthropometry*

I. INTRODUCTION

Disability is a problem with the body-function or body-structure, activity limitations, such as individual's difficulty in carrying out tasks or actions, and participation restrictions, such as problems experienced in involvement in life situations. At 2019 there were 14.2 disabled people in total of 30.38 million people in Indonesia.

Disabled people include those who have physical disabilities, intellectual disabilities, mental disabilities, and/or sensory disabilities. One of the activities is to shop. In Indonesia there are still no supporting facilities for disabled people, therefore we want to make it easier for disabled people by modifying an integrated and automated wheelchair which help them to shop at friendly supermarkets so it can facilitate and increase awareness of the importance of the rights of disabled people whose existence is still felt by a few people.

A wheelchair is an assistive device used by people who have difficulty in walking due to illness, injury, or disability (Crismana et al., 1998). Wheelchairs are designed to provide convenience for the user, such as ensuring travel without clashes, helping the performance and automatically transporting the user to a certain location (Deonalt et al, 2011).

Research on the design of a wheelchair that combines a trolley in front of a wheelchair has not existed in Indonesia. The author here wants to redesign the wheelchair as well as the driving

[1] Industrial Engineering Department, Faculty of Engineering, Universitas Pembangunan Nasional Veteran Jakarta, Jl. RS Fatmawati Pondok Labu Jakarta Selatan, 12450
[2] Electrical Engineering Department, Faculty of Engineering, Universitas Pembangunan Nasional Veteran Jakarta, Jl. RS Fatmawati Pondok Labu Jakarta Selatan, 12450

[a] email: nurfajriah@upnvj.ac.id
[b] email: mrw@upnvj.ac.id
[c] email: halimmahfud@gmail.com
[d] email: frahayu0205@gmail.com
[e] email: dwieachmad14@gmail.com
[f] email: renesha.fitri@gmail.com
[g] email: dinda.meimana@upnvj.ac.id
◆ corresponding author

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mechanism, such as the shape of the chair, armrests, footrests, and trolley hooks on the wheelchair and installing an introductory screw chain as an automatic mechanism. The used product attributes are derived from the ergonomics aspect of ENASE (Effective, Comfortable, Safe, Healthy and Efficient). Based on ENASE principle, we can see the consumer's needs for the product, then the design of the trolley is based on the needs of the respondents who pay attention to the comfort of their use (El Ahmady, et al, 2020). The comfort of an ergonomic chair is influenced by several things, including the height of the chair, the width of the chair, and the material used in making the chair to make it comfortable and prevents fatigue in its operation (Abobakr et al., 2019). To get the wanted comfortable seat, it is necessary to have a seat size that fits the user's body size based on Anthropometry (Mistarihi, 2020) (Taifa & Desai, 2017). With the appropriate size for the body parts of the seat user, the factors that cause fatigue-problem can be solved so it does not cause fatigue to come too quickly for the long-time seat user, by also paying attention to ergonomic aspects in designing the passenger seat (Purnamayudhia et al 2020; Akbar et al, 2013). Based on the results of a survey conducted by distributing about 22 questionnaires to vehicle users who observe disability, 80% of them still complain that disabled wheelchairs are uncomfortable, their features do not accommodate the needs of disabled people such as shopping. (Liansari et al. 2018)

In this study, the EFD method is used to design a trolley according to the respondents' needs. EFD is a development of QFD by adding a new relationship between consumer desires and the ergonomic aspects of the product (Hasibuan et al, 2017).

II. Research Method

The first stage in research on the design of disability chairs. At this stage, the statement of problems is related to things that disabled people need, especially for shopping at the market/supermarket. In this research we collect several raw datas. Raw datas in research includes: 1. Anthropometry data 2. Respondents' characteristic data 3. Product attribute data.

The next step is to collect data by observing and interviewing at one of the foundations that accommodate disabled people, the Wisma Cheshire Indonesia Foundation, which is located in South Jakarta. Then the Likert scale is also used to measure attitudes, opinions, and perceptions of a person or group of people about social phenomenon (Gauthier & Lagacé, 2015). With Likert scale, the measured variables are translated into variable indicators. Then the indicator is used as a starting point for compiling instrument items which can be in the form of questions or statements (Jasiak & Dewicka, 2015). After identifying consumer needs, a questionnaire was conducted for members of the Wisma Cheshire Indonesia Foundation from the results of interviews and the results of respondents to answer the questionnaire. An open questionnaire was created with the aim to know the product specifications that is needed by consumers. The next step is to test the validity and reliability to measure whether or not a questionnaire is valid (Deros et al., 2015).

The next step is to calculate the value of Ergonomic Function Deployment (EFD). The calculation of EFD value is done by identifying consumer needs and making a matrix plan (Planning Matrix) (Luansing et al., 2015). Then it proceeded with processing anthropometric data which includes various sizes of the human body such as weight, position when standing, when stretching your arms, body circumference, leg length, and so on (Hashim & Dawal, 2012). Anthropometric data used in this study is secondary data, obtained from the website anthropometri.org (El Ahmady, et al, 2020)

After obtaining the dimensions required for processing anthropometric data, an ergonomic wheelchair and trolley product design was carried out based on the dimensions obtained and consumer needs.

III. Result and Discussion

Anthropometric data is very necessary in

designing a product. Anthropometric data can also determine the size, shape, and dimensions which suitable for the physical condition of the user (Taifa & Desai, 2017). The appropriate Anthropometric data is obtained from Indonesian Anthropometric data with predetermined dimensions.

Validitity Test

Validity test is used to measure whether or not a questionnaire is valid. To test the validity of the question items with a value of n = 22 having a correlation r count greater than 0.4044, the data is valid. The test results of the statement items is shown in the Table 1.

Table 1. Validity Test

Statement	Correlation of coefficient (r)	r-table	Validity
Effective			
X1	0,702	0,4044	VALID
X2	0,757	0,4044	VALID
X3	0,835	0,4044	VALID
X4	0,552	0,4044	VALID
Comfortable			
X5	0,813	0,4044	VALID
X6	0,835	0,4044	VALID
X7	0,736	0,4044	VALID
Safe			
X8	0,716	0,4044	VALID
X9	0,768	0,4044	VALID
X10	0,704	0,4044	VALID
X11	0,835	0,4044	VALID
X12	0,849	0,4044	VALID
X13	0,816	0,4044	VALID
Efficient			
X14	0,725	0,4044	VALID
X15	0,704	0,4044	VALID
X16	0,742	0,4044	VALID
X17	0,766	0,4044	VALID
Healthy			
X18	0,882	0,4044	VALID
X19	0,926	0,4044	VALID

Statement items that have a correlation coefficient of r count 0.4044 for n = 22, then the data is declared valid. To test the validity of the statement items on the questionnaire, it was done by analyzing the statements of 5 variables which contained 19 statements from 22 respondents.

Reliability Test

Reliability test is used to measure the level of consistency of the questionnaire. Reliability test is done by using the Cronbach's alpha (α) coefficient (Eldar & Fisher-Gewirtzman, 2019) (see Table 2).

Table 2. Reliability Test

Variable	α	Limit of Cronbach's Alpha	Reliability
Effective	0,683		Reliable
Comfortable	0,697		Reliable
Safe	0,863	0,6	Reliable
Efficient	0,707		Reliable
Healthy	0,769		Reliable

From the results of reliability test conducted on the data that we have, the effective variable has = 0683, the comfortable variable has = 0.697, the safe variable has = 0.863, the Efficient variable has = 0.707, and the healthy variable has = 0.769. Therefore, the whole variable has a reliability coefficient value of Cronbach's Alpha > 0.6 then the results of the processed data are considered to be reliable.

Ergonomic Function Deployment (EFD)

Ergonomic Identification of Consumer Needs is derived based on 5 aspects of ENASE ergonomics (Zhang et al., 2014). as shown in Table 3.

Composing a Planning Matrix

The next step is to create a planning matrix by calculating ITC (Importance to Customer), CSP (Customer Satisfaction Performance), Goal, IR (Importance Rating), SP (Sales Point), RW (Raw Weight), NRW (Normalized Raw Weight) and prioritizing consumer needs. This data is obtained from the questionnaire and applied in the HOQ (House of Quality). The results of the preparation are as in Table 4.

Identifying Matrix Requirements

The next stage is the identification of technical requirements that are derived based on product attributes (customer needs) contained in the table below. Technical requirements consist of metrics and metric values (units) (Bitan et al., 2019). The results of the identification of technical requirements are in Table 5.

Table 3. Identification of Consumer Needs

No	Aspect	Variable	Product attribute (*Customer Needs)*
1	Effectiveness	Effective in developing wheelchair by completing the walk of wheel and adding the function of wheelchair	Wheelchair is completed with controlling mechanism to move forward and backward Wheelchair can turn Wheelchair can be run automatically Wheelchair is completed with additional trolley basket
2	Comfortable	Comfortable in developing wheelchair by making a not so narrow seat and paying attention to the comfort of wheelchair	Comfortable space between the chair and the feet Width of the backrest of the wheelchair is comfortable and suitable with body dimension Wheelchair is completed with fluffy backrest and seat
3	Safe	Safety is applied in wheelchair by developing locking system and materials from wheelchairs	Wheelchair and trolley is completed with locking-system A brake is put to control the speed of the trolley Chair and trolley is completed with strong material Wheelchair is able to pass through a rough road Wheelchair is completed with anti-rust material Wheelchair is completed with fire-proof material
4	Efficient	Eficiency is applied in wheelchair by making an easier process for the wheelchair work mechanism	Energy efficiency (little energy to move the trolley-wheelchair) Trolley can be easily taken out from the wheelchair Wheelchair and trolley can be easily taken care of Wheelchair can be easily lifted
5	Healthy	Health is applied in wheelchair by reduciang the work-load	The product is saved for the body posture of the user The load inside the trolley doesn't add the user's-load (can be run automatically)

Table 4. Planning Ma Table 6. Identification Relationship Ergonomic Customer Needs trix

No.	***Customer Needs***	**ITC**	**CSP**	***Goal***	**IR**	**SP**	**RW**	**NRW**	**Priority**
1	Wheelchair is completed with controlling mechanism to move forward and backward	4	3,77	4,00	1,06	1,20	4,80	0,04412	16
2	Wheelchair can turn	4	3,77	4,00	1,06	1,00	4,00	0,03676	18
3	Wheelchair can be run automatically	3	3,41	4,00	1,17	1,50	6,00	0,05515	1
4	Wheelchair is completed with additional trolley basket (opening additional trolley)	3	3,27	4,00	1,22	1,50	6,00	0,05515	2
5	Comfortable space between the chair and the feet	3	3,32	4,00	1,21	1,20	4,80	0,04412	9
6	Width of the backrest of the wheelchair is comfortable and suitable with body dimension.	4	3,45	4,00	1,16	1,20	4,80	0,04412	10
7	Wheelchair is completed with fluffy backrest and seat	4	3,55	4,00	1,13	1,50	6,00	0,05515	3
8	Wheelchair and trolley is completed with locking-system	4	3,59	4,00	1,11	1,50	6,00	0,05515	4
9	A brake is put to control the speed of the trolley	4	3,50	4,00	1,14	1,50	6,00	0,05515	5
10	Chair and trolley is completed with strong material	4	3,68	4,00	1,09	1,50	6,00	0,05515	6
11	Wheelchair is able to pass through a rough road	4	3,27	4,00	1,22	1,50	6,00	0,05515	7
12	Wheelchair is completed with anti-rust material	4	3,73	4,00	1,07	1,20	4,80	0,04412	11
13	Wheelchair is completed with fire-proof material	3	3,41	4,00	1,17	1,20	4,80	0,04412	12
14	Energy efficiency (little energy to move the trolley-wheelchair)	4	3,45	4,00	1,16	1,50	6,00	0,05515	8
15	Trolley can be easily taken out from the wheelchair	4	3,77	4,00	1,06	1,20	4,80	0,04412	17
16	Wheelchair and trolley can be easily taken care of	3	3,41	4,00	1,17	1,20	4,80	0,04412	13
17	Wheelchair can be easily lifted	4	3,55	4,00	1,13	1,00	4,00	0,03676	19
18	The product is saved for the body posture of the user	4	3.32	4.00	1.21	1.20	4.80	0.04839	14
19	The load inside the trolley doesn't add the user's-load (can be run automatically)	4	3.45	4.00	1.16	1.20	4.80	0.04839	15

Identifying the Relationship between Consumer Ergonomic Needs and Technical Requirements

In this stage, the identification of the relationship between the ergonomic customer needs is listed in Table 5.4 and the technical requirements contained in the table, there are 4 types of weights used in the identification of this relationship which are shown in Table 6.

Table 6. Identification Relationship Ergonomic Customer Needs

Relation	Weight	Symbol	Relation	Weight	Symbol
No relation	0	(Blank)	Medium relation	3	□
May contain relation	1	△	Very strong relation	9	○

No.	Relation	Load	Description
1	1-A	0	wheelchair is completed with controlling mechanism to move forward and backward and has no relation with dimension of wheelchair
2	1-B	0	wheelchair is completed with controlling mechanism to move forward and backward and has no relation with dimension of wheelchair
3	1-C	1	wheelchair is completed with controlling mechanism to move forward and backward and barely pays attention to additional function
4	1-D	0	wheelchair is completed with controlling mechanism to move forward and backward and has no relation with dimension of wheelchair
5	1-E	9	wheelchair is completed with controlling mechanism to move forward and backward and is related to wheel mechanism
6	1-F	0	wheelchair is completed with controlling mechanism to move forward and backward and has no relation with dimension of wheelchair
7	2-A	1	Wheelchair can turn and barely pays attention to dimension of wheelchair
8	2-B	1	Wheelchair can turn and barely pays attention to the used wheelchair material
9	2-C	0	Wheelchair can turn and has no relation with additional function.
10	2-D	0	Wheelchair can turn and has no relation with locking system
11	2-E	3	Wheelchair can turn and barely affected by wheel mechanism
12	2-F	0	Wheelchair can turn and has no relation with energy and effort
13	2-A	0	Wheelchair can be run automatically and has no relation with dimension of wheelchair
14	3-B	0	Wheelchair can be run automatically and has no relation with the used wheelchair material
15	3-C	9	Wheelchair can be run automatically and very affected by additional function.
16	3-D	1	Wheelchair can be run automatically and barely pay attention to locking system
17	3-E	0	Wheelchair can be run automatically and has no relation with wheel mechanism
18	3-F	3	Wheelchair can be run automatically and barely affected by energy and effort
19	4-A	0	Wheelchair is completed with additional trolley basket and has no relation with dimension of wheelchair
20	4-B	0	Wheelchair is completed with additional trolley basket and has no relation with the used wheelchair material
21	4-C	9	Wheelchair is completed with additional trolley basket and very affected by additional function.
22	4-D	0	Wheelchair is completed with additional trolley basket and has no relation with locking system
23	4-E	0	Wheelchair is completed with additional trolley basket and has no relation with wheel mechanism
24	4-F	1	Wheelchair is completed with additional trolley basket and barely pays attention to energy and effort
25	5-A	9	Comfortable space between the chair and the feet is very affected by the dimension of the wheelchair
26	5-B	3	Comfortable space between the chair and the feet is barely affected by the used wheelchair material
27	5-C	0	Comfortable space between the chair and the feet has no relation with additional function
28	5-D	0	Comfortable space between the chair and the feet has no relation with locking system.
29	5-E	0	Comfortable space between the chair and the feet has no relation with wheel mechanism
30	5-F	0	Comfortable space between the chair and the feet has no relation with energy and effort.

Table 6. Identification Relationship Ergonomic Customer Needs (contd.)

31	6-A	9	Width of the backrest of the wheelchair is comfortable and suitable with body dimension is very affected by dimension of wheelchair
32	6-B	9	Width of the backrest of the wheelchair is comfortable and suitable with body dimension is very affected by the used wheelchair material
33	6-C	0	Width of the backrest of the wheelchair is comfortable and suitable with body dimension and has no relation with additional function
34	6-D	0	Width of the backrest of the wheelchair is comfortable and suitable with body dimension and has no relation with locking system
35	6-E	0	Width of the backrest of the wheelchair is comfortable and suitable with body dimension and has no relation with wheel mechanism
36	6-F	0	Width of the backrest of the wheelchair is comfortable and suitable with body dimension and has no relation with energy and effort.
37	7-A	9	Wheelchair is completed with fluffy backrest and seat and is really affected by dimension of the wheelchair.
38	7-B	9	Wheelchair is completed with fluffy backrest and seat and is really affected by the used wheelchair material
39	7-C	0	Wheelchair is completed with fluffy backrest and seat and has no relation with additional function.
40	7-D	0	Wheelchair is completed with fluffy backrest and seat and has no relation with locking system
41	7-E	0	Wheelchair is completed with fluffy backrest and seat and has no relation with wheel mechanism.
42	7-F	0	Wheelchair is completed with fluffy backrest and seat and has no relation with energy and effort
43	8-A	0	Wheelchair and trolley is completed with locking-system and has no relation with dimension of wheelchair.
44	8-B	0	Wheelchair and trolley is completed with locking-system has no relation with the used wheelchair material
45	8-C	0	Wheelchair and trolley is completed with locking-system and has no relation with additional function
46	8-D	9	Wheelchair and trolley is completed with locking-system and is really affected to locking system.
47	8-E	3	Wheelchair and trolley is completed with locking-system and barely affected by wheel mechanism.
48	8-F	0	Wheelchair and trolley is completed with locking-system and has no relation with energy and effort
49	9-A	0	A brake is put to control the speed of the trolley has no relation with dimension of wheelchair.
50	9-B	1	A brake is put to control the speed of the trolley and doesn't really pay attention to the used wheelchair material
51	9-C	0	A brake is put to control the speed of the trolley and has no relation with additional function
52	9-D	9	A brake is put to control the speed of the trolley and is really affected by locking system.
53	9-E	3	A brake is put to control the speed of the trolley and doesn't really pay attention to wheel mechanism.
54	9-F	0	A brake is put to control the speed of the trolley and has no relation with energy and effort
55	10-A	0	Chair and trolley is completed with strong material and has no relation with dimension of wheelchair.
56	10-B	9	Chair and trolley is completed with strong material and is really affected by the used wheelchair material.
57	10-C	0	Chair and trolley is completed with strong material and has no relation with additional function.
58	10-D	0	Chair and trolley is completed with strong material and has no relation with locking system.
59	10-E	0	Chair and trolley is completed with strong material and has no relation with wheel mechanism.
60	10-F	0	Chair and trolley is completed with strong material and has no relation with energy and effort.
61	11-A	0	Wheelchair is able to pass through a rough road and has no relation with wheelchair dimension.
62	11-B	9	Wheelchair is able to pass through a rough road and is really affected by the used wheelchair material.
63	11-C	3	Wheelchair is able to pass through a rough road and is not really affected by additional function
64	11-D	0	Wheelchair is able to pass through a rough road and has no relation with.
65	11-E	0	Wheelchair is able to pass through a rough road and has no relation with wheel mechanism.
66	11-F	0	Wheelchair is able to pass through a rough road and has no relation with energy and effort.
67	12-A	0	Wheelchair is completed with anti-rust material and has no relation with dimension of wheelchair.
68	12-B	9	Wheelchair is completed with anti-rust material and is really affected by the used wheelchair material.
69	12-C	1	Wheelchair is completed with anti-rust material barely pays attention to additional function

Table 6. Identification Relationship Ergonomic Customer Needs (contd.)

70	12-D	0	Wheelchair is completed with anti-rust material and has no relation with locking system.
71	12-E	0	Wheelchair is completed with anti-rust material and has no relation with wheel mechanism.
72	12-F	0	Wheelchair is completed with anti-rust material and has no relation with energy and effort.
73	13-A	0	Wheelchair is completed with fire-proof material and has no relation with wheelchair dimension.
74	13-B	9	Wheelchair is completed with fire-proof material is really affected by the used wheelchair material.
75	13-C	1	Wheelchair is completed with fire-proof material and additional function
76	13-D	0	Wheelchair is completed with fire-proof material and has no relation with locking system.
77	13-E	0	Wheelchair is completed with fire-proof material and has no relation with wheel mechanism.
78	13-F	0	Wheelchair is completed with fire-proof material and has no relation with energy and effort.
79	14-A	0	Energy efficiency (little energy to move the trolley-wheelchair) has no relation with wheelchair dimension.
80	14-B	0	Energy efficiency (little energy to move the trolley-wheelchair) has no relation with the used wheelchair material.
81	14-C	0	Energy efficiency (little energy to move the trolley-wheelchair) has no relation with additional function
82	14-D	0	Energy efficiency (little energy to move the trolley-wheelchair) has no relation with locking system.
83	14-E	0	Energy efficiency (little energy to move the trolley-wheelchair) has no relation with wheel mechanism.
84	14-F	9	Energy efficiency (little energy to move the trolley-wheelchair) is really affected by energy and effort.
85	15-A	0	Trolley can be easily taken out from the wheelchair and has no relation with wheelchair dimension.
86	15-B	1	Trolley can be easily taken out from the wheelchair and barely pays attention to the used material.
87	15-C	0	Trolley can be easily taken out from the wheelchair and has no relation with additional function
88	15-D	0	Trolley can be easily taken out from the wheelchair and has no relation with locking system.
89	15-E	0	Trolley can be easily taken out from the wheelchair and has no relation with wheel mechanism.
90	15-F	9	Trolley can be easily taken out from the wheelchair and is really affected by energy and effort.
91	16-A	0	Wheelchair and trolley can be easily taken care of and has no relation with wheelchair dimension.
92	16-B	0	Wheelchair and trolley can be easily taken care of and has no relation with the used material.
93	16-C	1	Wheelchair and trolley can be easily taken care of and barely pays attention to additional function
94	16-D	0	Wheelchair and trolley can be easily taken care of and has no relation with locking system.
95	16-E	0	Wheelchair and trolley can be easily taken care of and has no relation with wheel mechanism.
96	16-F	0	Wheelchair and trolley can be easily taken care of and has no relation with energy and effort.
97	17-A	0	Wheelchair can be easily lifted and has no relation with wheelchair dimension
98	17-B	3	Wheelchair can be easily lifted and is not really affected by the used wheelchair material.
99	17-C	1	Wheelchair can be easily lifted and and barely pays attention to additional function
100	17-D	0	Wheelchair can be easily lifted and has no relation with locking system.
101	17-E	0	Wheelchair can be easily lifted and has no relation with wheel mechanism.
102	17-F	0	Wheelchair can be easily lifted and has no relation with energy and effort.
103	18-A	9	The product is saved for the body posture of the user andis really affected by wheelchair dimension.
104	18-B	3	The product is saved for the body posture of the user and is not really affected by the used wheelchair material.
105	18-C	0	The product is saved for the body posture of the user and has no relation with additional function
106	18-D	0	The product is saved for the body posture of the user and has no relation with locking system.
107	18-E	0	The product is saved for the body posture of the user and has no relation with wheel mechanism.
108	18-F	0	The product is saved for the body posture of the user and has no relation with energy and effort.
109	19-A	0	The load inside the trolley doesn't add the user's-load (can be run automatically) and has no relation with wheelchair dimension.
110	19-B	0	The load inside the trolley doesn't add the user's-load (can be run automatically) and has no relation with the used wheelchair material.
111	19-C	1	The load inside the trolley doesn't add the user's-load (can be run automatically) and and barely pays attention to additional function
112	19-D	3	The load inside the trolley doesn't add the user's-load (can be run automatically) and is not really affected by locking system.
113	19-E	3	The load inside the trolley doesn't add the user's-load (can be run automatically) and is not really affected by wheel mechanism.
114	19-F	9	The load inside the trolley doesn't add the user's-load (can be run automatically) and is really affected by energy and effort.

Identification of Relationships Between Technical Requirements

The next stage is identifying the relationship between the technical requirements contained in the table above. In this stage there are 4 types of weights used in the identification of this relationship which are shown in Table 7.

Composing Technical Requirements Matrix

The next stage is composing the technical requirements matrix. In the process of composing the planning matrix, calculation of contribution, normalized contribution and determination of the priority of technical requirements is carried out. The results of the composing of technical requirements matrix are shown in Table 8.

Improvement

Based on the results of data processing on the needs of the Ergonomic Function Deployment (EFD) results, it is found that the identification of consumer needs is derived based on 5 aspects of ergonomics ENASE. Effectiveness in the development of this wheelchair is reached by complementing the wheel speed and adding additional functions of the wheelchair. The development of this wheelchair is paying attention to the comfort of the wheelchair and making sure that the size of the wheelchair is enough and not too narrow. Safety that is applied to the development of a wheelchair is by locking system and materials (Sylla et al., 2014). Applied efficient to wheelchairs, is by simplifying the mechanism of the wheelchair's work process and

Table 7. Relationships Between Technical Requirements

Relation	Weight	Symbol	Relation	Weight	Symbol
No relation	0	(Blank)	Medium relation	3	□
May contain relation	1	△	Very strong relation	9	○

No.	Interaction	Weight	Description
1	A-B	3	There is a medium relation between wheelchair dimension with the used wheelchair material.
2	A-C	9	There is a strong relation between wheelchair dimension and additional function.
3	A-D	0	There is no relation between wheelchair dimension and locking system.
4	A-E	1	There may be a relation between wheelchair dimension and wheel mechanism.
5	A-F	0	There is no relation between wheelchair dimension and energy and effort.
6	B-C	3	There is a medium relation between the used wheelchair material and additional function.
7	B-D	0	There is no relation between the used wheelchair material and locking system.
8	B-E	1	There may be a relation between material the used wheelchair material and wheel mechanism.
9	B-F	3	There is a medium relation between the used wheelchair material with energy and effort.
10	C-D	9	There is a very strong relation between additional function and locking system.
11	C-E	3	There is a medium relation between additional function and wheel mechanism.
12	C-F	9	There is a very strong relation between additional function with energy and effort.
13	D-E	9	and
14	D-F	3	There is a medium relation between locking system with energy and effort.
15	E-F	3	There is a medium relation between wheel mechanism with energy and effort.

Table 8. Composing Technical Requirements Matrix

Code	Technical statement	*Contribution*	*Normalized Contribution*	Priority
A	Effective	5,20	0,05242	2
B	Comfortable	5,20	0,05	3
C	Safe	5,60	0,05645	1
D	Efficient	4,90	4,90	5
E	Healthy	4,80	4,80	4

the convenience of the wheelchair. The health that is applied to the development of this wheelchair is that it reduces the workload when it is added to the trolley function (see Fig. 1).

Figure 1. Design of wheelchair with the trolley function

The design proposal is assessed based on several factors of importance and priority. The wheelchair can be run automatically which is needed in a wheelchair with an electric design, and increasing the ability of a wheelchair with an ergonomic push trolley can increase the capabilities of the device. Wheelchairs and Trolleys are designed based on Indonesian anthropometric data.

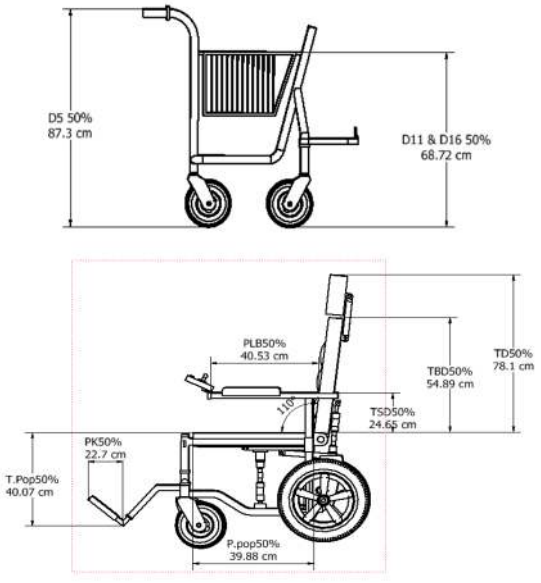

Figure 2. Dimension of wheelchair

Wheelchairs and trolleys are designed based on ergonomic activities and operator comfort for both disabled people and normal people. Both sides of the trolley can be used as handles. As it is seen in Figure 2, the trolley on the right can be controlled by persons with disabilities with a locking handle for the wheelchair trolley and on the left it can be controlled by normal people with adjustable size standards. The distance between the wheelchair and the trolley is easy to reach and easy to adjust (adjustable). With the design, it is hoped that the problems of disabled people can be resolved and can be mass produced for disabled people to have the right and youth to shop in supermarkets calmly without feeling difficult.

IV. CONCLUSION

Judging from the Ergonomic function Deployment (EFD) based on the variables that become the priority of product design, such as trolley aids for disabled people that run automatically, have an additional trolley basket (opening an additional trolley), have a backrest and a soft seat, and have a strong locking system that makes it easy to use so it can facilitate users with a weight of 0.06048. The obtained result is a design of a trolley for ergonomic disabled people according to their needs with dimensions of 60 x 60 cm.

Judging from the Ergonomic Function Deployment (EFD) based on the identification of consumer needs, it is derived based on 5 aspects of ENASE ergonomics. Effectiveness in the development of this wheelchair is reached by complementing the wheel speed and adding additional functions of the wheelchair. The development of this wheelchair is paying attention to the comfort of the wheelchair and making sure that the size of the wheelchair is enough and not too narrow. Safety that is applied to the development of a wheelchair is by locking system and materials from the wheelchair. Applied efficient to wheelchairs, is by simplifying the mechanism of the wheelchair's work process and the convenience of the wheelchair. The

health that is applied to the development of this wheelchair is that it reduces the workload when it is added to the trolley function.

The priority of consumer needs (Customer Needs) from the results of the HOE design are 3,4,7,8,9.10,11,14,5,6,12,13,16,18,19,1,15,2, and 17 and the Priority of Technical Requirements from the results of the HOE design are C, A, B, E and D.

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