

Design of garbage picking up tool at mangrove ecopark in North Jakarta

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Abstract. Well managed visitor destination is an important key to pursuing sustainability in tourism. There are several issues to achieve the goals, and one of the important things is sanitation. It is vital to equip the maintenance facility team with a tool to help their duty well. In this research, a waste grabber in Mangrove Eco-park is designed for that purpose. The problem was found is the distance from visitor's bridge to the ground that makes cleaning staff difficult to reach and pick the garbage. To collect the discarded item, they need to step down the bridge which takes more than 3 minutes and it is not convenient because of the wet swamp. This research uses 4-phase product design which 3 alternative concepts are designed in the form of picking up tools and 2 prototypes that had gone through the evaluation phase until later become a finished product. It has features to hold 250 cm picker in steady position by placing it on the fence of the bridge. Due to its length, storing and carrying the device becomes another issue. These problems can be solved by creating a folding mechanism. Evaluation is conducted by the janitor after they test the product and fill out the questionnaire. From the questionnaire, the performance value of the tools is measured in function, with the value of the grabber tools performance rating is 4.3 which is high because of having good waste capture and easy to use.

Keywords: picking up tools, product design

I. Introduction

Mangrove eco-park faces at least 2 kinds of function, as a natural conservation and tourist destination. The beautiful and well-managed spot will attract visitors to come and spend their time there. This will increase pressure to the environment that people might deteriorate and decrease the quality of the environment, such as littering. Therefore, the mangrove area must be kept clean so there is no unpleasant smell and uncomfortable experience. The long-term goal should be sustainable tourism where there are four important criteria that should be kept in mind [1]. By applying the principle of responsibility, it will benefit the local community at the end [2]. In this park, trash was difficult to reach by hand or common tools. Hence, the environmental issue is the main trigger of the product development which already gains attention for a long time [3]. The problem in Mangrove Ecopark is littering which causes the difficulty to reach the waste under the visitor bridge with a distance of 200 cm from the



ground. This problem also causes the janitor to go down the bridge to the swamp and the time required is up to 3 minutes. Moreover, the worker has to deal with the unpleasant land condition because of the surface of wet soil and swamps that have water depths up to 50 cm. The research is a focus to design a tool that can reach the item in radius 250 cm..

2. Methodology

All the activities of the research are illustrated in figure 1, with the first step is to find information about product development. Next phase is the problem statement, aim and goal, and literature. The core of this research is a process of designing and making the product. The activity also including searching online for the existing product of the grabber tool, making the voice of the customer (Voice of Customer). Because the end user is the workers that involve in daily operation, that is essential to know the main needs of customers about the product to be made, especially for the new one [4]. After that, the House of Quality is made to transform the level of interest of the consumer's voice and the development of ideas for the product to design the concepts of the grabber tool. Then, three different design alternatives are developed according to VOC. Phase 2 is to make the system level design to develop the form of the product so there would not be the faulty mechanism. At the 3rd phase which is ergonomic study, to gather anthropometric data for Indonesian people with the characteristics of an adult male to analyze and develop the product so that the product is easy and comfortable to use. Next is creating 3D product images complete with dimensions and product details. The forth phase is an evaluation stage by testing the prototype to discover is there any faulty design, and it's discovered that the prototype has a good functionality and the only problem is the weight of the product because of the material. The refinement is to change the material with a lighter one and so aluminium is used for the final product. Next is the evaluation of the product, product testing is done with the user at the site and to gather feedback with a questionnaire to the janitors of eco-park so the result of the questionnaire can be used to develop performance rating of the product.

The last step of this research is summary and suggestion. This section is the final stage of the study, where conclusions are made to answer the predetermined research objectives. In this section also provided a recommendation for further research activities.

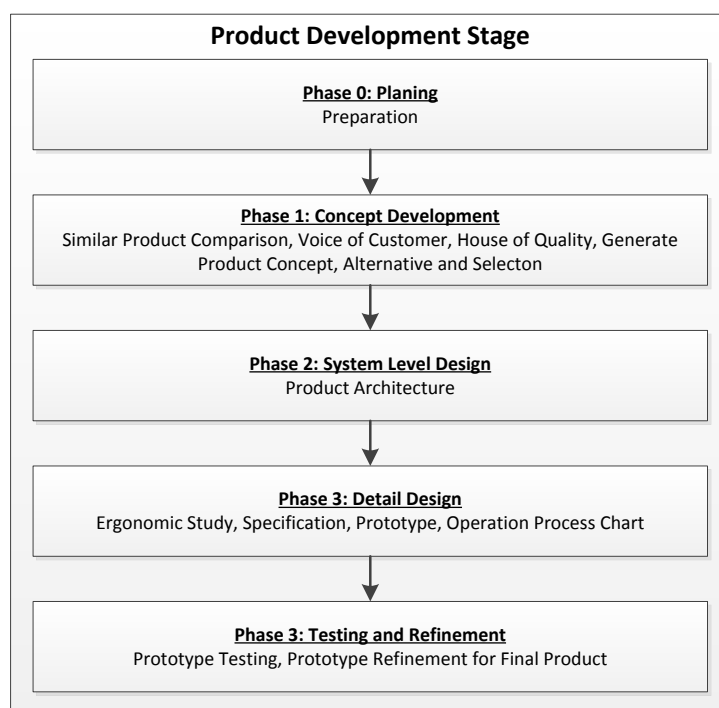


Figure 1. Product Development Phase

3. Product Development Phase

In this section consists of a description of the design and development of the product [5]. It starts with concept development in phase 1, system-level design in phase 2, detailed design in phase 3, test and refinement in final phase 4.

3.1. Phase 0 (Product Planning).

The initial stages of product development include such things as opportunity identification, user segmentation, and mission statement. At Mangrove Ecopark as a place where people gather for leisure is often found garbage scattered on some spots. Not only give long negative effect to the environment, however, this situation, in turn, will create an unpleasant view for the visitors. Therefore, it is very challenging for the management to make the clean environment, natural preservation, and local tourist destination at the same time. Moreover, some part in the conservation is wet, and that is why for certain type of trash is difficult to reach by hand or common tools.

Developing of grabber tool will be made based on the voice of the user to help the janitors clean up the garbage under the bridge. There is a gap between the bridge and the ground that cannot be reached by hand or common tool. The design of the tool is customized to meet the job's requirement. First, after the observation, the product should have the length of 250 cm. The second one is the core benefit proposition which to clean the garbage that is littered under the bridge. The third is the tool must be easy to use by the cleaning staff.

3.2. Phase 1: Concept Development

Concept development consists of identification of similar product products, identification of user needs, development of concept selection and concept testing. This stage is expected to build the concept of grabber tools and provide added value in accordance with the needs of users. The principle of as make the prototype as simple as possible is an important consideration in the early stage [6].

One of the important approaches here is to evaluate the similar existing product. Although this product is not for sale, product design requires analysis of existing similar products in order to know their strengths and weaknesses. It is common that in practical company follow the market leader and imitating the current product technology [7]. It is found that the waste taker tools with other products that have a similarity. Given the advantages that exist in similar products, it is expected that the designed products have similar advantages and eliminate the drawbacks that exist in similar products. Following similar products from the garbage pickup tool are long arm garden kitchen stick and waste grabber tool. The first one has the advantages of the foldable body which is very convenient for carrying and storing the tool. Meanwhile, it has its drawbacks which are the grabber is not suitable for all-purpose and the body length is only 75 cm which can not be used for huge distance in eco-park. Next one has the advantage of simple, easy to use and the grabber is big. These features really help with taking various forms of garbage. Still, it has its drawbacks such as the body is not foldable unlike the long arm garden kitchen stick and the body length is only 100 cm which cannot be used for huge distance in that area.

The identification of user needs includes user data collection, data interpretation which then becomes customer statement, hierarchy needs grouping (Voice of Customer), then the determination of the importance of requirement. Data collection is obtained from interviewing the cleaning officers, with the purpose to get information about the difficulties of taking garbage on the visitor's bridge.

Table 1 is a customer statement which also the statements are given in the questionnaire for the user to state the importance of each of the statements. Later the data will be used for generating a house of quality so that the focus of the product is known.

Table 1. Customer Statement

No	A statement that tools should be
1	For picking up.
2	Able to reach an item that is quite far
3	Have durability
4	Easy to move
5	Able to pick up a plastic bottle
6	Able to take small packaging
7	Able to take paper waste
8	Ergonomic

House of Quality describes the importance between the technical response and customer statements. The statement in the questionnaire is answered in the form of an interest level which will become the importance of the statement of the user.

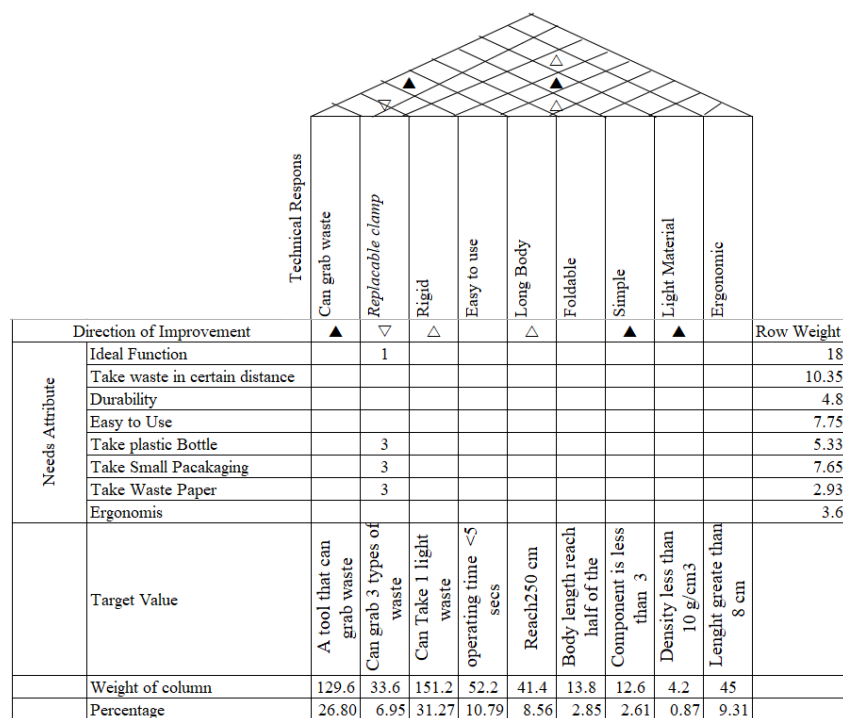


Figure 2. House of Quality

Figure 2 shows the first house of quality (HOQ) that describes the important relation between technical response and customer statements. The HOQ above shows the technical response aspects of “material is rigid” associated with the “ideal function” has the highest value of 31.27 and the level of importance between the attribute needs and a strong technical response that is 9. Followed by the relationship of the technical response “can grab the garbage” and “ideal function” with a value of 26.80 and a strong level of relationship that is 9 so that from this HOQ can be known that the material is rigid is the most important for this product development.

Figure 3 shows the second HOQ which describes the importance between critical components and technical response so that the development can be focused on particular components. The results show that the “clamp” part has the highest value at 543.42, so this part is the highest priority component. Then followed by the body of the component at 419.11. The third critical component is the body of the trigger at 152.98 and the last is the trigger at 151.86.

		Critical Part				
		Body	Body of Trigger	Trigger	Clamp	Weight
Technical Response	Able to grab waste				9	26.80
	Replaceable clamp				3	6.95
	Durable	9	3	1	9	31.27
	Easy to use	3		9		10.79
	Long boy	9	3			8.56
	Foldable	9	9			2.85
	Simple		3	9		2.61
	Light	3				0.87
	Ergonomy	9		3		9.31
	Column Weight	419.11	152.98	151.86	543.42	
	Percentage	33.07	12.07	11.98	42.88	

Figure 3. Second House of Quality

The grabber tool that will be made is developed in advance the concept of VOC-based data for the final product in accordance with the needs. Some concepts prioritize important things like House of Quality, then on the development of this product concept consists of searching externally, internally, and systematically. Generating product concept internally includes brainstorming from the developer team about what will be designed, such as clamping design, body, trigger body, and trigger. The results of this brainstorming will be an alternative concept that will be selected alternatives to be finished products. Generating product concept systematically is intended to get an alternative design of grabber tool. The design of the product will show the aspects that exist in the HOQ so that the designer knows what is important for the user.

Selection of concepts based on Failure Mode and Effect Analysis (FMEA) which can be applied not only to the product but also to the system [8]. FMEA itself is a systematic method used to analyse the failure of a product in which FMEA focuses on the reliability of a product whether the product is vulnerable or resistant to failure. The early step is to identify the severity, probability, and detection. These tools help to show the risk value to each alternative.

Three alternatives were generated and the next step is to evaluate the FMEA of each alternative. The first alternative has 80% medium risk and 20% low risk, the second alternative has 83.3% medium risk and 16.7% low risk, and the last one has 16.7% medium risk and 83.3% medium risk. The goal of this analysis is to select the least risk and the third alternative has it.

3.3. Phase 2: System Level Design

This step is a system-level design stage that details the entire section. System level design is required so that components can be known throughout the size and can describe the function so that the mechanism of the tool can be known. Where in this tool consists of:

A. Clamp

The clamp is the main component in this tool which serves to be the objective part which is to take garbage. The clamping architecture is designed so that the potential for failure can be prevented because in this part of the clamp will get a lot of pressure and load from the object.

B. Body

The body of the tool serves as the framework for this tool and it is this body which gives the function of the extension of the hand. Body tool is designed simple straight with the use of a strong hollow iron but also lightweight so as to withstand the load given the object of the waste. In the centre of the body, it has a hinge so the tool can be folded.

C. Trigger and Trigger Body

The trigger body is a component that serves to transfer the power input from the operator to the clamp, where the operator pulls the trigger tool, the tool will clamp the object and when the trigger is removed, the clamp will open again with the help of the spring.



Figure 4. Grabber Tool Design

3.4. Phase 3: Detail Design

The detailed design phase is the stage after the confirmed final design of the three alternatives that have been planned. At this stage conducted ergonomic studies, material selection, component design, prototype manufacturing, and finished products.

An ergonomic study based on anthropometry data is done so that the design of the tool adjusts the human body with the aim of help the users do not get tired quickly. With Indonesian adult male and female anthropometric data, the design of this product has the width of the hand is relevant to the design of the grabber tool on the bottom handles: 5% percentile data which has 7 cm and 6 cm wide breadth, then a 50% percentile with a width of 9 cm and 8 cm, and a 95% percentile at 11 cm and 10 cm, with a standard deviation of 1.09 cm and 4.85 cm[9]. After some consideration, tool design on the bottom of the handle is made along the 8 cm to adjust anthropometry.

Material studies are needed to establish the right materials for applied tools. Adjusting to the design mentioned in the sub-section of component planning, the strong material with the aspect of the sturdy and lightweight materials becomes a consideration in the design of this product. The material used for this tool are iron, aluminium, and wood. The wood material will be used for designing the prototype.

Bill of material is developed to show the components used to make one product of a grabber tool. Bill of material also describes the level of the component where it can describe where the components are placed on some level.

Table 2. Bill of Material

1	Level	Item	Number
1	0	Clamp	1
2	1	Clamp Edge	1
3	2	Aluminium Plat	4
4	2	Hinge	5
5	2	Rubber	1
6	1	Body	1
7	2	Aluminium Hollow	1
8	2	Hinge	1
9	3	Trigger Body	1
10	3	Trigger	1

4. Prototype Development

The making of prototypes needs to be planned in detail in order to make the product accurate and make it easier to detect the faults and drawbacks of a product. Table 3 describes the difference between prototype Alpha and Beta. The two important things on this table are the type of material and dimension. The first one is a wood scale product

Table 3. Prototype

Prototype name	Material	Dimension
Alpha	Wood	Scale
Beta	Iron	Real

Two prototypes are developed which the first is called an Alpha prototype. The alpha prototype is made using woods and the purpose of this prototype is to show the mechanism and function of the product so it doesn't have to use the real material and dimension for economic purpose.



Figure 5. Alpha and Beta Prototype

The beta prototype was shown on the right side in figure 5 is made with the real dimension and materials to take waste with full functionality. The beta prototype weighs 1.3 kg with the total length of 259 cm, the total width of 17 cm, and height of 8 cm.

Because the grabber tool is heavy and long, a complementary tool is designed. A complementary tool is a buffer tool which supports the use of grabber tool to eliminate the difficulty of using the long tool and its heaviness.



Figure 6. Buffer Tool

As seen in figure 6, the buffer tool has a lock to prevent the tool shifts place as it is being used. It can be locked on to the handrail of the visitor's bridge in eco-park. The head of the buffer tool has 360° rotation to provide free movement of the grabber tool.

5. Testing and Refinement

The testing and refinement is the final phase of product design that includes finalization of a product. Finalization of the product is a garbage grabber tool needs to pass the trial and refinement until eventually ready to be a finished product so there is no faulty product design.

The prototype testing was done by self-test by conducting tests to assess the functionality of the grabber tool. The test is completed by trying to simulate waste cleaning activities like taking garbage at a distance up to 2.5 meters until the garbage is successfully taken. From the test, it can be concluded that the function of the grabber tool is able to answer the statement on the aspect of taking the waste. The clamp can pick up trash or a small item with a load that does not exceed 2 kilograms. The important thing to be considered is the material is too heavy. The iron material used in the clamp is intended to hold its own weight, but the iron material has a weight that is still less than ideal for use. The iron dominates all the material for the clamp, the handle, and especially the tool body that reaches 250 cm length makes the tool heavier.

After prototype testing is finished, prototype improvements can be started because it is found what part needs to be improved. In the prototype test, it can be concluded that the weight of the grabber tool is still too heavy so the use becomes uncomfortable because the energy that needs to be used is greater. To solve the problem of the weight, the team use other alternative materials that are lighter. The answer is by replacing the iron material with aluminium and the result is the weight of the tool is reduced to 0.8 kg. The drawback of this product is a hinge that can be detached at the time of use or storage.

Product evaluation of the grabber tool is measured by function or user interface. The grabber tool is brought to eco-park and tested by the workers to get the performance level of the tool.

Table 4. Questionnaire Statement

No	Note	Score	Average
1	Help you for picking up garbage.	26	4.33
2	Able to take a variety of item	23	3.83
3	Easy to use	26	4.33
4	Long enough to take the garbage	24	4
5	Foldable, easy for mobility	28	4.67
6	Foldable, easy to store	27	4.5
7	The weight of the material light	27	4.5
8	The tool makes me convenience in work	26	4.33
9	Holder ease the picking up waste activity	26	4.33
10	I am satisfied with this tool	25	4.17
		Average:	4.33

The data obtained from the questionnaire is then calculated the average value of the statement per question. Table 34 shows the questionnaire statement that will be used for generating the performance rating of the user interface of the grabber tool. Supposed the number of respondents that choose "Agreed" is 4 people and "Strongly Agree" is 2 people, the score for that row will be 26. The average number then converted to the assessment table [4]. The maximum number of Likert- scale of 5 can be converted to a performance rating of the low-to-high category by equally divided and set the range. This method will result in a range for a high score is from 3.66 to 5.

Table 5. Performance Rating

Assessment Category	Performance Rating			Explanation of Rating
	Low	Medium	High	
Usage of Grabber Tool	-	-	4.3	The tool which is easy to use also has good quality due to its ability to pick up waste well

The score in table 5 the average number is 4.3 which can be considered high. So it can be concluded that the grabber tool helps janitor to do their duty in eco-park.

6. Conclusion

This research covers a series of process design and development of product of garbage grabber tool, hereby following is the conclusion from research which has been completed. This research succeeded in producing 3 grabber tool to assist the cleaning officer in the eco-park area in garbage cleaning activity at the location. The finished product in this study is the result of improvement of the prototype and still need further evaluation for the next version of the product. The finished product is evaluated by a product trial to be tested by janitors and then they have to submit the questionnaire. The grabber tool succeeds to help the officer to take the waste with a high-performance value of 4.3. The suggestion that can be given for the next research is the design of waste recycling equipment according to the request from the local management area.

References

- [1]. Global Sustainable Tourism Council - <https://www.gstcouncil.org/gstc-criteria/>
- [2]. P. V. Mathew and S. Sreejesh, "Impact of responsible tourism on destination sustainability and quality of life of community in tourism destinations," *Journal of Hospitality and Tourism Management*, vol. 31, pp. 83–89, Jun. 2017.
- [3]. J.-G. Persson, "Current Trends in Product Development," *Procedia CIRP*, vol. 50, pp. 378–383, 2016.
- [4]. The Impact of Voice of Customer on New Product Development, Rashid Saeed, Rab Nawaz Lodhi, Jazba Munir, Shazza Riaz, Fareha Dustgeer and Amna Sami, *World Applied Sciences Journal* 24 (9): 1255-1260, 2013
- [5]. Karl T., Ulrich, Steven D., Eppinger. *Product Design and development* sixth edition, McGraw-Hill Education, 2016.
- [6]. C. W. Elverum, T. Welo, and S. Tronvoll, "Prototyping in New Product Development: Strategy Considerations," *Procedia CIRP*, vol. 50, pp. 117–122, 2016.
- [7]. C. Giachetti and G. Lanzolla, "Product Technology Imitation Over the Product Diffusion Cycle: Which Companies and Product Innovations do Competitors Imitate More Quickly?," *Long Range Planning*, vol. 49, no. 2, pp. 250–264, Apr. 2016.
- [8]. M. Sasiadek and W. Babirecki, "Improving Reliability of Designed Technical Products Using FMEA," p. 6.
- [9]. T. K. Chuan, M. Hartono, and N. Kumar, "Anthropometry of the Singaporean and Indonesian populations," *International Journal of Industrial Ergonomics*, vol. 40, no. 6, pp. 757–766, Nov. 2010.