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A Product Design on the MG-513 MegaBath Laundry Basket

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Abstract: Laundry baskets are significant in day to day household activities, from retrieval and storage of both clean and dirty clothes. The aim of this study is to determine the current problems in the present MG-513 MegaBath Laundry Basket and propose a design that would address the prioritized problems. In order to identify the significant issues, needs analysis through a survey was conducted to determine the levels of significance and satisfaction on the design issues observed by the researchers. Quality Function Deployment was then used to rank the top three problems encountered by the users. From the identified problems, concepts were generated and screened for the proposed design. Results showed that the top three problems on the MG-513 MegaBath Laundry Basket were ease of sorting, ease of carry and transport, and durability with 20.4%, 20.0%, and 14.9% overall importance scores respectively. In addition to this, it was also found after the Failure Modes and Effects Analysis that the current handle design exhibited the highest Risk Priority Number which indicates the high potential failure in the said part.

Key Words: product design; laundry basket; concept generation; prototype

1. INTRODUCTION

A laundry basket is a type of receptacle that is used for containing both dirty and clean clothes. However, the conventional laundry baskets has exhibited problems on its handling mechanisms (Park, 2016), and sorting and transportation (Friday, 1997). Park (2016) stated that users may be subjected to an increased risk of having musculoskeletal disorders (MSD) due to the awkward posture when carrying heavy loads. Park (2016) explains that this is caused by poor and insufficient handling mechanisms in baskets which causes users to exert more pinching force. Aside from the handles, there are also difficulties in sorting since conventional laundry baskets do not have space for sorting. Because of the insufficient compartments and space for sorting, wet clothing can cause other articles to be damaged as all articles are mixed together (Friday, 1997).

Given the aforementioned problems, it is necessary that laundry baskets improvements must increase the overall ease of use of the product. To reduce the risk of MSDs, and address issues on sorting and transportation, it is essential for laundry baskets to be sturdily designed in such a way that it will enable its users to exercise proper posture, and allow easy sorting and transportation.

For the past years, improvements have been made to address the different problems brought by laundry basket designs. Recently, Alexander (2013)

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invented a wheeled laundry basket which includes a basket, wheel assemblies, and a rope pull to address problems on carrying. The reason for Alexander's invention is to enable users to carry loaded laundry baskets from one place to another without having difficulties. The assembly of wheels allow users to move heavy laundry items in a quick, easy and effective manner.

Lee, et. al. (2009) has also addressed difficulties in handling mechanisms as they conduct a research on handle grip spans. Lee, et. al (2009) promotes measurements of handles that could optimize the user's capability of using handles in terms of amount of force used. According to the study, it is possible for objects to be lifted with lesser force capability of each finger when the size of the handle is compatible to the size of the user's hand. The grip spans for each size of hand gave varying percentage of satisfaction in terms of comfort.

In addition to these improvements, Philip (2014) invented what he called "liners" to address difficulties in sorting clothes. Liners serve as dividers in a laundry basket which allow the baskets to have compartments. These liners are made out elastic materials, exhibiting a modulus of elasticity of about 2000 MPa or less and an elongation rating of 100% or more. Another feature of the liner is that it is detachable. This gives the users the option to remove the liners when they are not needed. The same issue on sorting has also become the basis of the design improvement of Bisceglia (1993) in trash receptacles where a removable apparatus is added to support bags at the rim of the receptacle in order for the bags to be easily suspended and adjusted.

With these current improvements, this paper especially wants to study the current design of the MG-513 MegaBath Laundry Basket. Hence, this paper aims: (1) to identify the design issues in the current design of the MG-513 Laundry Basket; (2) to generate concepts that would be integrated in the proposed design; (3) to create an improved laundry basket that would address the previously mentioned problems. With these objectives, this paper will only include the analysis of the MG-513 MegaBath Laundry Basket which is manufactured by MegaBox Philippines. The collected data will only encompass users who have been using the product for at least three months.

2. PROBLEM IDENTIFICATION

2.1 Needs Analysis

Before any survey was conducted, the current design of the chosen product was first observed and analyzed by the researchers. Figure 2.1 shows the chosen laundry basket for this paper.

Figure 2.1 MG-513 Laundry Basket

The MG-513 Laundry Basket has an overall base dimension of 40 cm 40 cm 50 cm, and a volume capacity of 36 L (36,000 cu.cm.). Table 2.1 shows the current product specifications

Table 2.1. Current Product Specifications

Model	MG-513 Laundry Basket
Product Type	Laundry basket
Primary Material	Polypropylene plastic
Available Colors	White, Green, Blue
Machine Washable Lining	No
Number of Handles	2
Volume capacity	36 L (36,000 cu. cm.)
Country of Manufacturer	Philippines (Mega Box)
Height	50 cm
Width (Top)	45 cm
Width (Base)	40 cm

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Handle length	8 cm
Handle height	45 cm
Hole diameter	2 cm
Hole length	8 cm
Volume Capacity	36,000 cu. cm.

Aside from listing the product specifications, user observations were also listed in Table 2.2. These were utilized in the construction of the survey forms

Table 2.2 User Observations

Negative	Positive
Painful to carry when full	Well ventilated
Getting clothes from under the pile is a hassle	Holds folded clothes efficiently
Clothes are getting damaged	
Not space saving	

To understand the needs of the customer and to evaluate the current product further, a survey was conducted to product users. This survey aims to capture the importance and satisfaction rating of the current product. Results from this survey will be utilized in the formulation of the planning matrix or the House of Quality 1. The sample size for this survey was calculated using the formula

$$N = \left[\frac{Z_{\frac{\alpha}{2}}}{E}\right]^2 \times (p \times q) \qquad \text{(Eq. 1)}$$

where:

N = sample size
Z = critical value for area α/2
α = degree of confidence
E = margin of error
p = percentage of picking a positive answer
q = 1 – p

Given this equation, the survey must then be conducted to at least 93 respondents. As an added criteria, the respondents must have the exact same brand and type of laundry basket, and must have used the said laundry basket for at least three (3) months. Survey forms were distributed, and a total of 106 respondents have been collected.

Table 2.3 Problems encountered

Problems	Result (%)
Carrying it with full load	79.2
Having difficulty in getting clothes from the bottom of the pile	52.8
Having difficulty in sorting clothes	41.5
Laundry basket easily topples over	14.2
Clothes get damaged	17.0
Not space saving	25.5
Breaks under heavy load	2.25
Transferring clothes	2.25

Of the survey results gathered, the top 3 problems as shown in Table 2.3 are as follows: (1) Carrying with full load with 79.2% of the respondents choosing the said option; (2) Having difficulty in sorting clothes at 41.5%; and (3) Having difficulty in getting clothes from the bottom of the pile at 52.8%.

Table 2.4 Importance and Satisfaction Rating

Product characteristic	Importance rating	Satisfaction rating
Ease of sorting	4.7573	2.8058
Ease of carry and transport	4.6602	2.8058
Volume capacity	4.4757	3.6796
Durability	4.7767	3.8641
Space saving	4.1456	3.3301
Lightweight	4.4757	3.6602
Visually attractive	2.9515	3.4563

Respondents were also asked to rate the importance of the characteristics by giving a score of 5 for the most important characteristic, and 1 for the least important. Durability had the highest importance rating, equating to 4.7767. Succeeding it

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is ease of sorting with a score of 4.7573, and followed by ease of carry and transport with a score of 4.6602. Aside from rating the importance, the respondents were also asked to rate their satisfaction for the same set of characteristics using the same score scale. Results show that users are most satisfied with the durability of the current product, which they also considered to be of high importance. However, it must be noted that although this customer requirement gained the highest satisfaction score, it only exhibited a total satisfaction rate of 3.8641. Aside from this, it can also be seen that users were not quite satisfied when it came to ease of sorting and ease of carry and transport.

2.2 House of Quality I

The House of Quality 1 or the Planning Matrix shows the Customer Requirements and Technical Requirements of the product. Through this matrix, the top problems will be identified based on the overall importance score which was computed by considering the Importance score from the survey, Sales point score of each requirement, and Improvement ratio which was computed by dividing the target satisfaction score by the current satisfaction score.

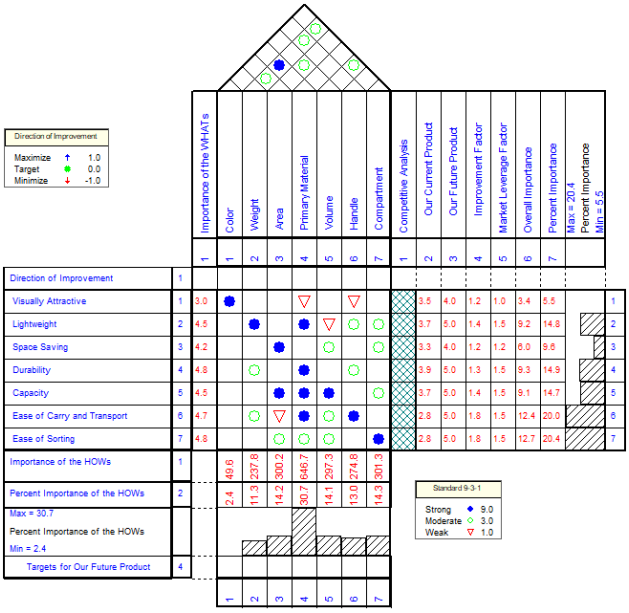

Fig 2.2 House of Quality 1

Figure 2.2 shows the House of Quality 1 for the MG-513 MegaBath Laundry Basket. From the House of Quality, it can be seen that the top 3 customer requirements that will be addressed for this paper are: (1) Ease of carry and transport; (2) Durability; and (3) Ease of sorting.

2.3 Problem Statement

Based on the overall importance scores of 20.4%, 20.0%, and 14.9% for *ease of sorting*, *ease of carry and transport,* and *durability* respectively, the MG-513 MegaBath Laundry Basket exhibits problems on its sorting capacity, durability, and handling mechanisms.

3. METHODOLOGY

3.1 Design Process

3.1.1 House of Quality 2

To start the design process, the House of Quality 2 was formulated in order to systematically relate the functional requirements from House of Quality 1 to the needs of the customer.

3.1.2 Concept Generation

Concept generation falls in the divergent side of Cross' model (1994). A concept generation tree was used to generate and conceptualize the possible design solutions for improvement. Each product concept will be subjected to initial pruning and will then be utilized to construct the concept screening matrix. The concept screening matrix will be used to determine which solutions will be developed and/or combined.

3.2 Detailed Design

After finalizing the concepts of the product, a more detailed design was made using the software: CATIA V5-6R2016. It was made sure that the conceptualized design addressing the problems of the initial product was made specific and achievable in the detailed design.

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3.3 Failure Mode and Effects Analysis

Possible causes of failure and the risks pertaining to the improved design were listed down. Recommendations to prevent this possible failure were also enumerated.

3.4 Alpha Prototyping

The three-dimensional design of the improved laundry basket made in the software CATIA was used to print the small-scale model using a three-dimensional printer. A ratio of 1cm:1.43mm was used as comparison to the actual size of the laundry basket.

3.5 Product Costing

Product costing using activity-based costing was done on the proposed laundry basket. It assumes a mass production of 500 units of the proposed product. Manufacturing, direct materials, and direct labor costs were estimated. The production of the product is divided into four activities namely: (1) Receiving, (2) Production, (3) Quality Assurance, and (4) Packing and Shipping

4. RESULTS AND DISCUSSION

4.1 House of Quality 2

The House of Quality 2 or the Design Matrix will determine how each technical requirement will be designed to improve the problems that were identified in House of Quality 1.

The final House of Quality 2 for the MG-513 MegaBath Laundry basket is shown in the Figure 4.1. From here, it was found that the top three functional requirements are *thickness of plastic, handle type material, compartment material and number of compartments.* This means that these are the parts of the laundry basket that will be adjusted to address the previously identified problems.

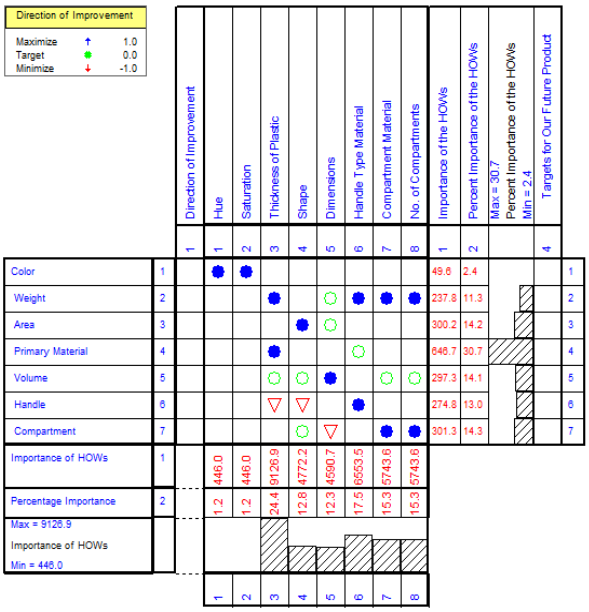

Fig 4.1 House of Quality 2

4.2 Concept Generation

After determining the requirements that need to be improved, concepts are generated for each sub-problem using concept classification trees. The initial classification trees were pruned of concepts that were not feasible or economical, hence, the final concept classification trees for sub-problems 1 to 3 are shown in Figures 4.2 until 4.4.

Fig 4.2 Final Classification Tree for Sub Problem 1

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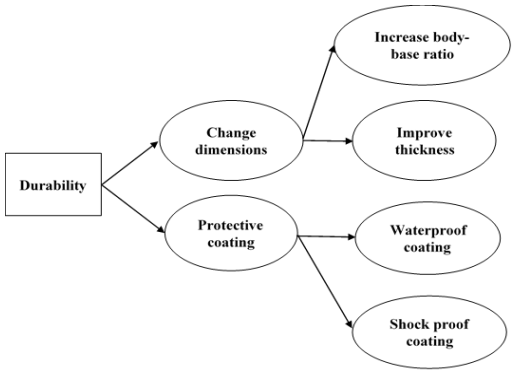

Fig 4.3 Final Classification Tree for Sub Problem 2

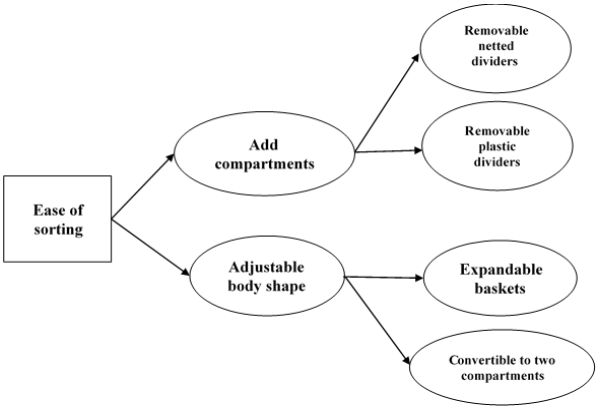

Fig 4.4 Final Classification Tree for Sub Problem 3

These concepts were screened based on convenience, comfortability, stability and adjustability in Tables 4.1 to 4.3. Concepts that have passed the screening will be further selected using the concept selection matrix in order to determine which concepts will be removed, developed, or combined. The concept selection matrices for sub-problems 1 to 3 are shown in Tables 4.4 until 4.6.

After finally selecting the accepted concepts, Table 4.7 summarizes the final selected concepts that will be integrated in the proposed design.

Table 4.7 Final Selected Concepts

Sub-problem	Concept
Ease of carry and transport	• Rubber-integrated handles • Adjustable handle with lock • Swivel wheels with brakes
Durability	• Improve thickness
Ease of sorting	• Removable netted dividers • Convertible to two compartments

4.3 Detailed Design

The proposed laundry basket, as a whole, can be described as a medium-sized basket, with a rectangular base and two removable netted dividers. It is convertible to two compartments and will also have four swivel wheels with brakes, and two grip handles - one of which may be adjustable to the desired height of the user.

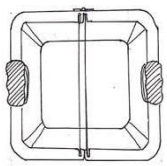

Fig 4.5. Top view - Closed

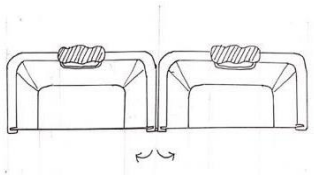

Fig 4.6. Top view – Opened

Figures 4.5 and 4.6 show the top view of the whole hamper when it is closed and opened. The user may choose to use the laundry basket closed without the two compartments if sorting is not needed. However, if the user deems sorting to be necessary, the user may choose to open the lock and use the laundry basket opened for easy sorting. The front views are shown in Figures 4.7 and 4.8.

Fig 4.7. Front view - Closed

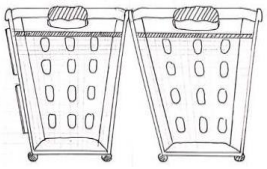

Fig 4.8. Front view – Opened

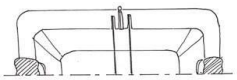

Fig 4.9. Closed

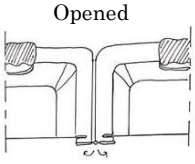

Fig 4.10. Opened

The positioning of the hinges when the laundry is open and closed is shown in Figure 4.9. and 4.10. The removable netted dividers may also be seen in Figure 4.11. These dividers may be easily placed at the open end of one side of the opened laundry basket to allow the users to see the contents of the basket from top to the bottom. They are held in

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Table 4.1 Concept Screening Matrix for Sub-Problem 1

Selection criteria	MG-513 Laundry Basket	Foam integrated handle	Rubber integrated handle	Adjustable handle with lock	Adjustable handle without lock	Hip Hugging surface	Vertically curved surface	Pure Polyolefin casters	Swivel wheels with wheel brakes	Swivel wheels without wheel brakes
Convenient	0	+	+	+	-	+	+	+	+	-
Comfortable on hands	0	+	+	0	+	0	0	0	0	0
Durable	0	0	+	0	0	0	0	+	0	0
Easy to maneuver	0	+	+	+	-	+	0	+	+	+
Stable	0	0	0	+	-	0	-	0	+	-
Adjustable	0	0	0	+	+	0	0	0	+	0
Sum of +'s	0	3	4	4	2	2	1	3	4	1
Sum of 0's	6	3	2	2	1	4	4	3	2	3
Sum of -'s	0	0	0	0	3	0	1	0	0	2
Net score	**0**	**3**	**4**	**4**	**-1**	**2**	**0**	**3**	**4**	**-1**
Rank	**4**	**2**	**1**	**1**	**5**	**3**	**4**	**2**	**1**	**5**
CONTINUE?	**No**	**No**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**No**

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Table 4.2 Concept Screening Matrix for Sub-Problem 2

Selection criteria	MG-513 Laundry Basket	Improve thickness	Increase body-base ratio	Waterproof	Shock proof
Convenient	0	+	+	0	+
Lightweight	0	-	-	0	0
Comfortable on hands	0	+	0	0	0
Sum of +'s	**0**	**2**	**1**	**0**	**1**
Sum of 0's	**3**	**0**	**1**	**3**	**2**
Sum of -'s	**0**	**1**	**1**	**0**	**0**
Net score	**0**	**3**	**0**	**0**	**1**
Rank	**3**	**1**	**3**	**3**	**2**
CONTINUE?	**No**	**Yes**	**No**	**No**	**Yes**

Table 4.3 Concept Screening Matrix for Sub-Problem 3

Selection criteria	MG-513 Laundry Basket	Permanent netted compartments	Removable plastic compartments	Convertible to two sorters	Expandable baskets
Convenient	0	+	-	+	-
Durable	0	0	0	0	0
Adjustable	0	0	+	+	+
Sum of +'s	**0**	**1**	**1**	**2**	**1**
Sum of 0's	**5**	**2**	**1**	**1**	**1**
Sum of -'s	**0**	**0**	**1**	**0**	**1**
Net score	**0**	**1**	**0**	**2**	**0**
Rank	**3**	**2**	**3**	**1**	**3**
CONTINUE?	**No**	**Yes**	**No**	**Yes**	**No**

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Table 4.4 Concept Selection Matrix for Sub-Problem 1

Selection criteria	Wt	Rubber integrated handles		Adjustable handle with lock		Swivel wheels with wheel brakes		Pure Polyolefin casters		Hip hugging surface	
		Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score
Convenient	10	5	50	5	50	5	50	5	50	5	50
Comfortable on hands	25	5	125	5	125	4	100	3	75	3	75
Durable	15	5	75	3	45	4	60	5	75	5	75
Easy to maneuver	25	5	125	5	125	5	125	4	100	4	100
Stable	5	5	25	3	15	5	25	5	25	4	20
Adjustable	20	3	60	5	100	5	100	3	60	2	40
Total Score Rank		**460**		**460**		**460**		**385**		**365**	
Continue?		**Combine**						**No**		**No**	

Table 4.5 Concept Selection Matrix for Sub-Problem 2

Selection criteria	Wt	Improve thickness		Shock proof	
		Rating	Score	Rating	Score
Convenient	35	5	175	5	175
Lightweight	20	5	100	3	60
Comfortable on hands	45	4	180	3	135
Total Score Rank		**455**		**370**	
Continue?		**Develop**		**No**	

Table 4.6 Concept Selection Matrix for Sub-Problem 3

Selection criteria	Wt	Netted compartments		Convertible to two sorters	
		Rating	Score	Rating	Score
Convenient	25	5	125	3	75
Durable	25	4	100	4	100
Adjustable	50	4	200	5	250
Total Score Rank		**425**		**425**	
Continue?		**Combine**			

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place by the grooves in the rim of the basket. The frame is made of polypropylene plastic while the net itself will be made up of net fabric.

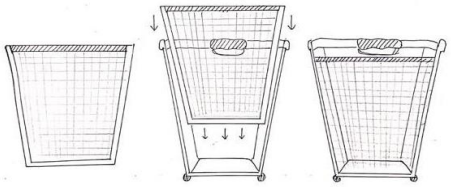

Fig 4.11. Removable netted dividers

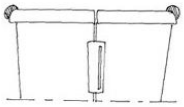

Fig 4.12. Closed

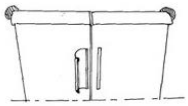

Fig 4.13. Opened

The front lock is shown in Figure 4.12 and 4.13. The lock will also be made of polypropylene plastic so as not to add significant weight to the product. Figures 4.14-4.17 shows the handling mechanism of the laundry basket. Figure 4.14 and 4.15 show that the right grip handle may be used as a fixed handle, or as a trolley if the user chose to adjust its height. These grip handles will be made of rubber foam in order to cushion the hands of the users when transporting heavy loads. Also, since one of the handles is retractable, the user may choose to use the laundry basket as a trolley for easy transportation.

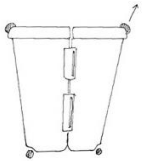

Fig 4.14. Handle down

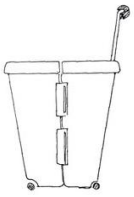

Fig 4.15. Handle Adjusted

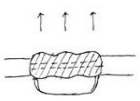

Fig 4.16. Close up - handle down

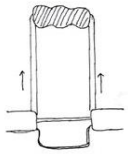

Fig 4.17. Close up - handle up

4.3 Alpha Prototype

After constructing the detailed design in CATIAV5-6R2016, the scaled-down physical prototype was produced and may be seen in Figure 4.18.

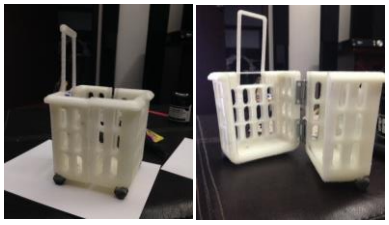

Fig 4.18. Physical Prototype

4.4 Failure Modes and Effects Analysis

Table 4.8 shows the failure mode and effect analysis of determined parts of the designed product that could possibly have defects. The potential failure and their effects were also shown. The table also suggests a possible cause of the failure. The risk priority number (RPN) of each potential failure mode was computed based on the severity, occurrence, and detection of failure scores for each item. These scores were graded based on a scale from 1 to 10, with 10 being the most severe failure (for severity), the most likely to fail (for occurrence), and the least likely to be detected (for detection). A high RPN means that the specific item has a high possibility of failing.

The failure with the highest RPN of 294 is identified to be the breakage of handles due to material not withstanding heavy loading. To address this potential failure mode, the thickness of the handle was increased. As shown in Table 4.9, the severity, occurrence and detection ratings for the handle are now 5, 3, and 3 respectively. With this adjustment, the new RPN is 45.

Table 4.9 FMEA Action Results

Item	Recommended Actions	Action Taken	Severity	Occurrence	Detection	RPN
Handle	Proper assembly, Increase the thickness of the handle	Increase the thickness of the handle	5	3	3	45

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Table 4.8 Failure Mode and Effects Analysis

Item	Potential Failure Mode	Potential Effect(s) of Failure	Severity	Potential Cause(s) of Failure	Occurrence	Current Controls	Detection	RPN
Handle	Breakage of handles (fixed and/or adjustable)	Laundry basket cannot be carried.	7	Material cannot withstand heavy loading	6	Strength test	7	294
Hinges	Hinges get detached from the basket.	Laundry basket cannot be closed.	6	Faulty assembly	2	Perform product testing	7	84
Zipper	Zipper slider and teeth separates from each other.	Clothes inside the laundry basket cannot be separated into compartments.	5	Poor quality of the material	6	Physical zipper test	7	210
Net	Net gets detached from zipper	Clothes inside the laundry basket cannot be separated into compartments.	6	Poor sewing of net and zipper	6	Quality assurance	7	252
	Net gets ripped	Laundry basket cannot be opened because clothes will fall.	6	Poor sewing of net and zipper	4	Quality assurance	7	168
Lock	Lock loosens its grip	Laundry basket cannot be closed properly.	6	Poor quality of the material	4	Grip test	7	168

4.5 Product Costing

To estimate the cost for each unit of the proposed laundry basket, this paper will utilize Activity Based Costing for its product costing. Assuming that for mass production, 500 units of the proposed laundry basket are to be produced, Table 4.10 shows the manufacturing costs for both the direct materials and direct labor.

Table 4.10 Manufacturing Cost, 500 units

Direct material cost	Php 60,000.00
Direct labor cost	Php 2,520.00
Direct labor hours	40 hours

After estimating the direct material and direct labor costs of the basket, the total overhead costs will be estimated using the values shown in Table 4.11. To compute for the overhead costs of the product, the production of the proposed laundry basket was first divided into four activities namely: (1) Receiving, (2) Production, (3) Quality Assurance, and (4) Packing and Shipping. The total overhead cost will be based on the cost driver rates of each activity which are all tabulated in Table 4.11.

Table 4.11 Applied Activity Rate

Activity	Cost Driver	Total Units	Rate
Receiving	no. of batches	25 batches	P150 / batch
Production	no. of machine hours	1,500 machine hours	P30 / machine hour
Quality Assurance	no. of inspections	500 inspections	P25 / inspection
Packing & Shipping	no. of products	500 products	P5 / product

Note: The following costs above are only ballpark estimates.

Table 4.12 shows that the total overhead costs amounted to P63,750.00. By summing up the direct material cost, direct labor cost, and total overhead cost, it was found that the 500 units

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amounted to a total of P126,270.00. This resulted to a final unit cost of P252.54 for each produced unit.

Table 4.12 Product Costing using Activity Based Costing, 500 units

Activity	Applied Activity Rate	Cost
Overhead costs	-	P 63,750.00
Receiving	150.00	3,750.00
Production	30.00	45,000.00
Quality Assurance	25.00	12,500.00
Packing	5.00	2,500.00
Direct material cost	-	P 60,000.00
Direct labor cost	-	P 2,520.00
TOTAL COST (500 units)	-	P 126,270.00
COST PER UNIT	-	P 252.54

5. CONCLUSIONS

For the MG-513 MegaBath Laundry Basket, it was found that the top three concerns stem from: (1) Ease of sorting, (2) Ease of carry and transport, and (3) Durability, with overall importance scores of 20.4%, 20.0%, and 14.9% from product users respectively. After thorough screening and selection of generated concepts, it was found that in order to address the problem on sorting capacity, durability, and handling mechanisms, the following product characteristics must be integrated into the current product design: (1) Rubber-integrated handles, (2) Adjustable handle with lock, (3) Swivel wheels with brakes, (4) Increase plastic thickness, (5) Removable netted dividers, and (6) Convertible to two sorters. In addition to the identification of the final concepts, the study also revealed that the handle is the component that exhibits the highest risk priority number (RPN) and recommended the increase in its thickness to prevent any possible failure modes from reaching the user.

For future studies, it is recommended to make a physical prototype before proceeding in Failure Modes and Effects Analysis (FMEA) to understand the product better and address more possible sources of failure modes. In addition, the group also suggests future studies to utilize Design of Experiments (DOE) in selecting the optimum mix of concepts generated in Chapter 4. Using DOE would prove beneficial for it can help provide a more optimal concept in developing the product. Lastly, it is recommended to establish a feasible and realistic feasible demand for the first batch of production of the product. This would help determine a more accurate product costing and its feasibility in an economic sense.

6. REFERENCES

Alexander, C. A. (2013). U.S. Patent No. US8602423 B1. Washington, DC: U.S. Patent and Trademark Office.

Bisceglia, R. D. (1993). U.S. Patent No. US5238139 A. Washington, DC: U.S. Patent and Trademark Office.

Cross, N. (1994). Engineering Design Methods - Strategies for Product Design. Chichester, UK: John Wiley & Sons.

Friday, S. A. (1997). U.S. Patent No. US 5690217 A. Washington, DC: U.S. Patent and Trademark Office

Park, J. (2016). Job Hazard Analyses for Musculoskeletal Disorder Risk Factors in Pressing Operations of Dry-cleaning Establishments. *Safety and Healt at Work, 7*(4), 389-393. doi:10.1016/j.shaw.2016.05.003

Philip, M. (2014). U.S. Patent No. US 20140263310 A1. Washington, DC: U.S. Patent and Trademark Office.