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Development of Traditional Market Garbage Bin

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Abstract

A garbage bin is a tool for handling waste in the Demangan and Sentul markets. Garbage leachate is terrible for the environment and humans and is a location for Aedes aegypti mosquitoes to breed due to ammonia compounds in leachate. This research aims to redesign the garbage bin so that it is optimal for controlling and managing waste and minimizing its impact. The garbage bin is designed using the Quality Function Deployment method. The garbage bin design has nine attributes from the customer's voice and sixteen technical response attributes. The technical response attribute becomes the part deployment input, resulting in twenty one part specification attributes. The priority attribute divides the shelter into two parts: the organic and non-organic waste has CW=662.16. The developed garbage bin design advantages are storage space according to type, wastewater storage, and minimizing waste's destructive impact.

Keywords: Attribute; Customer; Garbage; Leachate; QFD; Waste

INTRODUCTION

Traditional markets are synonymous with slums, muddy, smelly, and unhealthy shopping places. This condition is caused by market waste, the close relationship between waste and public health, due to waste being a place of life for various microorganisms that cause disease (pathogenic bacteria) and insects. Disease transmission (vector) (Liu et al., 2023). Garbage pollution from activities in the market in the form of vegetables, fruit, and other food materials and spoilage in the waste causes an unpleasant odor. In addition, water pollution and soil destruction can be caused by a garbage bin. Organic waste can cause water pollution from waste or garbage that has decayed or been degraded by microorganisms (Abadi et al., 2021). Piles of waste become a habitat for flies due to their instincts and bionomics in choosing a location where the larvae will later serve as a food source after hatching, all found in the garbage (ZHANG et al., 2023).

Leachate is liquid waste from outside water poured into the garbage pile, causing dissolved elements, including organic matter, to dissolve, resulting from biological decomposition (Bhambore & Kumar, 2022). Poor leachate management will have a short- and long-term impact on the environment and humans and reduce the surrounding groundwater quality (Nyirenda & Mwansa, 2022).

Garbage bins are an alternative to handling and minimizing the impact of waste on the environment. The garbage bin generated by traditional daily market activities will be stored first before going to the TPA, such as Sentul and Demangan Markets. The volume of waste at Sentul Market per day is 2 m^3 per day, and at Demangan Market is 5 m^3 per day; the large volume of waste is the reason for various problems; as stated earlier, according to traders at Sentul Market, the smell of garbage in the garbage bin is very strong, water Leachate in addition to the scent also gives an itching effect, and reduces the buyer's interest in shopping at merchants who are close to the location of the garbage bin. For this reason, it

is necessary to develop a garbage bin that can minimize the negative impact of waste using the QFD (Quality Function Deployment) method. The QFD method systematically determines consumer demands and then translates the needs into appropriate product planning (Yan et al., 2022). Research has developed products using the QFD method to create products, such as UMS garbage bins (Musthofa et al., 2015), electric batik stoves (Lestariningsih & Jono, 2019), tempeh chips (Rohmah et al., 2018), clotheslines (Wibowo & Purnomo, 2017), laser metal processing based on open innovation (Syreyshchikova et al., 2021), and integrated multiphase sustainable product design (Ocampo et al., 2020). Research on developing traditional market garbage bin bins with the QFD method has never been done. Therefore, this study aims to create a design for conventional market garbage bins using the QFD method.

LITERATURE REVIEW

This study uses some literature that is used as a literature review. The first literature review is about the garbage bin design at the Surakarta State University (UNS) Sebelas Maret using the QFD method. This study explains that the current waste problem is still one of the main concerns, especially in the UNS environment. As a state university, UNS provided a garbage bin consisting of an organic garbage bin and an inorganic garbage bin. The available garbage bins have not been able to change students' behaviour in disposing of waste in the right place (Musthofa et al., 2015). This study uses the QFD method in designing garbage bins with the hope that the products produced meet the needs and desires of customers. This research results in a proposed design of a garbage bin with a lid that is easy to open and a significant drain hole with a cap. In addition, the design of the body of the garbage bin is made of a box so that it is easy to lift from its support and add information on each type of garbage.

Another research is designing a means of collecting and distributing waste in the elderly park by paying attention to ergonomic aspects (Wicaksaningtyas et al., 2019). This research created a new design for garbage bags to make them comfortable. Now, garbage bags on the market have many shortcomings that cause inconvenience when used. Adding features to the garbage bin is a breakthrough so that later, it will be comfortable to use and reduce the risk of injury to its users. Some of these new features include the addition of a carrying strap, a carrying strap, and a garbage bag opening and closing system. The choice of striking colors is expected to eliminate the dirty impression due to use. In addition, the determination of various sizes and the provision of pictures on the face of the bag will be another feature of this garbage bag.

The redesign as a form of modification of the paper waste bin using the Kano Model approach and the Quality Function Development (QFD) method is another literature review used in this study (Dewi et al., 2015). This study aims to explain the attention of humans in maintaining the cleanliness of the environment and the natural surroundings. One form of engagement is to dispose of garbage in its place. Based on the results of distributing questionnaires to 30 correspondents, 97% of the garbage bins were inadequate, and 90% stated that there was a need for innovation in the form of garbage bins. There are two approach methods used in this study, namely the canoe model to classify the attributes of consumer needs and QFD to translate consumer needs in the form of technical characteristics. This research can produce a prototype of a garbage bin product that has innovation in its shape in the form of a press and has a size of (37x30) cm.

The following literature review is in the form of designing a garbage bin with an automatic lid opening and an indicator of the capacity of the contents of the waste (Rahardjo et al., 2018). This study aims to discuss the number of people who throw garbage carelessly

even though garbage bins are available. This research wants to try to make an attractive garbage bin design. This garbage bin is designed with several electronic modules, including sensor, processing, sending, and receiving modules. The design of this garbage bin has a way of working, and when the garbage is inserted, it will sound like, "Thank you for throwing garbage in its place; keep the environment around you clean." After that, if the garbage bin is whole, the photodiode sensor will detect the volume of the garbage bin and send a signal to the LED indicator module to give a warning.

Another reference this research uses is the garbage bin design with a participatory ergonomics approach (Aktoba, 2017). This research aims to get the garbage bin's design according to consumers' wishes. The object of this research is the Islamic University of Indonesia (UII), which is considered to have the potential as a high waste producer. The method used in this research is ergonomics participation, which involves several internal and external UII participants. This research resulted in a garbage bin design with new attributes, such as attractive, easy to use, adequate size, sturdy, and informative.

The following is an example of a garbage bin in the Sentul market, Gunungketur, Pakualaman, Yogyakarta.

Figure 1. Garbage Bin at Sentul Market

METHODS

Data

The research was conducted for six months with locations in Demangan Market and Sentul Market in the special region of Yogyakarta, Indonesia, using data collection techniques such as interviews and questionnaires. Interviews were conducted with several parties, including a supervisory officer from the market office, to obtain the volume of waste and several policies. Interviews were also conducted with traders regarding complaints about the current garbage bin. The questionnaire aims to get data about the market garbage bin, its level of importance, and satisfaction.

The volume of waste at Sentul Market per day is 2 m^3 per day, and Demangan Market is 5 m^3 per day, with provisions in calculating waste piles if not sampling, can use SNI 3242-2008 in predicting the volume of waste piles for big cities it produces 3 liters per day. People per day and small towns 2.5 liters per person per day, and the waste density can use the assumption of 200-300 kg per m^3 (0.2-0.3 kg per liter).

According to Tarwaka (Nurzaman, 2018; Saleh, 2017), anthropometry is a systematic or structured measurement study of the human physique, especially regarding body shape and size obtained in anthropological clarification and comparison (Tarwaka, 2014). Sritomo Wignjosoebroto also explains the notion of anthropometry in his book; anthropometry comes from "anthro," which means human, and "metric," which means size. Definitively, anthropometry is a study related to measuring the dimensions of the human body (Hartono, 2018). The anthropometric data used in this study are shown in Table 1.

Table 1. Anthropometric Data

Dimensions	Information	5th	50th	95th
D1	Height	142.72	163.37	184.02
D3	Shoulder height	123.26	136.76	150.25
D4	Elbow height	91.29	102.75	114.22
D15	Knee height	43.78	51.58	59.39
D18	Upper shoulder width	28.37	36.22	44.08
D29	hand width	5.42	10.44	15.46
D33	Elbow span length	69.16	86.11	103.06

Validity Test and Reliability Test

A validity test is used to tell if the questionnaire used is valid in collecting data for a study. The data processing results in SPSS software will know the calculated r-value to be compared with the value in the r table using the degree of freedom (df) = n-2; in this case, n is the nominal sample. If r count > r table and in positive form, the question item is declared valid (Uma, 2006; Widiyanti, 2020), reveals if the reliability test on an indicator on the research instrument aims to identify if a test user has a constant consistency even though it has been used repeatedly on subjects with the same conditions, Cronbach's Alpha or also known as the reliability coefficient can be used as a reference to determine the high and low reliability on a research test instrument with the provision that Cronbach's Alpha value of 0.8-1 means good reliability, Cronbach's Alpha value of 0.6-0.79 indicates that reliability is accepted. Cronbach's Alpha value < 0.6 means that reliability is not good.

Population and Sample

According to (Ul'fah Hernaeny, 2021), the population is a collection of elements or entities with several common characteristics owned and composed of fields to be studied. At the same time, Makhotra's (1996) opinion in (Ul'fah Hernaeny, 2021) reveals that the population is the whole person - people, events, or items the researcher is interested in or wants to study.

The sample is part of a population selected by a specific procedure and is expected to represent a population (Sumargo, 2020).

House of Quality (HoQ) Matrix

House of quality is a combination of all engineering characteristics. Making the House of Quality (HoQ) matrix aims to know what aspects consumers want and can realize consumer needs and expectations (Bolar et al., 2017; Fitriani et al., 2018). The data that has been obtained through a questionnaire, the results will be made in a house of the quality matrix, wherein creating a home of the quality matrix requires customer needs data obtained from product attributes in the questionnaire, planning matrix obtained from customer needs will be used as input in making house of quality matrix. The data needed to make the matrix is essential to customers, which determines customer requirements according to priority interests, selecting the mode of importance from distributing research questionnaires.

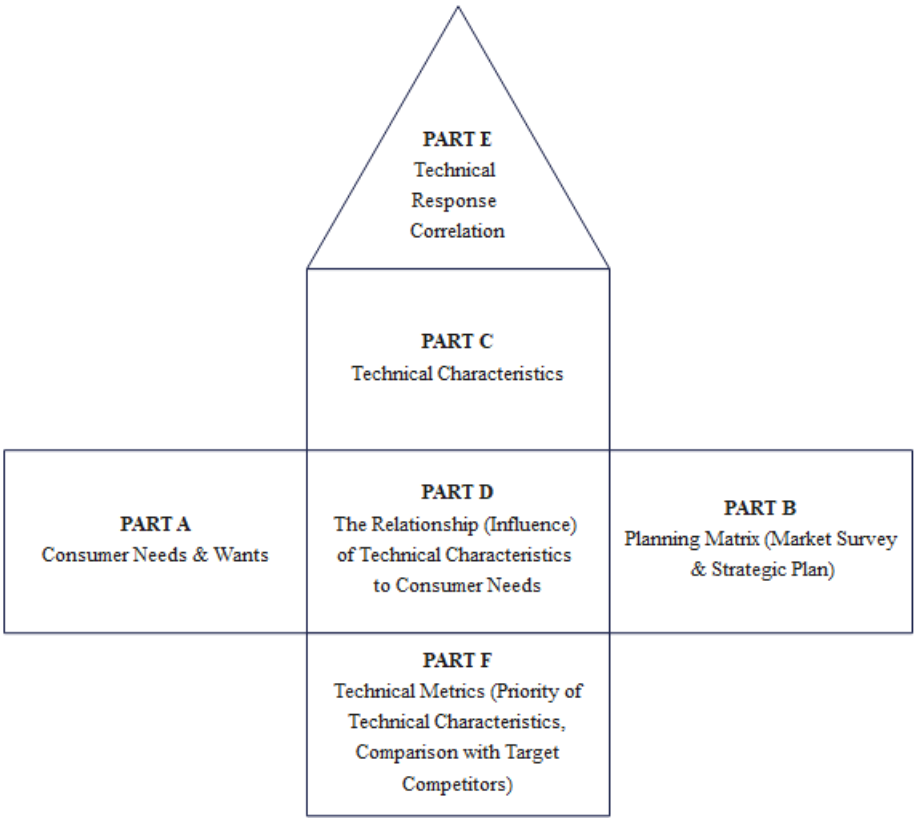


Figure 2. House of Quality (HoQ)

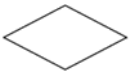
Part A of the matrix contains several consumer needs and desires from market surveys. Part B of the matrix consists of (1) the weight of the importance of consumer needs, (2) the level of customer satisfaction with products and services, and (3) the level of customer satisfaction with the product or service. Section C of the matrix services from competing companies consists of technical requirements for developing new products or services. This data is a derivative of information from matrix A (consumers' needs and wants). Part D of the matrix comprises management research on the relationship between elements in matrix C and the affected matrix A. Symbols mark solid and weak connections. Part E describes the relationship between technical requirements in matrix C. Symbols explains the relationship. Part F in the matrix represents the information to compare the technical performance of the product or service produced by the company with the product or services made by competing companies (3) performance targets for the technical requirements of newly developed products or services. Research describes the methods used to solve the problem. Includes tools, materials, and techniques used in problem-solving.

Part Deployment Matrix

Part deployment is a matrix to determine the components used in the design and development (Shang et al., 2023). The deployment part continues the first house matrix, namely the house of quality (HoQ), so the HoQ output will be the deployment part's input. Before making or compiling the part deployment, an initial analysis is done using Fault Tree Analysis. Fault Tree Analysis (FTA) is a technique that can be used to identify risks that can affect the occurrence of failure; the approach used in this method has a top-down nature, starting with the alleged negligence or loss originating from the peak event, which is then detailed in the reasons for the defeat at the top events (Ashraf et al., 2022). The purpose of

using FTA is to determine critical par deployments by analyzing the elements suspected to cause the discrepancy between the target and the technical recruitment. FTA has several symbols that are used to indicate the reason for the disparity of these elements, namely:

Table 2. Fault Tree Analysis

No	Symbol	Description
1		In the top event, the desired state is in the top position; then, research continues to other essential events by using logic to determine the source of failure.
2		Event logic, or combining the subsequent failure with the previous loss, has at least one element of the last error.
3		Event logic and combining two or more failures simultaneously
4		The transferred event, a symbol that describes the event description located on this page
5		The undeveloped iron cannot be further developed due to the unavailability of information.
6		Essential Event, an unwanted event because it is considered a fundamental reason; there is no need to do further analysis

The deployment part (planning matrix) is the second iteration of QFD. Part deployment produces critical parts that will be prioritized. Essential parts are specifications that must be met to realize the improvement concept that has been previously defined. Part deployment matrix planning can be done by making the following sections.

Table 3. Part Deployment Matrix

	Direction of Goodness		
	C		
	Critical Path		
A	**D**	**B**	→ Percentage Column Weight
Technical Response	Relationships		
Unit			
Current Situation			
Competitor			
Target	**E**		
Probability			
Column Weight			
Percentage Column Weight			
Ranking			

Part A contains the technical requirements obtained from QFD iteration one (HoQ). Part B has the results of normalizing the contribution of technical requirements obtained from QFD iteration one (HoQ). Part C contains Parts requirements related to and by the technical requirements obtained in QFD iteration one (HoQ) and the direction of the goodness of each part requirement. Part D describes the relationship between part requirements and technical requirements. This relationship is based on the impact of part requirements on technical requirements. Part E contains part specification, a unit of part requirements column weight, which is the contribution of target part requirements specifications to be achieved by each part requirement in the context of development.

RESULT AND DISCUSSION

Identification of Voice of Customer (VOC)

The results of the open questionnaire distribution got several consumer needs that became complaints or inputs in making a new garbage bin repair design. In contrast, the factors that got the most complaints were the smell that came from the garbage bin, which was very smelly and pungent, the volume of garbage that came from residents, the number of mosquitoes or flies that came from the garbage collection, a lot of untidy garbage scattered outside the garbage collection, conditions that get more annoying when it rains, and skin disorders in the form of itching caused by direct contact with leachate.

Identify Customer Requirement Attributes

The results of the open and closed questionnaires that have been obtained are converted into customer requirements attributes. The customer requirement attributes are as follows, watertight, airtight garbage bins equipped with lids, separating waste based on its nature (e.g., dry waste and wet waste) for easy destruction, garbage bin design based on the Stationery Container System (SCS) waste transportation model, equipped with wastewater reservoirs, the determination of the size of the garbage bin is based on the area of land. The garbage heap, fitted with a lock on the cover, provides an aesthetic aspect to the garbage bin, adding a small-scale garbage entry section and the position of the door or lid on the part that makes it easier for the janitor in garbage collection.

Table 4. Result of Customer Needs Identification Recap

No.	Voice of Customer (VOC)	Amount
1	The smell of garbage doesn't spread out	13
2	There is room for scavengers	2
3	Only used by market residents	2
4	Please keep it clean	1
5	Able to reduce the crowd of flies and mosquitoes	5
6	Able to accommodate all garbage	3
7	Able to prevent residents outside the market from throwing garbage	9
8	The trash can looks interesting	2
9	Make the job of the cleaners easier	5
10	No puddles from garbage water	2
11	Does not interfere with the convenience of consumers when shopping	2
12	Not muddy when it rains	4
13	Able to reduce contact with wastewater	5
14	Able to prevent the flow of sewage from flowing out	1

Table 4. above is the identification of customer needs based on the voice of the customer from an open questionnaire, then a summary of the customer needs is compiled into:

1. The smell of garbage doesn't spread out

2. Wet waste and dry waste are separated
3. Easy to take out the trash
4. No stagnant water
5. Garbage capacity according to the amount of waste
6. Prevent people outside the market from throwing trash
7. Neat and clean garbage bin
8. Easy to clean
9. Easy to pick up trash

Identify Technical Requirement Attributes

Technical requirements, also known as technical responses, are design characteristics that meet customer requirements (Xiao & Wang, 2024). It can also be said that technical reactions result from translating customer requirements (Kamvysi et al., 2023).

Table 5. Prioritized Technical Requirement Calculation Recapitulation

No.	Technical Response	DOD	TV	IR	RM	AWP	RWP	RANK
1	Covered	4	4	3.8	7	26.6	186	4
2	Locked	4	4	3.8	4	15.2	61	6
3	Added leachate reservoir	4	4	3.9	13	50.7	659	2
4	Added aesthetics	3	4	3.5	6	21	126	5
5	Adjust the location of the door	4	4	3.7	12	44.4	533	3
6	SCS model garbage bin	4	4	3.7	18	66.6	1199	1

From the calculation results of the Prioritized Technical Requirements in Table 5, it can be seen which Technical Response is the priority to be fulfilled so that consumers feel satisfied (point of Customer Satisfaction). The ranking results are as follows:

Priority 1: Technical response 6 “garbage bin design based on SCS (Stationery Container System) waste transportation model”
Priority 2: Technical response 3 “Added leachate reservoir”
Priority 3: Technical response 5 “Adjust the location of the door”
Priority 4: Technical response 1 “Covered”
Priority 5: Technical response 4 “Added aesthetics”
Priority 6: Technical response 2 “Locked”

House of Quality (HoQ)

Based on the HoQ matrix, the land area of the Sentul Traditional Market is 320cm x 200cm, with a daily waste volume of 2000 liters of waste. The Demangan Traditional Market land area is 320cm x 210cm with a waste weight of 1500 kg, equal to 5000 liters, a priority for technical requirements for developing a tub. Traditional market waste with the lowest focus is about the volume per person per day according to SNI 3242-2008 to estimate the volume of waste heaps. Based on the overall calculation results, a HoQ matrix can be drawn up for the garbage bin development plan at Sentul Market Yogyakarta, as presented in Table 6.

Table 6. HOQ Matrix Garbage Bin

	Covered	Locked	Added leachate reservoir	Added aesthetics	Adjust the location of the door	SCS model garbage bin	Importance Rating	Target Value	Scale Up	Sales Point	Absolut Weight and Percent
The smell of garbage doesn't spread out.	◎		○			○	3.95	3.66	1.08	1.5	6.40
Wet waste and dry waste are separated.				○			3.95	3.80	1.04	1.5	6.16
Easy when taking out the trash					◎	○	3.85	3.33	1.16	1.5	6.70
No stagnant water			◎			○	3.90	3.63	1.08	1.5	6.32
Capacity according to the amount of waste							3.76	3.63	1.04	1.5	5.86
Prevent people outside the market from throwing garbage.	○	◎				○	3.70	3.23	1.13	1.5	6.27
Neat and clean garbage bin			○	○			3.42	3.26	1.05	1.0	3.59
Easy to clean			○		◎	○	3.61	3.29	1.10	1.0	3.97
Easy when picking up garbage by officers					◎	○	4.00	3.84	1.04	1.5	6.24
Degree of Difficulty	4	4	4	4	3	4					
Target Value	4	4	4	4	4	4					
Absolut Weight and Percent	26.6	15.2	50.7	21	44.4	66.6					
Relative Weight and Percent	186	61	659	126	533	1199					
Ranking	4	6	2	5	3	1					

Part Deployment

In this section, steps are taken to place critical values obtained from the House of Quality and have been translated through making Fault Tree Analysis. Based on the part deployment matrix, the part specification with the most considerable column weight is obtained. Separation by dividing the shelter into two parts, one part for organic waste and the other for non-organic waste, which is the priority while the lowest priority is on using the image of throwing garbage in its place, recycling shape, reducing, and reusing, use Green (organic waste), Red (Plastic), Yellow (Paper), and writing markers for organic and non-organic waste and Yogyakarta City Regulation No. 10 of 2012 article 41.

Garbage Bin Design Making

The new design from the data processing results to the part deployment house that has been obtained is shown in Figure 3.

Figure 3. New Garbage Bin Design

Material Selection and Cost Analysis

A morphological chart must be prepared to determine or select the material for making the trash can. Several material selection criteria are presented in Table 7 below:

Table 7. Selection of Garbage Bin Raw Materials

Bahan	Kelebihan	Kekurangan	Keputusan
Wood	Cheap, Hard to Clean	Easily Weathered	Rejected
Porcelain	Expensive, Easy to Clean	Easily Broken	Rejected
Cement	Affordable, Easy to Clean	-	Received
Concrete Brick	Cheap, Hard to Clean	Easily Broken	Rejected

From the results of the morphological chart, it can be seen that the comparison of the four raw materials to be used and cement was selected as the raw material for making garbage bins. Furthermore, an ergonomic product design is designed which includes several criteria according to the needs and desires of consumers as well as the ability of the development team to meet the following aspects:

1. Easy to make
2. Easy to use
3. Easy to clean
4. Quick to make
5. It was cheap.

The estimated cost needed to make a garbage bin according to the design above is as follows:

Table 8. The Estimated Costs

No.	Material	Cost (Rp.)	Unit	Amount (Rp.)
1.	Red Brick 1540 Pieces	20.000	Rupiah/m^2	360.000
2.	Sand 3 Cubics	300.000	Rupiah	900.000
3.	Cement 4 Sacks	75.000	Rupiah	300.000
4.	Aluminum 2 Sheets	150.000	Rupiah/Sheet	300.000
5.	Prototype Filament	400.000	Rupiah	400.000
6.	2 Prototype Workers	100.000	Rupiah/Person	200.000
7.	2 People Making Garbage Bins	100.000	Rupiah/Person for 4 Days	800.000
8.	Galvalume	200.000	Rupiah/m^2	600.000
9.	Galvalume Installation Services	-	-	400.000
	Total			**4.260.000**

CONCLUSION

Based on the research objective, namely making improvements to the existing garbage bins at the Traditional Market, and from the results of the analysis and discussion regarding the repair of the garbage bins used by the Sentul Traditional Market and the Demangan Traditional Market, a product improvement design was obtained based on the last house, namely the part deployment house with the priority. One section is for organic waste, and the other for non-organic; the second priority container used is a fixed type of container with a Stationery Container System (SCS) waste collection system, and the third priority is the size of the organic and non-organic waste storage can change according to the amount of waste type and so on concerning the column weight values starting from the largest to the smallest value. The advantages of the product design, when compared to current garbage bins, are having a storage room according to the type of waste, having a wastewater reservoir, and minimizing the adverse effects of waste (breeding places (flies, mosquitoes, and other microorganisms), garbage odors, and garbage puddles which seeps out of the garbage bin, especially during the rainy season).

REFERENCES

Abadi, B., Mahdavian, S., & Fattahi, F. (2021). The waste management of fruit and vegetable in wholesale markets: Intention and behavior analysis using path analysis. *Journal of Cleaner Production*, *279*, 123802.

Aktoba, R. (2017). *DESAIN TEMPAT SAMPAH DENGAN PENDEKATAN ERGONOMI PARTISIPATORI*. Universitas Islam Indonesia.

Ashraf, A. M., Imran, W., & Vechot, L. (2022). Analysis of the impact of a pandemic on the control of the process safety risk in major hazards industries using a Fault Tree Analysis approach. *Journal of Loss Prevention in the Process Industries, 74*, 104649.

Bhambore, N., & Kumar, M. S. (2022). Municipal solid waste generation, management scenarios, and leachate treatment using sequencing batch biofilter granular reactor. *Process Safety and Environmental Protection*.

Bolar, A. A., Tesfamariam, S., & Sadiq, R. (2017). Framework for prioritizing infrastructure user expectations using Quality Function Deployment (QFD). *International Journal of Sustainable Built Environment*, *6*(1), 16–29.

Dewi, P. P., Jazuli, & Setyaningrum, R. (2015). PRANCANG BANGUN MODIFIKASI

TEMPAT SAMPAH KERTAS MENGGUNAKAN PENDEKATAN KANO MODEL DAN METODE QUALITY FUNCTION DEPLOYMENT (QFD). *Eprints.Dinus.Ac.Id*. http://eprints.dinus.ac.id/17518/1/jurnal_16307.pdf

Fitriani, A., Purnomo, H., & others. (2018). Perancangan dan Pengembangan Bed Shower Menggunakan Metode Quality Function Deployment (QFD) Berdasarkan Prinsip Ergonomi. *Jurnal Sistem Dan Manajemen Industri*, *2*(2), 85.

Hartono, M. (2018). Indonesian anthropometry update for special populations incorporating Drillis and Contini revisited. *International Journal of Industrial Ergonomics*, *64*, 89–101.

Kamvysi, K., Andronikidis, A., Georgiou, A. C., & Gotzamani, K. (2023). A quality function deployment framework for service strategy planning. *Journal of Retailing and Consumer Services*, *73*, 103343.

Lestariningsih, S., & Jono, J. (2019). PENGGUNAAN METODE QUALITY FUNCTION DEPLOYMENT (QFD) DALAM REDESAIN KOMPOR BATIK ELEKTRIK â€œKOMBATRIKâ€. *Jurnal Rekayasa Industri (JRI)*, *1*(1).

Liu, T.-K., Chang, H., & Chen, Y.-S. (2023). Public awareness of marine environmental quality and its relationship for policy support on marine waste management. *Marine Pollution Bulletin*, *195*, 115456.

Musthofa, N. H., Suhardi, B., & Astuti, R. D. (2015). Perancangan Desain Tempat Sampah Dengan Metode QFD Di Universitas Sebelas Maret. *Prosiding SNST Fakultas Teknik*, *1*(1).

Nurzaman, G. (2018). *Rancang Bangun Mesin Perontok Padi Menggunakan Metode Nordic Body Map (NBM) Dan Pendekatan Antropometri*. *2*(2), 48–52.

Nyirenda, J., & Mwansa, P. M. (2022). Impact of leachate on quality of ground water around Chunga Landfill, Lusaka, Zambia and possible health risks. *Heliyon*, *8*(12).

Ocampo, L. A., Labrador, J. J. T., Jumao-as, A. M. B., & Rama, A. M. O. (2020). Integrated multiphase sustainable product design with a hybrid quality function deployment--multi-attribute decision-making (QFD-MADM) framework. *Sustainable Production and Consumption*, *24*, 62–78.

Rahardjo, A. P., Suraidi, S., & Utama, H. S. (2018). Perancangan Tempat Sampah Pembuka Tutup Otomatis dan Indikator Kapasitas. *TESLA: Jurnal Teknik Elektro*, *19*(2), 133–145.

Rohmah, W. G., Rasyidah, F., Deoranto, P., & others. (2018). KAJIAN PERBAIKAN MUTU KERIPIK TEMPE DENGAN PENDEKATAN QUALITY FUNCTION DEPLOYMENT. *PROCEEDINGS OF NATIONAL COLLOQUIUM RESEARCH AND COMMUNITY SERVICE*, *2*.

Saleh, A. R. (2017). Rancang Bangun Mesin Pengiris Ubi Kayu menggunakan Pendekatan Nordic Body Map (NBM) dan Pendekatan Antropometri. *Jurnal TIN Universitas Tanjungpura*, *1*(2).

Shang, K.-C., Huang, S. T., Buchari, E., Lirn, T.-C., & Della, R. H. (2023). Integration of safety quality function deployment in ferry services: Empirical study of Indonesia. *Research in Transportation Business \& Management*, *47*, 100938.

Sumargo, B. (2020). *Teknik sampling*. Unj press.

Syreyshchikova, N. V., Pimenov, D. Y., Yaroslavova, E. N., Gupta, M. K., Sharma, S., & Giasin, K. (2021). Product quality planning in laser metal processing based on open innovation using quality function deployment. *Journal of Open Innovation: Technology, Market, and Complexity*, *7*(4), 240.

Tarwaka, B. (2014). *Ergonomi Industri: Dasar-Dasar Ergonomi dan Implementasi di Tempat Kerja*. Surakarta: Harapan Press.

Ul'fah Hernaeny, M. P. (2021). POPULASI DAN SAMPEL. *Pengantar Statistika 1*, 33.

Uma, S. (2006). Research Methods For Business (Metode Penelitian untuk Bisnis). *Edisi Empat Buku*, *1*.

Wibowo, S. A., & Purnomo, H. (2017). Desain produk jemuran anti hujan menggunakan metode quality function deployment (QFD). *Sinergi*, *21*(2), 141–148.

Wicaksaningtyas, S., Muchlis, M., & Yudiarti, D. (2019). Perancangan Alat Penampung Dan Pendistribusian Sampah Di Taman Lansia Pada Aspek Ergonomi. *EProceedings of Art & Design*, *6*(2).

Widiyanti, W. (2020). Pengaruh Kemanfaatan, Kemudahan Penggunaan dan Promosi terhadap Keputusan Penggunaan E-Wallet OVO di Depok. *Moneter-Jurnal Akuntansi Dan Keuangan*, *7*(1), 54–68.

Xiao, J., & Wang, X. (2024). An optimization method for handling incomplete and conflicting opinions in quality function deployment based on consistency and consensus reaching process. *Computers \& Industrial Engineering*, *187*, 109779.

Yan, J., Luo, W., Wang, J., Yang, W., Ma, Y., Jiang, D., & Jia, J. (2022). Application of the quality function deployment method in the mechanical structure design of subsea power devices. *Ocean Engineering*, *247*, 110536.

ZHANG, L., Zhidong, C., Rui, C., Sijia, Z. H. U., Jinna, L. I. N., & Pei, T. A. I. (2023). Compressive strength of fly ash based geopolymer utilizing waste completely decomposed granite. *Case Studies in Construction Materials*, *19*, e02667.