Design an innovative waste recycling trash bin based on the requirements from customers (Binusian) in Bina Nusantara University

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Abstract. The problem regarding waste recycling is still difficult to do, especially in an environment where the level of public awareness is still less concerned with the importance of cleanliness. At Bina Nusantara University there are organic and nonorganic trash bins, but the function is still not optimal due to the unfavorable interest of Binusian to use it or to carry out recycling activities. The survey was conducted using a questionnaire to 114 Binusian respondents qualitatively to get responses from 14 attributes related to recycling care and the design of the trash. The response from these 14 attributes will be the customer voice that is processed using Quality Function Deployment (QFD) to determine technical priorities that can be used to meet customer requirements. From the planning matrix, the factors that must be improved are the availability of organic and nonorganic waste bins, as well as improvements to the design of existing trash bins at Bina Nusantara University. Implementation of technical requirements in the form of rewards for recycling activities carried out especially for plastic waste, making redesigns for unique and innovative bins with 70% stainless steel and 30% fiberglass, and making a system that is integrated with accounts for rewarding is expected to be able meets 14 customer requirement attributes.

Keyword: waste recycling, questionnaire, Quality Function Deployment (QFD), innovative bins

1. Introduction
Collecting of garbage is pollution that can pollute air, soil and water. Waste is divided into organic and inorganic. Waste management is important to do in order to maintain environmental cleanliness, the handling that can be done for the first stage is by recycling or sorting any type of waste. Waste management and efficient sorting of them have been considered as an important role for ecologically sustainable development worldwide. It is essential for the society to reduce waste accumulation by recycling and re-using disposed of products. Efficient selective sorting is often implemented to improve recycling and reduce the environment impact [1]. The main problem in waste management in Indonesia and also a problem in Bina Nusantara University are having non-optimal, credible, and professional waste management planning systems [2] that can increase Binusians interest in waste recycling from its environment.
The survey was conducted to examine how sensitivity to recycling activities and get customers voices about the desire of Binusians to improve a design for the waste recycling trash bins at Bina Nusantara University. Improving the criteria of the waste management system can improve the trash bin especially for solid waste, where solid waste (paper, glass, plastic, and metal) is the unwanted or useless solid materials generated from combined residential, industrial and commercial activities in a given area [3], which can be implemented in Bina Nusantara University.

Customer voice obtained will be used in designing Quality Function Deployment (QFD), which is QFD can be called with Quality House is the main tool for the implementation to bridge consumer demands and design elements, a relationship to be quantified by the degree of attention consumer pay to product design on weights and priorities [4]. QFD component provide product or service functionality to satisfy customer needs. The technique based on analysis of customer needs, which are expressed in qualitative terms [5]. Collecting customer voice to fill and develop data for QFD by using questionnaire as a series of questions asked to individuals to obtain statistically useful information about a given topic [6]. In this study, design of questionnaire was developed to get many information related to awareness of recycles, interest of recycle, and design of trash bin. Some question of questionnaire refers with designing a better product [6] and increasing service quality from the systems [7].

The purpose of this study is to check, improve, and analyze the interests and characteristics of Binusian to recycle and find out the desired criteria by Binusian (employees, lecturers, students) for the recycling trash bins that can increase the awareness of waste recycling activity.

2. Materials and methods
2.1 Design questionnaire attribute for voice of customer
This research was conducted at Bina Nusantara University Syahdan Campus, West Jakarta, using qualitative research methods in the data collection process. Data collection was carried out using the survey method with the aid of a closed questionnaire. The survey was conducted on 114 respondents were qualitative to Binusian (lecturers, employees, students). From this data, the idea of complaints, suggestions, and innovations can be captured that can lead to the interest of recycling activities and the availability of waste recycling trash bin on campus. Data obtained from respondents are analyzed in depth and detail for each attribute of the questionnaire based on designing product summarizing principal for every category [6] shown in Table 1.

| No. | Question                                                                 | Category                        |
|-----|--------------------------------------------------------------------------|---------------------------------|
| 1   | Status of work                                                           |                                 |
| 2   | Availability of organic and nonorganic trash bin                          | Awareness of recycles            |
| 3   | Recycling for nonorganic waste than dispose it                            |                                 |
| 4   | The type of material usually used for recycling                          | Interest of recycle              |
| 5   | Frequency of recycling                                                   |                                 |
| 6   | Interest in recycling                                                    |                                 |
| 7   | Willingness for getting reward if participating for every recycling activities |                                 |
| 8   | Nominal of reward for once recycling activity                            |                                 |
| 9   | The type of material with highest reward                                 |                                 |
| 10  | Influence of the design for the trash bin on interest for recycling       |                                 |
| 11  | Type of material for a good design of the trash bin                      | Design of a trash bin            |
| 12  | Agreement if the existing trash bins are developed based on technology, especially rewards that can be directly received |                                 |
| 13  | Suitable specification (length, width, high) for the design of trash bin  |                                 |
| 14  | The Kind of innovation for the trash bins are developed based on technology |                                 |
| 15  | Suitable price for technology based of trash bins                         |                                 |

Table 1. Design of questionnaire
2.2 House of quality design

Data was obtained from 114 respondents become customer requirements that are processed using the quality function deployment approach with the importance and needs faced by the customer. The stages of making a house of quality begin by determining the technical requirements which are a way to meet the needs found in the customer requirements. Next is determining the relationship between technical requirements, which is done by giving the value of the correlation strength for each technical requirement with the appropriate level. The next stage is to determine the relationship between technical requirements and customer requirements, where from this stage the value of the importance of the technical requirements are generated [6]. Sequentially the next step is to determine the value of importance level, customer satisfaction rating, target design, planned rating, sales point, technical priority, and overall weighting [7].

3. Results and Discussion

3.1 Questionnaire recapitulation

The recapitulation results from questionnaires from 114 respondents are shown in the following Table 2.

| Question                                      | Answer         | Respondent | Percentage |
|-----------------------------------------------|----------------|------------|------------|
| Status of work                                | Student        | 104        | 91.2%      |
|                                               | Lecturer       | 7          | 6.1%       |
|                                               | Employee       | 3          | 2.6%       |
| Availability of organic and nonorganic trash bin | Yes           | 67         | 58.8%      |
|                                               | No             | 47         | 41.2%      |
| Recycling for nonorganic waste than dispose it | Ever           | 44         | 38.6%      |
|                                               | Never          | 70         | 61.4%      |
| The type of material usually used for recycling | Plastic       | 34         | 52.3%      |
|                                               | Metal          | 2          | 3.1%       |
|                                               | Paper          | 29         | 44.6%      |
| Frequency of recycling                        | Every day      | 34         | 29.8%      |
|                                               | Once a week    | 52         | 45.6%      |
|                                               | Once a month   | 23         | 20.2%      |
|                                               | Others         | 5          | 4.4%       |
| Interest in recycling                         | 1              | 1          | 0.9%       |
|                                               | 2              | 8          | 7%         |
|                                               | 3              | 18         | 15.8%      |
|                                               | 4              | 55         | 48.2%      |
|                                               | 5              | 32         | 28.1%      |
| Willingness for get reward if participating for every recycling activities | 1 | 1 | 0.9% |
|                                               | 2              | 1          | 0.9%       |
|                                               | 3              | 13         | 11.4%      |
|                                               | 4              | 51         | 44.7%      |
|                                               | 5              | 48         | 42.1%      |
| Nominal of reward for once recycling activity | <Rp 5,000      | 9          | 7.9%       |
|                                               | Rp 5,000 - Rp 10,000 | 53 | 46.5% |
|                                               | >Rp 10,000     | 48         | 42.1%      |
|                                               | Others         | 4          | 3.5%       |
| Question                                                                 | Answer                  | Respondent | Percentage |
|-------------------------------------------------------------------------|-------------------------|------------|------------|
| The type of material with highest reward                                | Plastic                 | 52         | 45.6%      |
|                                                                         | Paper                   | 5          | 4.4%       |
|                                                                         | Metal                   | 57         | 50%        |
| Influence of the design for the trash bin on interest for recycling     | Yes                     | 82         | 71.9%      |
|                                                                         | No                      | 32         | 28.1%      |
| Type of material for a good design of the trash bin                     | Fiberglass              | 22         | 19.3%      |
|                                                                         | Acrylic                 | 41         | 36%        |
|                                                                         | Stainless Steel         | 51         | 44.7%      |
| Agreement if the existing trash bins are developed based on technology, especially rewards that can be directly received | 1                       | 1          | 0.9%       |
|                                                                         | 2                       | 2          | 1.8%       |
|                                                                         | 3                       | 9          | 7.9%       |
|                                                                         | 4                       | 47         | 41.2%      |
|                                                                         | 5                       | 55         | 48.2%      |
| Suitable specification (length, width, high) for the design of trash bin | Elongated box (150cm x 90cm x 100cm) | 22 | 19.3% |
|                                                                         | Escalate box (90cm x 60cm x 150cm) | 60 | 52.6% |
|                                                                         | Cylinder (Dia 60cm x 150cm) | 32 | 28.1% |
| The Kind of innovation for the trash bins are developed based on technology | Ability to sort waste based on the type of material automatically | 65 | 57% |
|                                                                         | Interconnection with personal accounts to receive a reward | 13 | 11.4% |
|                                                                         | Automatic retrieval by officer when the garbage is gone reaching the limit of capacity | 35 | 30.7% |
|                                                                         | Others                  | 1          | 0.9%       |
| Suitable price for technology based for trash bins                      | Rp 1,500,000 – Rp 2,500,000 | 63 | 55.3% |
|                                                                         | Rp 2,500,000 – Rp 3,000,000 | 39 | 34.2% |
|                                                                         | Rp 3,000,000 – Rp 4,000,000 | 9  | 7.9%       |
|                                                                         | Rp 4,000,000 – Rp 5,000,000 | 3  | 2.6%       |

From the results of the recapitulation of the questionnaire, the answers of respondents with the highest percentage were marked in green indicating that the customer's needs in this case Binusian must be met and prioritized. The other categories that have less percentage are also being considered since it is specific in accordance with the requests of some customers.
3.2 Improvement planning using quality function deployment

After obtaining the customer requirement attributes that must be prioritized, the next step is to carry out the process of repairing and improving the recycling activities and waste recycling trash bins existing at Bina Nusantara University. Table 3 shows the importance level for each attribute of customer voices of 14 attributes. The greatest value of 5 indicates that these attributes are very important and must be considered to improve and meet customer satisfaction (Binusian). At the attribute numbers of 1, 2, 5, 8, 10, 12, and 13 that has score for importance level is 5, it is shown that these attributes must be solved first.

| No. | Customer Voices                                                        | Importance level |
|-----|------------------------------------------------------------------------|------------------|
| 1   | Availability of organic and nonorganic trash bin                       | 5                |
| 2   | Recycling for nonorganic waste than dispose it                         | 5                |
| 3   | Plastic is the type of material usually used for recycling             | 4                |
| 4   | Frequency of recycling is once a week                                  | 3                |
| 5   | Interest in recycling                                                  | 5                |
| 6   | Get reward if participating for every recycling activities             | 4                |
| 7   | Nominal of reward for once recycling activity is between Rp5,000-Rp10,000 | 4                |
| 8   | The type of material with highest reward is a plastic                  | 5                |
| 9   | Design for the trash bin is influence on interest for recycling        | 3                |
| 10  | Stainless steel is a type of material for a good design of the trash bin| 5                |
| 11  | The existing trash bins are developed based on technology, especially rewards that can be directly received | 4                |
| 12  | Escalate box (90cm x 60cm x 150cm) for a suitable design of trash bin  | 5                |
| 13  | Ability to sort waste based on the type of material automatically      | 5                |
| 14  | Suitable price for technology based for trash bins are Rp1,500,000-Rp2,500,000 | 4                |

In the planning matrix, calculations are performed to determine some parameters for each customer voice attribute. Table 4 shows the results used to make improvements to the system and the quality of the recycling process and the waste recycling trash bin.

As shown in Table 4, attribute number of 1 with a rating from a customer rating of 3, has an improvement factor of 1.4 which the largest value compared to others. It means that this attribute has a high level of difficulty to do the improvement. Whereas the sales point of 1.2 means that if the availability of organic and nonorganic waste recycling trash cans be fulfilled, then it can improve services by 1.2 points in the middle level. The higher sales point can get when the higher level of satisfaction given by the customer. An Overall Weighting (OW) is the weight for each attribute, the value of overall weighting is obtained by multiplying the importance level and the improvement factor with the sales point owned by each attribute, while Percentage Overall Weighting (% OW) is a proportion for each attribute indicated by a percentage. The percentage value is obtained by dividing the value of each attribute with the total value of all attributes.

Determination of the correlation between technical requirements using two types of correlations in the form of a "+" sign which indicates strong correlation, while a "," sign indicates no correlation [8]. Figure 1 shows the correlation matrix between 10 specified technical requirements. To socialize the importance of recycling by increasing the number of available waste recycling trash bins, there is a
strong correlation between technical requirements as a mutual support. Meanwhile, there is no
correlation to escalate box with dominant material of stainless steel. Other relationships between
technical requirements have similar correlation that have a “+” sign or a “-” sign.

Table 4. Planning Matrix

| Attribute No. | Importance Level | Existing Rating | Improvement factor | Sales point | OW | %OW |
|---------------|-----------------|-----------------|-------------------|-------------|----|-----|
| 1             | 5               | 3               | 1.4               | 1.2         | 8.4| 8.6 |
| 2             | 5               | 4               | 1.2               | 1.5         | 9.0| 9.2 |
| 3             | 4               | 3               | 1.2               | 1.2         | 5.8| 5.9 |
| 4             | 3               | 3               | 1                 | 1.2         | 3.6| 3.7 |
| 5             | 5               | 4               | 1.2               | 1.5         | 9.0| 9.2 |
| 6             | 4               | 3               | 1.2               | 1.2         | 5.8| 5.9 |
| 7             | 4               | 3               | 1.2               | 1           | 4.8| 4.9 |
| 8             | 5               | 4               | 1.2               | 1.2         | 7.2| 7.3 |
| 9             | 3               | 3               | 1                 | 1.5         | 4.5| 4.6 |
| 10            | 5               | 4               | 1.2               | 1.5         | 9.0| 9.2 |

| Attribute No. | Importance Level | Existing Rating | Improvement factor | Sales point | OW | %OW |
|---------------|-----------------|-----------------|-------------------|-------------|----|-----|
| 11            | 4               | 3               | 1.2               | 1.2         | 5.8| 5.9 |
| 12            | 5               | 4               | 1.2               | 1.5         | 9.0| 9.2 |
| 13            | 5               | 4               | 1.2               | 1.5         | 9.0| 9.2 |
| 14            | 4               | 3               | 1.2               | 1.5         | 7.2| 7.3 |

Figure 1. Correlation matrix of technical requirement
The Quality Function Deployment (QFD) design is used to know the interest of recycling in the Binusian as well as the design of waste recycling trash bin, which is shown in Figure 2.

![Figure 2. Quality function deployment](image-url)

Based on the percentage of technical priority shown in Figure 2, it can be seen that the five highest categories of technical requirements will be chosen to be implemented in the design of repairs as well as an increase in recycling interest among Binusians. The design target of technical priorities shows that the value is the expectation of designer to meet the technical priorities of customer desires. The higher value of target design, the higher difficulty must be handled.

The value of technical priority is obtained from the sum of each technical requirement by the voice of customer. For the technical priority of the socialization of the importance of recycling only has priority with recycling inorganic waste and increasing interest in recycling. The relationship between both categories are very strong because they influence each other, therefore both of customer voices have a value of 9 resulting a total value of 18 for this technical priority. Percentage of technical priority percentage for each technical requirement valued by dividing each technical priority value
with the total number of existing technical priority values. QFD value with a scale of 1 to 5, describes a good reference value and maximum technical requirements that must be fulfilled customer needs.

The QFD result aims to meet the 14 existing customer voices by determining technical requirements. The ten technical requirements are expected to meet all customer voices by prioritizing the design changes, giving rewards, and making integrated trash bins system, and lead to more favourable in receiving rewards. The planning matrix provides information to assess the attributes of the improvement factor, the selling value when meeting the customer's voice, and the planned rating to simplify the determination of attributes that are the main focus for improvement.

3.3. Flow Processes for the smart trash bin

The priority of our technical requirements are creating unique and innovative designs for waste recycling trash bins at Bina Nusantara University. Based on this, the waste recycling trash bin will be built, which has features of receiving reward for customers and automatic notification when the container of waste recycling trash bin is full and need to be emptied the container.

Figure 3 shows the flow process of waste recycling trash bin. For the first step, this bin is designed for disposing plastic waste, particularly for plastic bottles. As shown in Figure 3, the customer (Binusian) can get reward in the form of electronic money top up. However, they must follow the instruction of the process, if not the reward is not applicable. Another feature is the automatic notification for emptying the bin when the container of the bin is full by detecting the condition of container using the sensor.

| FLOW PROCESS FOR THE SYSTEM OF AN EFFECTIVE TRASH BIN |
|------------------------------------------------------|
| **BINUSIAN**                                         |
| Start                                                |
| Dispose plastic bottles                              |
| Open bottle cap                                      |
| Tapping a card                                       |
| Reward sent                                          |
| Flash                                                |
| **MANAGEMENT**                                      |
| Sensor reads incoming garbage                         |
| Fit to regulation?                                   |
| Garbage forwarded to container                        |
| System stopped to work                                |
| Notification to empty the container                   |
| **TRASH BIN SYSTEM**                                 |
| Container full?                                      |
| NO                                                   |
| YES                                                  |
| YES                                                  |
| NO                                                   |

**Figure 3.** Flow process of waste recycling trash bin
Conclusions
The results of this study indicate that the level of concern from Binusians for recycling is still not optimal. Factors that must be improved or immediately addressed are the availability of organic and nonorganic waste recycling trash bins, as well as improvements to the design of existing bins at Bina Nusantara University. Thus, it can increase Binusian's attractiveness for recycling, especially for plastic waste, which is in line with customer voice. Improvements can also be done by implementing technical requirements, by giving rewards for recycling activities carried out especially for plastic waste, making a redesign for a unique and innovative trash with 70% stainless steel and 30% fiberglass, and making an integrated system with account for giving a reward. The waste recycling trash bin system that has designed, is providing the features of rewards and automatic notification for emptying the bin. Receiving the reward is valid when the customers follow the instruction process well.

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