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Development Of An Automatic Plant Watering System Through Kano Method And Quality Function Deployment To Optimize The Function

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Abstract— Applying the Kano Model and Quality Function Deployment (QFD) to the study can determine consumer preferences for higher-quality products. Kano Model is used to classify product aspects based on user satisfaction levels, While QFD is used to translate customer wants into certain technical qualities to determine the requirements and expectations of 35 potential users, data was gathered using questionnaires and interviews with the users. The Kano Model was then used to examine the survey data and classify the demands of potential users into six groups: Must-Be Attributes (M), Attractive Features (A), One-Dimensional Features (O), Indifferent Features (I), Reverse Features (R), Questionable Features (Q). These classifications aid in deciphering the relative importance that prospective buyers place on certain product attributes. In addition, to determine the technical qualities needed to satisfy consumer wants, the QFD matrix incorporates the findings of the Kano analysis. There are many phases in this process: defining the needs of the users, converting those needs into technical specifications, and setting development priorities based on a consideration of each attribute's relative value. The research findings are the Kano Model and QFD together may efficiently determine and rank the wants of potential customers and then convert those needs into practical steps to improve the plant watering system. When this technique is put into practice, it should help manufacturers and researchers create items that better satisfy the needs and expectations of potential users, which will boost users' satisfaction and sales.

Keywords: Model Kano, Quality Function Deployment (QFD), quality improvement, product attributes

I. INTRODUCTION

The rapidly changing market conditions in the field of product development require an improvement to improve product quality and increase purchasing interest so that the results obtained are effective and efficient. In a competitive market environment, understanding and meeting customer needs is critical for the success of any product or service. To do this, companies must effectively identify, prioritize, and address customer requirements. The development of automatic watering systems has been performed by previous research such as [1]–[3].

Two powerful tools that help in this process are the Kano Model and Quality Function Deployment (QFD). The Kano Model, developed by Professor Noriaki Kano in the 1980s, is a theory for product development and customer satisfaction [4]. It classifies customer preferences into five categories: basic needs, performance needs, excitement needs, indifferent needs, and reverse needs. This classification helps businesses understand which features will delight customers, which ones are necessary for customer satisfaction, and which ones may not significantly impact customer perceptions. By categorizing features this way, companies can strategically prioritize their efforts to enhance customer satisfaction and loyalty.

Quality Function Deployment (QFD), on the other hand, is a method developed in Japan in the late 1960s. It is used to transform customer needs (the voice of the customer) into engineering characteristics for a product or service. The QFD process involves the creation of one or more matrices (often referred to as the House of Quality) that help in translating customer requirements into specific, measurable technical specifications. This structured approach ensures that every aspect of the product development process is aligned with customer expectations[5].

When used in conjunction, the Kano Model and QFD provide a comprehensive framework for understanding customer needs and translating them into actionable product features [6], [7] and ergonomic design [8]. The Kano Model helps to categorize and prioritize customer requirements, while QFD ensures these requirements are systematically addressed in the design and development process. And some research also combined Kano, AHP and QFD [7], [9]. Integration of SERVQUAL, Analytical Kano, and QFD using fuzzy approaches to support improvement decisions

This research aims to design a product based on the user requirements using the integration of the Kano Model and QFD in product development. By combining these methodologies, Through a detailed case study, this research will demonstrate how these tools can be applied effectively to identify critical customer needs, prioritize them, and translate them into specific technical requirements, ultimately leading to the creation of products that better meet customer expectations.

II. Research Method

2.1 Research design

The integration of the Kano Model and Quality Function Deployment (QFD) involves a systematic approach to capturing customer requirements and translating them into specific product features. This method comprises several steps, each designed to ensure that customer needs are thoroughly understood and incorporated into the product development process. The steps are outlined as follows:

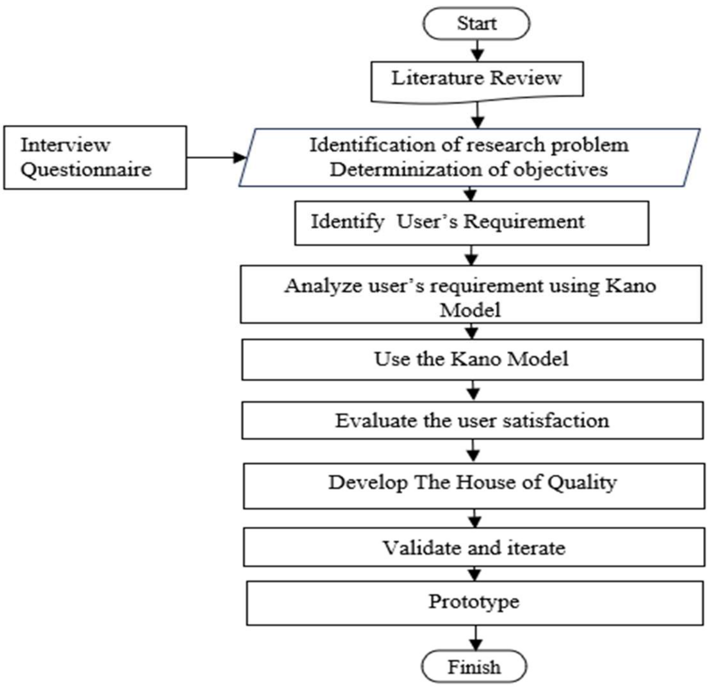

Figure 1. Framework of research

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Step 1: Identify user Requirements

1. User Surveys and Interviews: Conduct surveys and interviews to gather qualitative and quantitative data on user needs and preferences.
2. Data Collection: Collect feedback from various sources, including direct customer feedback, market research, and competitor analysis.

Step 2: Analyze user Requirements Using the Kano Model

1. Categorize Requirements: Use the Kano questionnaire to classify user requirements into five categories: Basic (Must-Be), Performance (One-Dimensional), Excitement (Attractive), Indifferent, and Reverse.
2. Evaluate Customer Satisfaction: Analyze how each category of requirements affects customer satisfaction. Basic needs prevent dissatisfaction, performance needs increase satisfaction linearly, and excitement needs significantly boost satisfaction when fulfilled.

Step 3: Develop the House of Quality

1. Prepare the QFD Matrix: Create the initial QFD matrix (House of Quality) to translate user needs into design requirements.
2. Integrate Kano Results: Input the categorized user requirements from the Kano Model into the QFD matrix. Each requirement is assigned a weight based on its impact on user satisfaction.
3. Technical Correlation: Establish relationships between customer requirements and technical specifications. Determine the strength of these relationships and indicate them in the matrix.

Step 4: Prioritize Technical Requirements

1. Assign Importance Ratings: Based on the Kano analysis, assign importance ratings to each customer requirement. Higher ratings are given to requirements that have a more significant impact on user satisfaction.
2. Calculate Priority Scores: Calculate the priority scores for each technical requirement by considering the importance ratings and the strength of their relationships to user needs.

Step 5: Develop Product Specifications

1. Define Technical Targets: Set specific, measurable targets for each technical requirement based on the priority scores. Ensure that these targets align with the overall product development goals.
2. Allocate Resources: Allocate resources to address the most critical technical requirements, focusing on those that will have the highest impact on user satisfaction.

Step 6: Validate and Iterate

1. Prototype and Test: Develop prototypes and test them with the user to validate that the technical requirements meet their needs.
2. Feedback Loop: Gather feedback from customers and iterate the design process. Update the QFD matrix and adjust technical specifications as necessary to continuously improve the product.

3.2 Discussion

The validity of the instrument was confirmed, as the significance level was 0.05, which is much greater than the obtained p-value of 0.000, indicating that the results are statistically significant and the instrument measures what it is intended to measure. The reliability of the instrument was also ensured, demonstrated by a Cronbach's Alpha coefficient of 0.989 across 13 items. This high coefficient indicates excellent internal consistency, meaning that the items on the instrument consistently measure the same underlying concept.

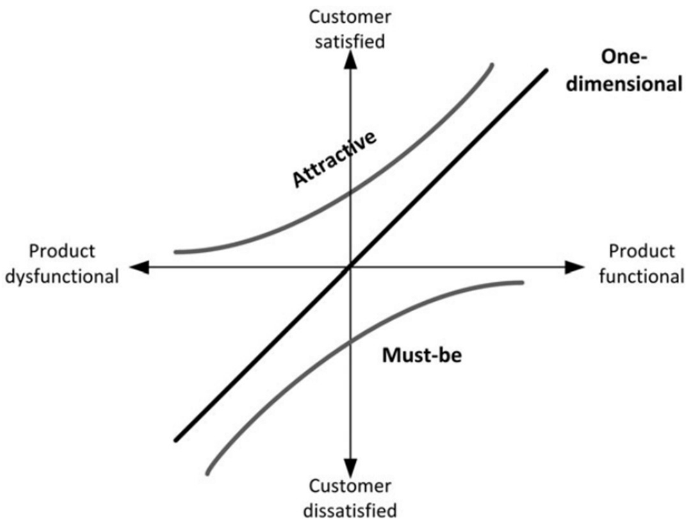

Figure 2. The Kano diagram [10]

Findings

To further explain the proposed methodology, we conducted a case study on an automatic plant watering system. This product was selected due to its increasing popularity and high market trend. Figure 2 provides detailed information about the product used in this case study.

Figure 3. The product's information.

Power Supply 5A 5V, Relay LYN2 12 V, Kit Step Up 5v – 12 v, Relay 5 V 2 Channel, Modul Development V3 CH340 NODE MCU, Lcd 12x6, Fuse, Indicator lamp, Soil Moisture, Termistor, Junction Box, Sensor DHT 11, Swict and water drum. These components collectively suggest a setup for an electronic or automation project, potentially involving monitoring and controlling environmental conditions (temperature, humidity, soil moisture) and managing electrical circuits (relays, power supply, step-up module). Each component plays a crucial role in the functionality and operation of the system it's integrated into.

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Table 1. The responses and categorization of attributes from users

No	Atribut	A	M	O	I	R	Q	Total	Grade	SC	DC
1	Suitable for expected quality	**6**	**3**	**24**	**2**	**0**	**0**	**35**	O	0,857	0,771
2	The product matches with the promotion	**6**	**12**	**15**	**2**	**0**	**0**	**35**	O	0,600	0,771
3	SMART watering system	**9**	**3**	**19**	**4**	**0**	**0**	**35**	O	0,800	0,629
4	Attractive and desirable expectation	**6**	**6**	**19**	**4**	**0**	**0**	**35**	O	0,714	0,714
5	Reasonable prices	**10**	**11**	**9**	**5**	**0**	**0**	**35**	M	0,543	0,571
6	Price range Rp.500.000 - Rp.600.000	**8**	**8**	**10**	**8**	**1**	**0**	**35**	O	0,529	0,529
7	Can be sold in Batam	**7**	**15**	**8**	**5**	**0**	**0**	**35**	M	0,429	0,657
8	The product can be sold using any platform	**9**	**11**	**10**	**5**	**0**	**0**	**35**	M	0,543	0,600
9	This plant irrigation tool can be sold and used anywhere that has an internet network.	**11**	**8**	**8**	**8**	**0**	**0**	**35**	A	0,543	0,457
10	Sellers know the details how the product works	**4**	**13**	**13**	**5**	**0**	**0**	**35**	M	0,486	0,743
11	Easy to use	**6**	**9**	**15**	**5**	**0**	**0**	**35**	M	0,600	0,686
12	This automatic plant irrigator can irrigate the plant and monitor its soil moisture from an indefinite distance.	**6**	**9**	**14**	**6**	**0**	**0**	**35**	O	0,571	0,657
13	It has good safety standards on the device.	**6**	**13**	**9**	**7**	**0**	**0**	**35**	M	0,429	0,629

The table depicts the different attributes, and their respective categories ('A' for Attractive, 'O' for One-Dimensional, 'M' for Must-Have, 'I' for Indifferent, 'R' for Reverse, and 'Q' for Questionable), and the total number of responses collected. The category chosen by a respondent for any feature represents the combination of responses to functional and dysfunctional questions in the survey, according to the Kano evaluation scheme. A sample set of 35 people was taken in Step 1. Table 1 presents the results obtained from the Kano questionnaire analysis, showing the responses and categorization of attributes for the automatic plant watering system. Out of 13 attributes, 6 were categorized as One-Dimensional Attributes (O), 6 as Must-Have Attributes (M), and 1 as an Attractive Attribute (A).

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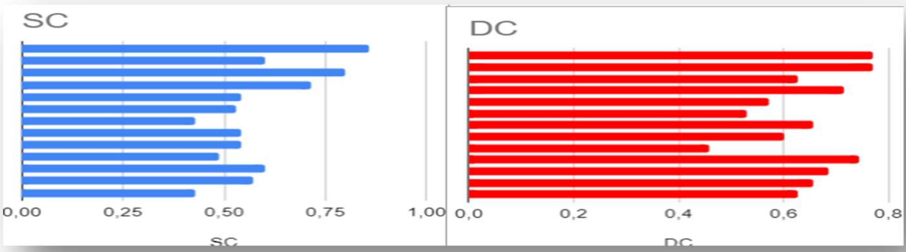

Figure 4. Range of SC and DC.

Figure 4 illustrates the range of satisfaction to dissatisfaction that each feature of the automatic plant watering system exhibits. This range is determined by analyzing user feedback on how each feature affects their overall satisfaction with the product. Features that fall towards the satisfaction end of the range are those that users find particularly valuable and pleasing. Conversely, features that fall towards the dissatisfaction end are those that users find lacking or problematic. By visualizing this range, we can identify which features are most crucial for enhancing user satisfaction and which need improvement to reduce dissatisfaction.

Quality Function Deployment

HOQ (House of Quality) is a matrix used to translate customer needs into food product development planning characteristics of "Automatic Plant Irrigation Tools" in this study. Translating customer needs, data is needed to fill the matrix. In the House of Quality (HOQ), the method of Quality Function Deployment (QFD) is the determination of the voice of the customer (VOC), the planning matrix, the definition of technical parameters (technical response), the analysis of relations WHATs and relations HOWs, the technical correlation and the technical matrix.

The final step is the house of quality (HOQ). The main components include:1. Customer Requirements 2. Correlation Matrix 3. Relationship Matrix 4. Technical Design Characteristics 5. Competitive benchmarking 6. Technical Benchmarking Assessment

Based on users' desires and the associated metrics, the House of Quality was constructed. It illustrates the interdependencies within the technical matrix, which is responsible for meeting users' desires. This detailed framework shows how different technical requirements are linked to user needs, helping to ensure that the product development process remains focused on satisfying customer expectations.

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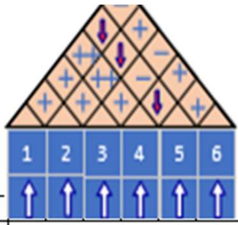

No	Rang	Customer Requirements (What)	Importance	1 Resistance of Packaging	2 Resonable price	3 Eseaness of usage	4 Promotion in all media	5 Certification	6 Seleted raw material	7 Goal	8 Improvement ratio	9 Sales Point	10 Raw Weight	11 Normalized raw weight
		Direction improvement		↑	↑	↑	↑	↑	↑					
1	13	Suitable for expected quality	3.63	●	○	○	●		●	2	0.6	1.2	2.4	0.1
2	1	The product match with the promotion	4.54	●	○					3	0.8	1.5	4.5	0.1
3	2	SMART watering system	3.34	▼	▼		●	▼	○	3	0.9	1.2	3.6	0
4	5	Attractive and desirable expectation	4.26	○	○	○	○		●	3	0.9	1	3	0.1
5	12	Resconable prices	3.86		○		●	▼	▼	2	0.5	1.5	3	0.1
6	11	Price range Rp.500.000 - Rp.600.000	3.97		○					3	0.9	1	3	0.1
7	9	Can be sold in Batam	4.09	●	○	●		●		3	0.8	1.5	4.5	0.1
8	4	The product can be sold using any platform	4.31	●	○	○	○	○	●	1	0.3	1	1	0
9	10	This plant irrigation tool can be sold and used anywhere that has an internet network.	4.03			●				2	0.5	1.2	2.4	0.1
10	2	Sellers know the detail how the product work	4.34	○	○	○	●		○	2	0.6	1.5	3	0.1
11	7	Easy to be used	4.11	○			○	●		2	0.6	1.2	2.4	0.1
12	6	This automatic plant irrigator can irrigate the plant and monitor its soil moisture from an indefinite distance.	4.23			●	▼			2	0.6	1	2	0.1
13	7	It has good safety standards on the device.	4.11			●			●	3	0.8	1.2	3.6	0.1
		Amount	#	52	41	66	64	25	47				38	1
		Percentage(%)		17	14	22	21	8	16					
		Priority		3	5	1	2	6	4					

Technical Specifications (How)

User Reqiuirment(WHATs)

Tehnical Requirements (HOWs)

Correlations:
++ Strong Positive
\+ Positive
-- Strong Negative
\- Negative

Relationships:
Strong= 9
Medium= 3
Weak= 1

Figure 5. House of Quality

Figure 4 presents The House of Quality provides a comprehensive analysis of how different features and their technical requirements are interrelated, and grounded in scientific research. This tool helps identify and prioritize the most critical aspects of the product. In this case, three key priorities were identified: packaging quality, product quality, and product price. Users highlighted the importance of specific features such as easy watering, effective media promotion, and durable packaging. These priorities reflect what users value most, guiding the product development process to focus on these crucial areas to enhance user satisfaction and meet market demands.

III. Conclusions

The integration of the Kano model and the Quality Function Deployment (QFD) method provides a comprehensive understanding of customer satisfaction and perception. The Kano model addresses users' desires and the level of satisfaction associated with specific features, while QFD focuses on prioritizing these needs and translating them into technical metrics for the product. In this study, it was crucial to assess every potential feature required by users to enhance their contentment. This process operates in a closed loop where designers fulfil users' demands. The process involves analyzing user opinions, categorizing collected data, preparing satisfaction and dissatisfaction coefficients, and formulating priority ranking indexes. This is followed by constructing the final House of Quality, which includes competitor benchmarking. The House of Quality offers a detailed explanation of the interdependencies between all features and their technical requirements based on scientific research. Three priorities were identified: packaging quality, product quality, and product price. Users emphasized the importance of easy watering, effective media promotion, and durable packaging. By applying these techniques, both established organizations and new entrants in the market can evaluate their products and services effectively. Further research with a larger sample size across various market segments is recommended to generalize the results from a marketing management perspective and improve product design.

IV. ACKNOWLEDGEMENT

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V. FUTURE RESEARCH AND DIRECTION

Future research can ensure the number of respondents and a combination of other methods are required to make the designed product will be more competitive and valuable. It is expected to use experts' judgment as a comparation.

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