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Original research article

Identifying customer needs for electric bicycle product design using the Kano model and Quality Function Deployment (QFD)

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ABSTRACT

This research aims to identify user preferences regarding product quality, specifically in the design of electric bicycles. The study was conducted using the Kano Model and Quality Function Deployment approaches. The research process began with identifying customer complaints about electric bicycle quality, followed by a literature review, designing research instruments, determining the target segment of electric bicycle users, collecting and processing data, and designing geometric representations of the product. The results identified seven attributes classified under the Attractive category in the Kano Model. Based on the House of Quality analysis and consumer needs, several recommendations were made to enhance product quality. The proposed design improvements include adding turn signals to the front and rear, designing a radius-shaped backrest with specific dimensions, implementing an adjustable height lever, creating social media advertisements and collaborating with public figures, modifying handlebars for better ergonomics, offering metallic and matte color options, and increasing battery capacity from 12 Ah to 20 Ah. These findings contribute to the development of electric bicycles that better meet consumer expectations and enhance user satisfaction.

1. Introduction

An electric bicycle is an electric vehicle classified as an innovative product and considered environmentally friendly [1]. The primary difference between electric vehicles and conventional vehicles lies in the drive chain, energy storage, and power transmission system. Electric bicycles have a simpler power transmission system compared to conventional vehicles [1]. The presence of electric vehicles in Indonesia is part of an effort to reduce pollution caused by combustion residues from conventional vehicles.

Electric vehicles are expected to be a key solution in addressing current climate challenges. They play a significant role in achieving the 7th Sustainable Development Goal (SDG), which focuses on clean and affordable energy. This SDG emphasizes the importance of ensuring access to energy that is affordable, reliable, and sustainable [2]. Indonesia has committed to achieving this goal by 2030 [3], a commitment supported by the issuance of Presidential Regulation No. 55 of 2019 regarding electric vehicles.

This policy aims to accelerate the development of electric motorcycles in Indonesia. Additionally, the government has issued Presidential Instruction No. 7 of 2022, mandating the use of Battery Electric Vehicles (BEVs) as operational and/or personal vehicles for central and regional government agencies.

According to sales volume data for the year 2023, the use of electric bicycles gradually increased from 6,500 in the first quarter to 6,594 in the second quarter [4, 5]. This trend indicates that electric bicycles are emerging as a new mode of transportation that will continue to develop and attract public interest, particularly among urban communities. However, despite the growing number of electric bicycle users, quality-related issues persist.

Based on online observations and interviews with several users, several concerns have been identified regarding the quality of Selis brand electric bicycles. Common complaints from Selis electric bicycle users include the rear seat not being securely locked, causing it to detach during use, as well as difficulties in obtaining spare parts, which pose challenges for users [6]. Other issues include rapid tire deflation and the use of flimsy, brittle plastic for the mirrors, making them prone to breakage [7].

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To address the quality complaints regarding Selis electric bicycles, research is needed to focus on meeting consumer needs through product development. This study aims to identify user preferences concerning the quality of Selis electric bicycles, as outlined in the product design, and to provide recommendations for further improvements. The research object in this study is the Selis Sanur model. Based on a literature review, the most suitable methods for addressing the identified issues are the Kano Model and the Quality Function Deployment (QFD) approach.

The Kano Model and QFD effectively accommodate user needs. Integrating the Kano Model with QFD provides a means for organizations to enhance customer satisfaction by incorporating customer feedback into the product design process. The application of the Kano Model helps distinguish customer needs more effectively, while its integration into the QFD matrix enables product designers to determine the most critical product development activities to maximize customer satisfaction [8].

In other research, the integration of the Kano Model and QFD has been used to identify service attributes requiring improvement [9]. Through this hybrid approach, the development and design of wood desks in open-plan offices have been optimized to improve the rationality and scientific nature of office furniture, thereby enhancing market competitiveness [10]. The combination of the Kano Model and QFD has also identified six service attributes classified as 'must-be' requirements. Among them, two technical responses—facility improvement and facility maintenance—should be prioritized, as their importance levels are above average [11].

The Kano Model can identify the product attributes required by consumers [7, 12, 13]. By using the Kano Model, manufacturers can better understand the quality characteristics that customers demand [14]. This model is widely used in quality management to analyze and manage customer expectations regarding the features or characteristics of a product or service [15]. The Kano Model is a valuable tool for understanding customer needs and evaluating how meeting these needs influences customer satisfaction levels [16].

Additionally, the Kano Model helps focus the product development process on aspects that are most important to consumers [17]. There are five categories of consumer needs in the Kano Model: basic needs, performance needs, excitement needs, indifferent needs, and reverse needs [18, 19].

Another approach used in this research is the Quality Function Deployment (QFD) method, specifically the House of Quality (HOQ) matrix. HOQ plays a fundamental and strategic role in the QFD process [20] and is a widely used design tool that supports information processing and decision-making in engineering design [21]. QFD is a quality management and product engineering method that translates customer preferences into product or service quality characteristics [22, 23]. It aims to improve quality and customer satisfaction by ensuring that product or service designs meet—or even exceeding customer expectations [15, 24]. The QFD method is an effective tool that enhances the quality of design teams and helps enterprises succeed in competitive markets [25]. The application of the Kano Model and QFD provides insights into the priority levels of product attributes and technical requirements [26].

This research introduces a new approach to address quality issues in electric bicycles. A review of previous studies shows that electric bicycle design has primarily relied on ergonomic approaches without fully considering consumer needs regarding overall product quality. Therefore, this study focuses on product design based on comprehensive consumer requirements, not just ergonomic factors. The product design aligns with consumer needs and prioritization scales. By integrating the Kano Model and QFD methods, this study emphasizes consumer-driven quality improvements. Once consumer needs regarding product quality are clearly identified, an ergonomic approach can be applied more effectively. Thus, the novelty of this research lies in its systematic approach to solving quality issues in electric bicycles.

2. Material and method

2.1. Research type

This research employs a mixed-methods approach, integrating both qualitative and quantitative methodologies. Qualitative research focuses on validating non-numeric hypotheses and typically involves observations [27], collecting data in the form of words and images rather than numbers [28]. In contrast, quantitative research addresses problems using measurement techniques applied to specific variables [29]. The research follows a descriptive method, which includes data collection, classification, and analysis, aiming to provide an objective depiction of a situation through situational descriptions [30].

2.2. Data sources

Qualitative and quantitative data were collected in this research. Qualitative data include product descriptions, consumer needs data (voice of customer), and technical requirements. Meanwhile, quantitative data consists of information on the number of consumers, consumer satisfaction levels (importance rating), the relationship between consumer needs and technical requirements, correlation, technical requirements, targets, and customer competitive evaluations.

The data sources are categorized into primary and secondary data. Primary data are obtained directly from first-hand sources through measurements or observations of the research object, including data from interviews, questionnaires, and field observations. In contrast, secondary data comes from literature and specific institutions, encompassing company profiles, organizational structures, product descriptions, sales data, and other relevant information.

2.3. *Researach flow*

The research involves a number of Selis electric bicycle users residing in Serang City and Cilegon City, Banten Province. The research process begins with identifying the type of Selis bicycle most commonly used by consumers in Serang and Cilegon, while also addressing complaints about the product. Next, a research instrument in the form of a questionnaire is developed for data collection. The subsequent stage involves data processing using the Kano Model and QFD to determine consumer preferences regarding the design of the Selis Sanur electric bicycle. The research flowchart is shown in Fig. 1.

The research process begins with problem identification, conducted through field observations and online information searches. The result of the problem identification was the discovery of customer complaints about the Selis Sanur model. Following this, a literature review was carried out to obtain relevant references regarding the appropriateness of the methods used in addressing the identified issues. The literature review was conducted through various sources, including scientific journals, books, and online sources.

Next, problem formulation and research objective setting were undertaken to ensure that the research process aligned with the issues to be addressed. By setting research objectives, the research process becomes more directed and focused. Once the objectives were established, the next step involved designing research instruments, primarily in the form of questionnaires. Two types of questionnaires were used: an open-ended questionnaire, designed to gather general information about consumer needs. Consumers were given general essay-type questions, and the survey was conducted using the purposive sampling method, which involves selecting participants who are well-informed about the phenomenon of interest [31, 32]. Additionally, a closed-ended questionnaire was developed based on responses from the open-ended questionnaire. The closed-ended questionnaire aimed to obtain information on the importance level of consumer needs regarding Selis electric bicycles and measured consumer preferences using a Likert scale of 1–5 [26]. The questionnaire involved nine respondents who had experience using the Selis Sanur model.

Data collection was conducted through field observations, where users of Selis electric bicycles were observed to understand their behavior and directly identify any issues related to product quality. Additionally, interviews and questionnaires were used to collect data directly from customers and the company. The collected data included customer needs (voice of customer), technical requirements, importance ratings, and competitive customer evaluations. According to David Garvin, product quality can be evaluated using eight dimensions: performance, features, reliability, conformance, durability, serviceability, aesthetics, and image or reputation [33].

The data processing stage applied the Kano Model and Quality Function Deployment (QFD) methods. The process began with determining the sample and conducting tests for data adequacy, normality, validity, and reliability. The Kolmogorov-Smirnov test was used to determine whether the data followed a normal distribution [34, 35]. Validity refers to the extent to which an instrument measures what it is intended to measure, ensuring the accuracy and legitimacy of the tool [36]. The validity test for functional and dysfunctional aspects, as well as the importance and satisfaction levels, was performed using Eq. (2). Reliability was tested using Cronbach's Alpha, a commonly used statistic to assess the reliability of research instruments. An instrument is considered adequately reliable if Cronbach's Alpha coefficient is ≥ 0.50 [36, 37].

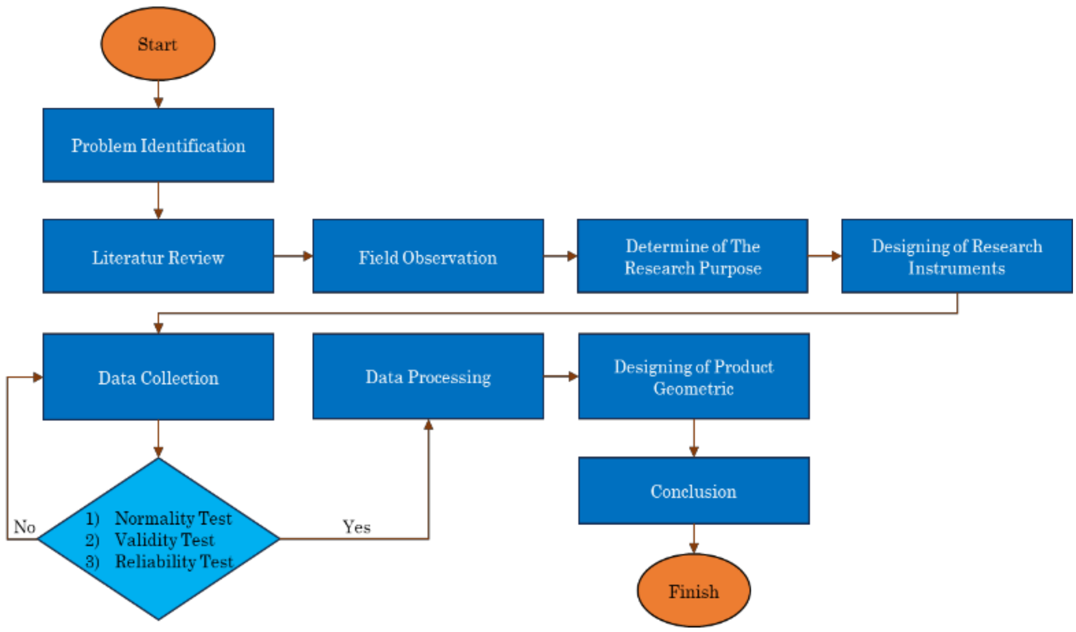

Figure 1. Research flow chart

Table 1.
Attribute in open-ended questionnaire

Dimension	Attribute
Performance	What is your opinion about the handlebars of the Selis Sanur electric bicycle?
	What is your opinion about the pedals of the Selis Sanur electric bicycle?
	What is your opinion about the wheels of the Selis Sanur electric bicycle?
Features	Are the features of the Selis Sanur bicycle sufficient?
	How do you feel when using the Selis Sanur bicycle, whether riding alone or with a passenger?
Reliability	Is the Selis Sanur bicycle suitable for you? Please provide your reasons.
Conformance	How is the battery life of the Selis Sanur bicycle?
Durability	How is the availability of spare parts for the Selis Sanur bicycle?
Serviceability	How is the customer service for the Selis Sanur bicycle?
	What do you think about the color and design of the Selis Sanur bicycle?
Aesthetic	How do you feel when using the Selis Sanur electric bicycle?
Perceived quality	What is your opinion about the pedals of the Selis Sanur electric bicycle?

Table 2.
Attribute in close-ended questionnaire

No	Dimension	Functional Attributes
1	Performance	The seat of the electric bicycle has a good level of flexibility.
2		The seat of the electric bicycle has a good level of ergonomics.
3		The handlebars of the electric bicycle offer good comfort.
4		The handlebars of the electric bicycle provide good stability.
5		The pedals of the electric bicycle are very easy to pedal.
6		The diameter of the electric bicycle's wheels is appropriate for the size of the bicycle.
7		The width of the electric bicycle's tires is suitable for the size of the bicycle.
8	Features	The electric bicycle needs the addition of turn signals.
9	Reliability	The size of the pillion backrest on the electric bicycle.
10		The electric bicycle is comfortable to use both when riding alone and with a passenger.
11	Conformance	The electric bicycle is suitable for use on flat road surfaces.
12		The electric bicycle is suitable for users of various body weights.
13	Durability	The battery of the electric bicycle has a long-lasting capacity.
14	Serviceability	Spare parts for the electric bicycle are very easy to obtain.
15		Customer service for electric bicycles is very friendly.
16		Customer service for the electric bicycle provides very clear information.
17	Aesthetic	The motifs on the electric bicycle are very diverse.
18	Perceived quality	The Selis brand positively impacts self-confidence.

Table 3.
Summary of electric bicycle quality attribute importance levels

Cathegory	Product Quality Attributes																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Importance Levels	4.2	3.8	4.1	4.1	4.2	3.9	3.6	4.7	4.4	4.3	3.7	3.9	3.8	3.9	3.9	4.0	3.7	3.9
Satisfaction Levels	1.4	4.1	4.2	4.2	4.4	4.1	4.3	4.3	4.3	4.4	4.2	4.2	4.4	4.3	4.0	4.2	4.1	4.2

Next, consumer needs were classified using the Kano Model, which categorizes needs into basic needs, performance needs, excitement needs, indifferent needs, and reverse needs [18, 19]. Each attribute was then further categorized using Blauth's Formula. Additionally, consumer satisfaction was measured, and Quality Function Deployment (QFD) was processed using the House of Quality matrix, allowing product designers to prioritize product development activities to achieve maximum customer satisfaction [8].

Based on the processed data, improvement recommendations were developed in the form of a geometric product design. The geometric design process was carried out using Inventor and AutoCAD applications. Finally, conclusions and recommendations were formulated based on the research findings, ensuring alignment with the problem formulation and objectives.

3. Results and discussions

3.1. *Quesionare*

This study employs a two-stage questionnaire approach. The first stage involves an open-ended questionnaire consisting of 12 attributes across Garvin's 8 quality dimensions. It was distributed to 9 respondents to gather their personal opinions on the Selis Sanur model bicycle, specifically focusing on consumer preferences. The recap of the open-ended questionnaire results is presented in Table 1. The respondents' answers were then used to develop attributes for the closed-ended questionnaire. There are four types of closed-ended questionnaires: functional, dysfunctional, importance, and satisfaction questionnaires. The attributes of the closed-ended questionnaires are presented in Table 2.

Table 4.
Results of the normality test

Attribute		Functional Aspects			Dysfunctional Aspects		
	N	Dmax	Dtable	Description	Dmax	Dtable	Description
1	9	0,281	0,430	Normal	0,317	0,430	Normal
2	9	0,197	0,430	Normal	0,208	0,430	Normal
3	9	0,256	0,430	Normal	0,208	0,430	Normal
4	9	0,196	0,430	Normal	0,284	0,430	Normal
5	9	0,186	0,430	Normal	0,181	0,430	Normal
6	9	0,258	0,430	Normal	0,195	0,430	Normal
7	9	0,138	0,430	Normal	0,196	0,430	Normal
8	9	0,281	0,430	Normal	0,264	0,430	Normal
9	9	0,238	0,430	Normal	0,206	0,430	Normal
10	9	0,161	0,430	Normal	0,221	0,430	Normal
11	9	0,191	0,430	Normal	0,269	0,430	Normal
12	9	0,170	0,430	Normal	0,317	0,430	Normal
13	9	0,242	0,430	Normal	0,245	0,430	Normal
14	9	0,222	0,430	Normal	0,186	0,430	Normal
15	9	0,190	0,430	Normal	0,278	0,430	Normal
16	9	0,147	0,430	Normal	0,278	0,430	Normal
17	9	0,175	0,430	Normal	0,383	0,430	Normal
18	9	0,275	0,430	Normal	0,316	0,430	Normal

Table 5.
Results of the validity test

Attribute	N	Functional Aspects			Dysfunctional Aspects		
		R Calculated	R table	Description	R Calculated	R table	Description
1	9	0.941	0,754	Valid	0.782	0,754	Valid
2	9	0.935	0,754	Valid	0.916	0,754	Valid
3	9	0.969	0,754	Valid	0.792	0,754	Valid
4	9	0.761	0,754	Valid	0.947	0,754	Valid
5	9	0.818	0,754	Valid	0.768	0,754	Valid
6	9	0.959	0,754	Valid	0.915	0,754	Valid
7	9	0.815	0,754	Valid	0.877	0,754	Valid
8	9	0.941	0,754	Valid	0.822	0,754	Valid
9	9	0.933	0,754	Valid	0.834	0,754	Valid
10	9	0.864	0,754	Valid	0.876	0,754	Valid
11	9	0.825	0,754	Valid	0.804	0,754	Valid
12	9	0.945	0,754	Valid	0.905	0,754	Valid
13	9	0.976	0,754	Valid	0.879	0,754	Valid
14	9	0.943	0,754	Valid	0.841	0,754	Valid
15	9	0.921	0,754	Valid	0.888	0,754	Valid
16	9	0.879	0,754	Valid	0.836	0,754	Valid
17	9	0.794	0,754	Valid	0.934	0,754	Valid
18	9	0.925	0,754	Valid	0.928	0,754	Valid

Subsequently, the importance level and consumer satisfaction regarding the quality of the Sanur model electric bicycle were measured using a Likert scale. The importance scale is as follows: 5 (very important), 4 (important), 3 (moderately important), 2 (slightly important), and 1 (not important). The satisfaction scale is: 5 (very satisfied), 4 (satisfied), 3 (neutral), 2 (dissatisfied), and 1 (very dissatisfied), as shown in Table 3.

3.2. Normality test

The results of the normality test for the questionnaire data on the Selis Sanur model electric bicycle, covering 18 attributes, showed that for attribute 1, the obtained Dmax value was 0.281, where $N = 9$, and the Kolmogorov-Smirnov table value was 0.430. Normality is considered met if Dmax < Dtable, in which case the null hypothesis (H_0) is accepted, indicating that the data is normally distributed. Conversely, if Dmax > Dtable, the null hypothesis is rejected, meaning the data is not normally distributed. Based on the calculations, where Dmax < Dtable, the data is confirmed to be normally distributed. The results of the normality test are presented in Table 4.

3.3. Validity test

For attribute 1, the calculated r value was 0.949, where $N = 9$ then the table r value is 0.754. The validity test is considered fulfilled if r-calculated > r-table, thus the result of the calculation is r-calculated > r-table, indicating that the data is valid.

Table 6.
Results of attribute recapitulation using blauth's formula

Kano Category	Attribute																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
A (Attractive)	5	1	5	1	3	0	1	6	5	1	3	2	5	2	3	1	5	5
M (Must-be)	0	1	1	2	1	2	2	0	1	2	0	0	0	0	0	0	0	1
O (One dimensional)	1	1	0	0	1	1	1	0	0	1	0	0	0	2	0	1	0	1
R (Reverse)	0	0	1	0	0	0	1	0	2	0	1	0	0	1	2	1	0	0
Q (Questionabe)	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
I (Indifferent)	3	6	1	6	4	6	4	2	1	5	5	6	4	4	4	6	4	2
Sum of Attribute	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Category	A	I	A	I	I	I	I	A	A	I	I	I	A	I	I	I	A	A

Table 7.
Voice of customer of electric bike

No	Technical requirement	Voice of customer	IR
1	The seat is adjustable in height.	The seat has a good level of flexibility.	4,5
2	The shape and size of the handlebars are designed ergonomically.	The handlebars provide a good level of comfort.	4,4
3	The bike is equipped with turn signal lights at the front and rear.	The electric bike needs additional turn signal lights.	4
4	The passenger backrest is designed ergonomically.	The passenger backrest has appropriate of size	4
5	Increasing the battery capacity of the electric bike.	The battery has a long-lasting capacity.	4
6	Adding more color variants for the electric bike.	The designs are very varied.	3,7
7	Rebranding the electric bike brand.	The Selis brand affects self-confidence.	3,6

The same calculation process is applied to the other attributes. After obtaining the validity coefficient for each item, the results are compared with the r values from the table at the 5% and 1% significance levels with df = N − 2. If r-calculated > r-table, then the item is considered valid. The validity calculation results for the attributes are shown in Table 5.

3.4. *Reliability test*

The results of the reliability test show that Cronbach's Alpha is considered reliable if its value is at least 0.50. In the reliability test of the functional aspect questionnaire, a reliability value of r = 0.988 was obtained, and for the dysfunctional aspect, a reliability of r = 0.98 was found, indicating very high reliability.

3.5. *Kano model analysis*

The Kano method in this study was used to categorize attributes or customer needs based on the Kano questionnaire results. This categorization was conducted after respondents completed the list of functional and dysfunctional aspect attributes. The classification of consumer needs includes Attractive, Must-be, One-dimensional, Reverse, Questionable, and Indifferent categories. Next, the quantity/value of each Kano attribute for all respondents was calculated, and the Kano category (grade) for each attribute was determined using Blauth's Formula.

The analysis using Blauth's Formula revealed that seven attributes fall under the "Attractive" category, meaning user satisfaction increases with the performance of these attributes; however, a decrease in performance does not lead to dissatisfaction. Additionally, eleven attributes were classified under the "Indifferent" category, indicating that their presence or absence does not impact customer satisfaction.

3.6. *QFD analysis*

The list of customer needs (voice of customer) is derived from attributes categorized as "Attractive," as shown in Table 6. Based on these customer needs, the technical requirements for each voice of customer are determined, as presented in Table 7. The results of the relationship analysis between the Voice of Customer and Technical Requirements are presented in Fig. A1 (see Appendices). The assessment is based on three parameters that measure how well the technical requirements meet customer needs. A strong relationship is scored 9 and represented by a filled circle, a moderate relationship is scored 3 and represented by an empty circle, and a weak relationship is scored 1 and represented by an empty triangle.

Based on Fig. A1, no contradictory or negative relationships were found among the technical requirements, so no elimination was necessary. To understand consumer perspectives on the electric bike brand, a customer competitive evaluation was conducted by comparing three electric bike brands: Selis, Goda, and Uwinfly. The comparison parameters were based solely on the selected Voice of Customer attributes, as shown in the House of Quality (HOQ) matrix in Fig. A1 (see Appendices). To address the consumer needs listed in the HOQ matrix, a list of proposed improvements was compiled in Table 8. The target specifications were determined using an ergonomic approach, user interviews, and relevant literature sources. These proposed target specifications then served as the basis for developing the geometric design of the Selis electric bike, as depicted in Fig. A2 (see Appendices).

3.7. Product geometry design

The product geometry was designed using the application of Inventor of 2018 version. Addition of product parts in accordance with the improvement recommendations in Table A1 (see Appendices). This research reveals an interpretation of customer need for new selis product especially sanur type as described in the house of quality in Fig. A1. and the product geometry design in Fig. A2 (see Appendices).

4. Conclusions

The research identified seven attributes considered important based on the Attractive category, such as the electric bicycle seat having good flexibility, the handlebars offering good comfort, the need for additional turn signals, the passenger backrest size being appropriate, the battery having long-lasting endurance, the bicycle design featuring a wide variety of patterns, and the Selis brand influencing self-confidence. Based on consumer needs, the recommended improvements are presented in the form of a product geometric design, including adding turn signals to the front and rear, a radius-shaped design for the side of the backrest with dimensions of 20 cm (length) × 13 cm (height) × 5 cm (width), an adjustable height lever, creating social media ads and collaborating with public figures, handlebars measuring 62 cm in length and 3.5 cm in diameter, metallic and matte color options, and increasing the battery capacity from 12 Ah to 20 Ah.

Declaration statement

Sahrupi: Conceptualization, Methodology, Writing-Original Draft. Dzulkifli: Collecting data, Resources, Design. Rosihin: Validation, Resources and Analysis data.

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Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

AI Usage Statement

This manuscript utilizes generative AI and AI-assisted tools to improve readability and language. All AI-generated content has been reviewed and edited by the authors to ensure accuracy and scientific integrity. The authors take full responsibility for the content and conclusions of this work and disclose the use of AI to maintain transparency and comply with publisher guidelines.

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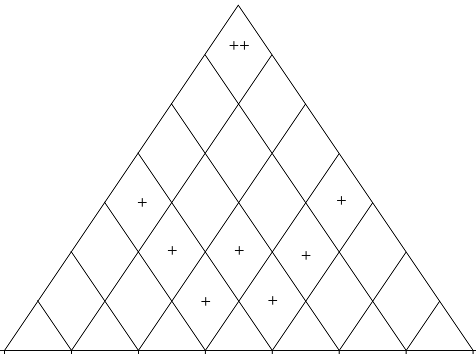
Appendices

Table A1.
Improvement

No	Voice of customer	Technical requirement	Spesification Target
1	The electric bike needs additional turn signals.	Add turn signals to the front and rear of the electric bike.	Add turn signals to the front and rear.
2	The size of the passenger backrest on the electric bike is appropriate.	Design the size of the passenger backrest on the electric bike ergonomically.	Side backrest with a radius shape, measuring 20 cm x 13 cm x 5 cm.
3	The seat of the electric bike has good flexibility.	Make the seat height of the electric bike adjustable.	Include a height adjustment lever.
4	The Selis brand influences self-confidence.	Rebrand the electric bike.	Create advertisements on social media and collaborate with public figures.
5	The handlebar of the electric bike provides good comfort.	Design the shape and size of the electric bike's handlebar ergonomically.	Handlebar measuring 62 cm in length and 3.5 cm in diameter.
6	The patterns on the electric bike are very diverse.	Add more color variants to the electric bike.	Metallic and matte colors.
7	The battery of the electric bike has good durability.	Increase the battery capacity of the electric bike.	Increase battery capacity from 12 Ah to 20 Ah



	Technical Requirement		Electric bikes with turn signals on the front and rear	The size of the electric bike seatback is ergonomically designed	The seat of the electric bike can be adjusted in height level	Re-branding electric bikes	The shape and size of the handlebar of an electric bike are ergonomically designed	Adding electric bike color variants	Increase the battery capacity of electric bicycles	Customer Competitiv Evaluation A = Selis B = Goda C = Uwinfly				
Variabel	Voice of Customer	IR	X1	X2	X3	X4	X5	X6	X7	1	2	3	4	5
Y1	Electric bicycles need to add turn signals	4,5	●			○					A	B	C	
Y2	Size of electric bike seatback	4,4		●		○					B	C	A	
Y3	Electric bike seats have a good degree of flexibility	4			●	○	△			A			B C	
Y4	Selis brand affects confidence	4				●		○			A	B	C	
Y5	Electric bike handlebars have a good level of comfort	4				○	●				C	B	A	
Y6	The motifs on electric bicycles are very diverse	3,7				○		●			B	C	A	
Y7	Electric bike batteries have a long durability	3,6	●			○			●				A C B	
	Coloum Weight		72,9	39,6	36	108,6	37	45,3	32,4					
		Target	Addition of turn signals on the front and rear	Radial shape on the side of the backrest with a length of 20cm X Height of 13cm X 5cm	There is a height adjustment lever	Making ads on social media, collaborating with public figures	Stang berukuran panjang 62cm, ⌀3,5cm	Metallic and doff colors	Initial battery capacity 12Ah to 20Ah					

Figure A1. House of quality

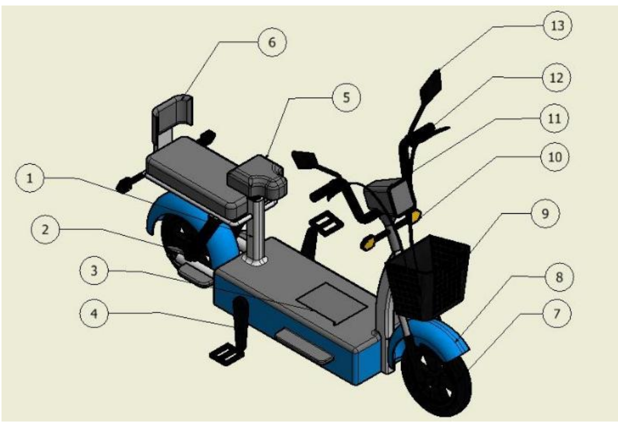


Figure A2. Product geometry design