Available online at: http://jurnal.untirta.ac.id/index.php/jiss

JOURNAL INDUSTRIAL SERVICESS

Industrial Engineering Advance Research & Application

eISSN 2461-0631

Improving the quality of mobile banking services using the integration of text mining, mobile banking service quality, and Quality Function Deployment

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ARTICLE INFO

Article history:
Received 6 June 2024
Received in revised form 23 June 2024
Accepted 25 June 2024
Published online 26 June 2024

Keywords:
Mobile banking
Service Quality
Text mining
House of Quality
Quality Function Deployment

Editor:
Bobby Kurniawan

Publisher's note:
The publisher remains neutral concerning jurisdictional claims in published maps and institutional affiliations.

ABSTRACT

Customer service quality is a key performance indicator that directly impacts a company's image. This study identified potential issues with a mobile banking app (m-banking) based on its low rating on the Google Play Store compared to similar apps. The app's rating likely reflects user satisfaction with the m-banking service. To address these concerns and improve service quality based on user feedback (voice of customer), a study was conducted using three methods: text mining, mobile banking service quality analysis, and Quality Function Deployment (QFD). The text mining method analyzed sentiment from comments on the Google Play Store. It employed a Support Vector Machine (SVM) algorithm, achieving high accuracy (0.86), precision (0.86), recall (0.84), F1-score (0.85), and AUC (0.84). Negative sentiment analysis identified five dimensions encompassing 15 attributes of m-banking service quality. These attributes were then incorporated into a questionnaire distributed to 100 respondents. Six attributes with the lowest gap values were identified as priority attributes, representing the most critical customer concerns. These attributes were used as the "voice of the customer" in the QFD method. By constructing a House of Quality (HoQ) matrix, the study established a priority ranking of technical responses. These responses include strategies to optimize tools, application features, and memory usage, reduce excessive animation and the use of live wallpapers, create an update mechanism, provide content localization features, continuously incorporate customer feedback into application improvements.

1. Introduction

The industrial revolution 4.0, with its emphasis on technological innovation, is significantly impacting the service sector, and the banking industry is no exception. Several factors are driving this digital transformation in banking, including evolving customer expectations, data-driven improvements in product and service quality, the emergence of partnerships with fintech and big tech companies, and a shift towards digital business models [1]. Data from Central Bank of Indonesia highlights this trend [2]. The value of electronic money (e-money) transactions in August 2023 surged by 8.62% year-on-year (YoY) to IDR 38.51 trillion. Similarly, digital banking transactions saw an 11.87% YoY increase, reaching IDR 5,098.46 trillion. This data suggests a growing preference for electronic money transactions among Indonesians.

Mobile banking (m-banking) utilizes applications to facilitate electronic money transactions. Defined as a platform for customer interaction with banking institutions via mobile devices (cell phones, PDAs) [3], m-banking empowers users to conduct banking services anytime, anywhere [4].

A major conventional bank in Indonesia offers an m-banking service. However, with a rating of 3.9 out of 5 on the Google Play Store (as of October 2023), the service falls short compared to its competitors. This suggests that many customers find other m-banking services more satisfying. Customer satisfaction is directly linked to service quality [5]. When customers are satisfied, they are more likely to use a service frequently, which can lead to increased revenue for the company [5]. Similarly, improving user satisfaction can be expected to boost the number of active users and contribute positively to the bank's revenue.

This research aims to identify user satisfaction with a mobile banking app and propose improvement strategies based on user feedback. It integrates three methods: text mining, mobile banking service quality analysis, and Quality Function Deployment (QFD). The research begins with text mining to analyze sentiment in user comments on the Google Play Store. Sentiment analysis categorizes the emotional tone of a text

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http://dx.doi.org/10.62870/jiss.v10i1.25907

(positive, negative, or neutral) [6]. In this study, we utilize a Support Vector Machine (SVM) algorithm to classify sentiment and assess its accuracy based on user ratings.

The research utilizes the Mobile Banking Service Quality (M-banking SERVQUAL) model to identify key dimensions of user satisfaction [6]. This model consists of two main categories: (1) M-Banking Application Quality that includes factors like content accuracy, convenience, speed, aesthetics, security, variety of features, and overall mobile usability, and (2) M-Banking Customer Service Quality that focuses on aspects like reliability, responsiveness, competence, courtesy, credibility, access to support, clear communication, understanding customer needs, and continuous improvement efforts.

By combining the M-banking SERVQUAL model with Quality Function Deployment (QFD), the study aims to identify the most critical user concerns (the "voice of the customer") based on text mining analysis. Integrating these methods is expected to lead to significant improvements in mobile banking service quality.

2. Material and method

This research integrates three methods to improve the quality of mobile banking service: Text Mining, Mobile Banking Service Quality (M-banking SERVQUAL) model, and Quality Function Deployment (QFD). The research begins with user reviews on the Google Play Store. Text mining is used to analyze these reviews and identify user sentiment (positive, negative, or neutral). Specifically, the focus is on negative sentiment, as it highlights areas for improvement.

Insights from the text mining are then used to identify relevant quality dimensions based on the M-banking SERVQUAL framework. This framework considers two key areas: application quality and customer service quality.

These quality dimensions serve as the basis for a questionnaire distributed to 100 users. The questionnaire aims to gather more detailed user feedback on these critical aspects of the service. The following section will describe the specific stages involved in each of these three methods.

2.1. Text mining

Text mining is a technique for extracting valuable information and knowledge from unstructured text data [7]. The process involves collecting text from various sources and then analyzing it to identify patterns, trends, and key concepts [8]. This analysis helps generate insights that can be beneficial for users of the system.

A specific type of text mining, sentiment analysis classifies the emotional tone (positive, negative, or neutral) of a text [9]. In this study, we leverage the Support Vector Machine (SVM) algorithm, a supervised learning method that learns patterns from labeled data for classification [10].

2.2. Mobile banking SERVQUAL

This research utilizes the Mobile Banking Service Quality (M-banking SERVQUAL) model developed by Jun and Palacios [6] to identify the key dimensions influencing user satisfaction with mobile banking services. The M-banking SERVQUAL framework consists of 17 dimensions categorized into two main areas: M-Banking Application Quality (content accuracy, convenience, speed, aesthetics, security, variety of features, and overall mobile usability and M-Banking Customer Service Quality (reliability, responsiveness, competence, courtesy, credibility, access to support, clear communication, understanding customer needs, and continuous improvement efforts).

2.3. Quality Function Deployment (QFD)

Quality Function Deployment (QFD) is a management tool that leverages customer expectations to guide product development or service improvement in various industries [11]. Developed by Akao in Japan in 1966, QFD translates customer needs into specific design targets and quality assurance points throughout the production process, ultimately enhancing design quality and customer satisfaction [12].

Quality Function Deployment (QFD) relies on a core data processing technique called the House of Quality (HoQ) matrix [13]. This matrix acts as a bridge between understanding customer needs and translating them into actionable technical specifications for improvement. The HoQ is comprised of six sections. First, the "Voice of Customer" section captures what customers want and expect. Next, the "Planning Matrix" defines the relationship between these customer needs and the technical measures that can address them. The technical measures themselves, or "HOWs", are detailed in another section. A crucial aspect of the HoQ is the "Relationship Matrix," which shows how strongly and in what direction customer needs are linked to technical measures.

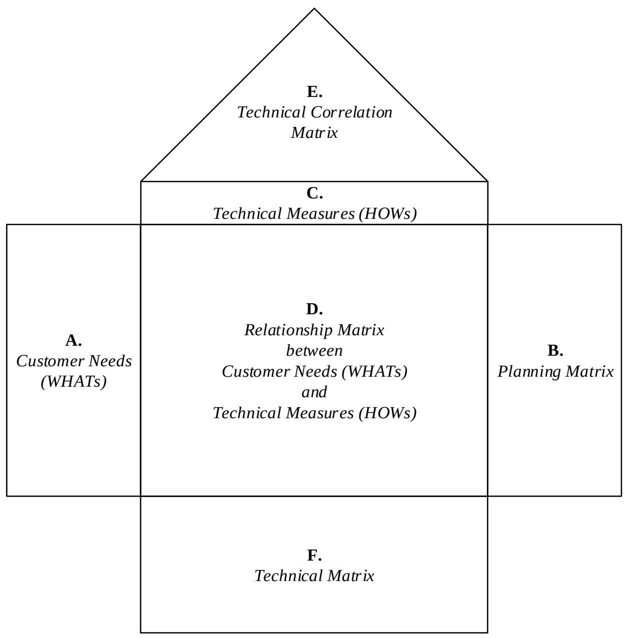

Figure 1. House of Quality (HoQ) matrix

Table 1.
M-banking SERVQUAL attributes

Dimensions	Notation	Attribute
Accuracy	X3	Accuracy in m-banking application content
	X4	The accuracy of the display in the m-banking application
	X5	Accuracy in conducting financial transactions
Ease of Use	X6	Easy to use m-banking application
	X7	Easy to create and customize passwords
	X8	Easy to switch between apps or open apps simultaneously
Speed	X9	Fast m-banking application download process
	X10	Fast in processing (loading)
	X11	Fast in providing the latest information
Mobile Convenience	X17	Comfortable when accessing the m-banking app
	X18	Convenient to use an m-banking app that supports multiple versions of mobile device operating systems
	X19	The m-banking app is convenient to use for long periods of time and efficient in power usage
Reliability	X20	The service on the application is precise in serving users
	X21	The m-banking user service fulfills the promoted promise
	X22	The m-banking user service provides consistent information services

The "Technical Correlation Matrix" explores the relationships between the technical measures themselves. Finally, the "Technical Matrix" translates these technical measures into specific actions or areas for improvement in the product or service. Fig. 1 shows a visual representation of the HoQ [14].

3. Results and discussions

This study involves various data processing steps, including sentiment labeling, SVM algorithm performance evaluation, labeling based on the M-banking SERVQUAL model, sample size calculation, gap calculation, and House of Quality (HoQ) development.

3.1. Classification using SVM

For this analysis, we collected reviews of the mobile app on the Google Play Store from August to September 2023. The dataset consists of 5566 reviews, with 3325 classified as negative sentiment and 2241 classified as positive sentiment. Next, the reviews underwent text pre-processing to convert them into a structured format suitable for analysis. Following pre-processing, sentiment classification was performed using the Support Vector Machine (SVM) algorithm with the RBF kernel. The training and test data split was set at a 90:10 ratio. The calculated accuracy measures all exceed 80%, indicating strong model performance (well above the benchmark of 50%). Furthermore, the AUC value surpasses 70%, demonstrating the model's effectiveness in sentiment classification [18].

3.2. Model validation with k-fold cross validation

To reduce bias in the data, this research employs k-fold cross-validation [19]. This technique involves randomly dividing the sample data into k groups (folds). In this study, we utilize 10-fold cross-validation to obtain accuracy values on the testing data for each fold. The results are above 0.8, which is a good indicator.

3.3. Questionnaire preparation

The questionnaire was designed to target the most relevant dimensions of Mobile Banking Service Quality, as identified from the analysis of user reviews on the Google Play Store. Table 1 presents the five key M-banking SERVQUAL dimensions, encompassing a total of 15 attributes. The table also shows the expectation, satisfaction, and gap values for these attributes.There are two main types of validity tests commonly used in survey research: construct validity and content validity [20]. Construct validity assesses whether the questionnaire measures the intended concepts. Content validity checks if the questionnaire items comprehensively cover the relevant domain.

In this study, a pilot test was conducted on the first 30 respondents' data to assess the construct validity of the questionnaire. For construct validity, a common criterion is to examine the correlation between individual questionnaire items and the overall scale. If the correlations are statistically significant (usually at a 5% significance level), it suggests that the items are measuring the intended construct. For this study, the test of construct validity using a 5% significance level resulted in a correlation value of 0.374. Since correlation values closer to 1 indicate a stronger relationship, further refinement of the questionnaire may be considered to improve construct validity.

However, when examining the content validity of the questionnaire attributes (individual questions), all items were deemed relevant based on their high correlation values (all above 0.374) to the overall M-banking SERVQUAL dimensions being measured.

3.4. Reliability test

A reliability test is conducted to assess the consistency of responses to the questionnaire attributes. Reliability is measured using Cronbach's Alpha (α), a statistical coefficient. Generally, a Cronbach's Alpha value greater than 0.7 indicates that the data is reliable [21]. The results of the reliability test indicate that all the questionare is reliable.

Table 2.
Conformance level of attributes

No	Attributes	Total Satisfaction	Total Expectation	Gap	Level of Conformity	Description
1	X3	414	451	-37	91.80%	Action
2	X4	448	458	-10	97.82%	Hold
3	X5	438	463	-25	94.60%	Hold
4	X6	440	461	-21	95.44%	Hold
5	X7	432	452	-20	95.58%	Hold
6	X8	414	441	-27	93.88%	Action
7	X9	418	447	-29	93.51%	Action
8	X10	408	447	-39	91.28%	Action
9	X11	415	439	-24	94.53%	Hold
10	X17	437	458	-21	95.41%	Hold
11	X18	406	450	-44	90.22%	Action
12	X19	418	449	-31	93.10%	Action
13	X20	431	446	-15	96.64%	Hold
14	X21	415	440	-25	94.32%	Hold
15	X22	422	442	-20	95.48%	Hold
		Average			94.24%	

Table 3.
Technical response

Attribute	Customer Requirements (WHATs)	Technical Response (HOWs)
X3	Accuracy in m-banking application content	Availability of a large selection of financial transaction features
X8	Easy to switch between apps or open apps simultaneously	Apps do not take up much device memory
X9	Fast m-banking application download process	Application size <100 MB
X10	Fast in processing (loading)	App response <2 seconds
X18	Supports multiple versions of mobile device operating systems	The app supports Android 7 or later
X19	Convenient to use for long periods and efficient in power usage	Does not take up much memory thus saving battery usage

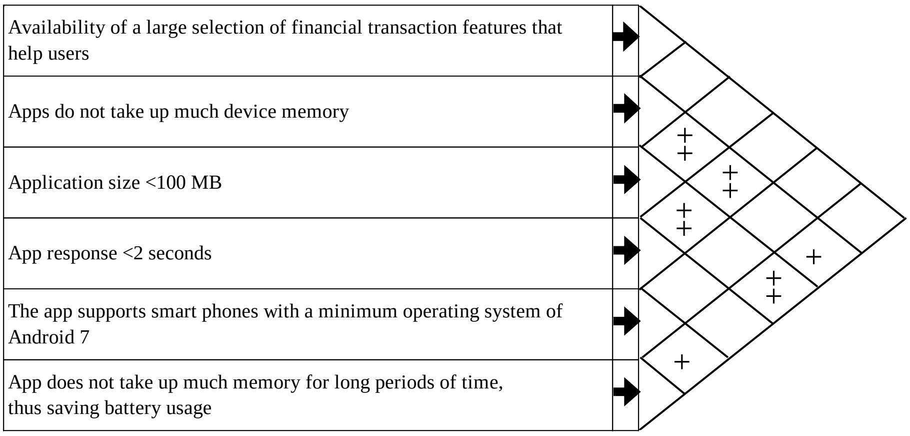

Figure 2. Technical correlation

3.5. Gap calculation

In M-banking SERVQUAL, the gap value is calculated as the difference between user expectations and their satisfaction level for each attribute [22]. Table 2 presents the gap values for the selected attributes.

3.6. HoQ development

Once the gap values for each dimension are identified, Quality Function Deployment (QFD) is employed to translate customer needs into actionable technical requirements. This process involves several key steps: determining the voice of customer, determining the technical response, technical correlation, determining the relationship between technical response and technical correlation, calculating the planning matrix, technical matrix, and creating a House of Quality (HoQ).

The "Voice of Customer" (VOC) is identified based on the attributes with the most significant gaps, as indicated by the level of conformity in Table 2. These priority attributes represent the most critical customer needs in terms of M-banking service quality. Specifically, the following attributes from Table 2 are selected as VOC: accuracy in m-banking application content (X3), easy switching between apps or opening apps simultaneously (X8), fast processing speed or loading time (X10), convenience of using an m-banking app that supports multiple mobile device operating systems (X18), and convenience and efficiency of the m-banking app for long-term use (X19).

Following the identification of user needs (Voice of Customer), the next stage in HoQ development involves defining the technical responses. These responses represent the technical actions or improvements required to address the user needs. To determine these technical responses, a brainstorming session was conducted with the developers. Table 3 presents the technical responses corresponding to each user's need, along with the existing company standards relevant to those needs.

The technical correlation matrix within the HoQ explores the relationships between the defined technical responses. This analysis helps identify whether certain technical improvements support or hinder each other. In this study, technical correlations were determined through brainstorming with developers at Bank Mandiri. Fig. 2 illustrates the relationships between the technical responses.

As observed in Fig. 2, there are no negative correlations between the technical responses. This means that if one technical attribute is improved in the service, it will not negatively impact the implementation of other technical responses. Analyzing these relationships is crucial for evaluating the feasibility and effectiveness of the technical responses in addressing user needs [17, 23].

The "WHATs-HOWs" relationship matrix is a critical component of the HoQ, providing a systematic method to assess the strength and direction of the relationships between user needs (WHATs) and the corresponding technical responses (HOWs) [14]. In this study, the development team at the company participated in a brainstorming session to determine the strength of these relationships. The symbols defined in the legend of Fig. A1 (see Appendices) are used to represent the different relationship levels.

The planning matrix within the HoQ incorporates competitor analysis. This section details how competing mobile banking services address similar user needs, providing valuable market information and insights for service strategy formulation and user preference comparison [23]. Table 4 presents the calculated values for Importance to Customer (ItC), Competitive Strength of the Provider (CSP), Importance Rating (IR), Relative Weight (RW), and Normalized Relative Weight (NRW).

An IR value greater than 1 indicates an area for improvement [24]. Based on the NRW values in Table 4, the priority for improvement is: X3, X18, X10, X19, X9, and X8, with X3 having the highest weight. The planning matrix also includes a benchmarking section that incorporates user feedback from similar services. This research compared M-banking X with its competitors, M-banking Y and M-banking Z. User satisfaction surveys were conducted using the six identified priority attributes (refer to Fig. A2 in Appendices) on 30 users of each mobile banking service.

A relative satisfaction evaluation was conducted using a 5-point scale, with 5 indicating the best service and 1 indicating the worst. The results showed that M-banking X ranked second, behind M-banking Z and ahead of M-banking Y [23].

The technical matrix section of the HoQ focuses on translating the technical responses into specific actions or improvements for the service [14]. This matrix assigns a weight or "contribution value" to each technical response, indicating its relative importance in addressing user needs. Table 5 presents the calculated contribution values and the corresponding normalized contribution values.

Table 3.
Planning matrix

No	Attribute	ItC	CSP	Sales Point	Target Value	IR	RW	NRW	Priority
1	X3	4,51	4,14	1,2	4,51	1,09	5,90	19,60	1
2	X8	4,41	4,14	1	4,41	1,07	4,70	15,62	6
3	X9	4,47	4,18	1	4,47	1,07	4,78	15,89	5
4	X10	4,47	4,08	1	4,47	1,10	4,90	16,28	3
5	X18	4,5	4,06	1	4,5	1,11	4,99	16,58	2
6	X19	4,49	4,18	1	4,49	1,07	4,82	16,03	4
				Total			30,08	100	

Table 4.
Technical matrix

No	Technical Response (HOWs)	Contribution	Normalized Contribution	Priority
1	Availability of a large selection of financial transaction features that help users	176,39	9,33	5
2	Apps do not take up much device memory	479,04	25,33	2
3	Application size <100 MB	574,38	30,37	1
4	App response <2 seconds	193,37	10,22	4
5	The app supports smart phones with a minimum operating system of Android 7	165,26	8,74	6
6	App does not take up much memory and saving battery usage	302,93	16,02	3
Total		1891,37	100	

The House of Quality (HoQ) is a six-matrix tool that visually integrates customer needs, technical responses, and their relationships [14]. Decision-making is guided by the results of the HoQ analysis, particularly the priorities identified in the technical matrix section. This matrix highlights the interrelationships between technical responses, allowing for informed decisions about resource allocation and improvement implementation [25]. Due to paper limitations, the HoQ diagram can be requested through the corresponding author (baha@untirta.ac.id).

3.7. Proposed improvement

Based on the HoQ results, the company can prioritize the following improvements for development and implementation:

1) The top priority is to optimize the application size to less than 100 MB. This can be achieved by using efficient formatting tools and eliminating unnecessary features.
2) A recommended strategy is to optimize memory usage. This can be done by improving data processing algorithms to leverage primary memory more effectively.
3) To improve battery usage, reduce the use of excessive animations or live wallpapers.
4) To improve app response time, the company can choose a high-performance server and upgrade the application framework and libraries. Additionally, routine performance monitoring and maintenance are crucial for identifying and resolving performance issues.
5) To ensure the content meets user expectations, the company can implement strategies such as creating dynamic content, updating mechanisms with detailed information, and content localization features.
6) The company should consider user feedback on minimum operating system requirements to ensure proper app function across various versions.

These proposed strategies aim to enhance user experience and satisfaction by considering user capacity, comfort, and safety. By implementing these continuous improvements, the application can evolve to better serve its users.

4. Conclusions

This research analyzed user sentiment using an SVM algorithm with an RBF kernel, achieving a classification accuracy of 0.86, precision of 0.86, recall of 0.84, F1 score of 0.85, and AUC of 0.84. These results demonstrate the effectiveness of the model in sentiment classification.

Further analysis focused on the dimensions of Mobile Banking Service Quality with the lowest gap values. This identified the "Accuracy" dimension (X3: accuracy in m-banking application content) as the top priority. Additionally, the "Ease-of-Use" dimension (X8: easy switching between apps), "Speed" dimension (X9: fast download process, X10: fast processing), and "Mobile Convenience" dimension (X18: supporting multiple operating systems, X19: efficient power usage) were also found to be important areas for improvement.

Based on the normalized contribution values obtained from the House of Quality (HoQ) analysis, quality improvement strategies were formulated. These include optimizing tools, application features, and memory usage; reducing excessive animations and live wallpapers; implementing an update mechanism; providing content localization features; and continuously incorporating customer feedback into the application development process.

Declaration statement

Achmad Bahauddin: **Conceptualization, Methodology, Supervision, Project administration, Data curation, Validation**. Maria Ulfah: **Conceptualization, Methodology, Supervision, Writing - Review & Editing Resources, Validation**. Aditya Rahadian Fachrur: **Resources, Validation, Formal analysis, Software**. Nurul Fadillah Boru Angin: **Resources, Visualization, Investigation**. Nurul Fadillah Boru Angin: **Writing - Original Draft**.

Acknowledgement

The authors wish to thank anonymous referees for their constructive feedback.

Disclosure statement

The authors report there are no competing interests to declare.

Funding statement

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Data availability statement

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

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Appendices

Dimension	No Attribute	Voice of Customers \ Technical Responses	Availability of a large selection of financial transaction features that help users	Apps do not take up much device memory	Application size <100 MB	App response <2 seconds	The app supports smart phones with a minimum operating system of Android 7	App does not take up much memory for long periods of time, thus saving battery usage
Accuracy	X3	Accuracy in m-banking application content	◎					
Ease of Use	X8	Easy to switch between apps or open apps simultaneously		◎	◎	○		△
Speed	X9	Fast m-banking application download process		○	◎			◎
	X10	Fast in processing (loading)		◎	◎	◎		
Mobile Convinience	X18	Convenient to use an m-banking app that supports multiple versions of mobile device operating systems					◎	
	X19	The m-banking app is convenient to use for long periods of time and efficient in power usage		◎	◎		△	◎

Figure A1. Relationship between WHATs and HOWs

Dimension	No Attribute	Voice of Customers \ Technical Responses	Positioning of m-banking developed by competitors				
			Worst				Better
			1	2	3	4	5
Accuracy	X3	Accuracy in m-banking application content			●	■	▲
Ease of Use	X8	Easy to switch between apps or open apps simultaneously			■	●	▲
Speed	X9	Fast m-banking application download process			■	▲	●
	X10	Fast in processing (loading)			■	●	▲
Mobile Convinience	X18	Convenient to use an m-banking app that supports multiple versions of mobile device operating systems			■	●	▲
	X19	The m-banking app is convenient to use for long periods of time and efficient in power usage			■	●	▲

Description
- ● M-banking X
- ■ M-banking Y
- ▲ M-banking Z

Figure A2. Benchmarking matrix