Analysis of Service Quality and User Satisfaction Improvement in Public Transportation System

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Abstract
Public transportation is one of the most fundamental services in every country. Increasing the use of public transports can reduce traffic congestions in the city as well as decreasing the effects of global warming. Improving public transportation services is a very important effort to help increasing the use of public transport. One major problem that exists in public transportation is delay, resulting in an increase of waiting time spent by users. Therefore, in this paper, we propose an approach to reduce users’ waiting time using a web application that shows the real time positions of public vehicles. Thus, users can manage their time and choose when to go to the nearest station. We have analysed the performance of the proposed approach on a public transportation as a case study based on user satisfaction and service quality indexes. We have measured the service quality of the web application using five dimensions including the usefulness of information, ease of use of web pages, quantity of information provided on the web, the interactive communication and feedback from the users. The performance analysis shows that the proposed approach has improved user perceived satisfaction and the service quality of the public transportation.

Keywords: Vehicle Tracking System, Online Positioning, User Satisfaction, Service Quality

1. Introduction

Every public transportation system has different facility services depending on its budget and financial supports. For example, some public transportation systems offer modern facility services while others offer conventional facility services to users. The measures of service quality and user satisfaction in public transportation systems are different compared to their facility services. One of the major problems of public transportation systems is customer dissatisfaction with the existing services. This paper proposes an approach to improve user satisfaction and service quality of public transportsations. Service quality and user satisfaction are the two major factors that can create competitive advantages in every area. The service quality of a public transportation system is dependent on several factors such as the bus drivers and the information and communication technology (ICT) services provided in the public transportation system. If one of these factors has a problem, then it will affect user satisfaction and service quality of the public transportation system. For example, when bus drivers do not come to the bus stations according to schedule, users will waste a lot of time waiting at the bus stations and this will cause dissatisfaction among users. If the weather condition is bad at a particular time, users’ safety and health condition might be affected. When the service quality of public transportation is low, users will choose other transportation systems. The long waiting time is the main reason users do not like to use public transportation. Hence, they are forced to use their personal vehicles. Thereafter, several problems such as traffic congestion, pollution, and global warming will occur due to the high use of personal vehicles. Several approaches have been proposed to improve the service quality and user satisfaction of public transportation [4][7]. We propose an approach that will allow users to manage their time when they use public transportation. Users can see real time positions of public vehicles via the Internet, so they can estimate their time before going to the nearest station. We have measured the amount of improvement in user satisfaction and service quality after using the proposed approach. We have measured the service quality of the
web application using five dimensions including the usefulness of information, ease of use of web pages, quantity of information provided on the web, the interactive communication and feedback from the users. The proposed approach has been implemented as a web application.

The rest of the paper is organized as follows: In Section 2, related works on service quality and user satisfaction measurement are discussed. In Section 3, methodology of this research is explained. This methodology explains measurement of service quality and user satisfaction of public transportation that has been chosen as a case study as well as the web-based vehicle tracking system that has been developed and implemented. In section 4, the analysis of the service quality of the web-based application is discussed. Finally, the conclusion is given in Section 5.

2. Related works

Several researches have measured service quality and user satisfaction using different dimensions in different areas. For example, SERVQUAL is a framework that compares customer expectation and perception of service quality. Yang et al. [32] have measured user perceived service quality of web portals using five dimensions that are usability, information adequacy, accessibility, interaction and usefulness. They found the correlation coefficients of these dimensions on the overall service quality using regression analysis. The analysis has shown the impact of every dimension towards the overall service quality. Website quality (WEBQUAL) is an instrument for websites service quality measurement. The WEBQUAL has been introduced by Loiacono et al. [16] that measure the websites service quality using twelve dimensions that are interaction, trust, visual appeal, design, response time, information fit to task, innovativeness, flow, integrated communication, business process, intuitiveness and substitutability. Furthermore, Zakaria et al. [33] have studied the effect of service quality dimensions on the overall service quality of public transport system in Lembah Bujang area in Malaysia. They have identified the relationships between service quality of the public transport system with three dimensions that are reliability, tangible, and responsiveness based on the multiple regression analysis approach.

Budiono [4] has analysed travellers’ satisfaction of public bus transportation in Indonesia. He has evaluated the relationship between user satisfaction and service quality dimensions. The first dimension is reliability that consists of travel time, punctuality, and service reliability. The second dimension is drivers’ treatment. The third dimension is information simplicity that consists of availability of ticket retailer and ticket price. The fourth dimension is related to cleanliness, safety and comfort. He has measured user satisfaction using these dimensions: frequency, travel time, punctuality, price, information, cleanliness, staff behaviour, bus comfort, seat availability, bus stop security, safe from accident, on board security, bus stop condition and information in bus stop. He used regression analysis for finding correlation between overall user satisfaction and the service quality dimensions. There are several statistical methods for comparison of data sets that each of them is appropriate for special data sets. For example, t-test is a statistical test that compares parametric data. “One sample T-Test” finds the difference between mean of one group and population mean. “Paired T-Test” measures the difference between means of two paired groups. “Unpaired T-Test” measures the difference between means of two unpaired groups. Wilcoxon test is a statistical test that compares nonparametric data. The Wilcoxon test compares two paired groups or one group. The Wilcoxon test on one group compares the mean of the group with a hypothetical value that is defined by us. Mann-Whitney test is a statistical test that compares two unpaired samples and nonparametric data. The Mann-Whitney test is also called the Rank Sum test. “One-way ANOVA” is a statistical method that compares parametric data. The method is used for finding the comparison of three or more unpaired data groups when the data are categorized in one way. “Repeated-measures ANOVA” test is used for three or more paired groups. Kruskal-Wallis test is used for nonparametric data. The test examines the significance of three or more unpaired groups [28][30].

3. The service quality and web-based vehicle tracking system

In this paper, we measure the amount of improvement in service quality and user satisfaction. Thus, we have designed a pre-questionnaire and a post-questionnaire for gathering users perceived satisfaction and service quality as well as introduce a web based vehicle tracking system. These
questionnaires consist of three service quality dimensions (i.e., reliability, responsiveness and empathy) and four user satisfaction dimensions (frequency, time table information, speed or travel time and comfort). The user satisfaction dimensions are based on the work done by Budiono [4], Chuang and Cheng [5], and Liu and Bei [15]. The service quality dimensions are determined in the SERVQUAL model. After the questionnaires have been gathered, the user perceived service quality and satisfaction are measured based on service quality and user satisfaction with the PERQUAL model. The PERQUAL model measures service quality using the following equations:

\[
SQ = \sum_{i=1}^{n} P_i
\]

Where
- \( SQ \) - Service quality
- \( P_i \) - Perception of indicator ‘i’
- \( n \) - Number of samples

\[
US = \sum_{i=1}^{n} P_i
\]

Where
- \( US \) - User satisfaction
- \( P_i \) - Perception of indicator ‘i’
- \( n \) - Number of samples

We have designed the questionnaires based on 5-point Likert scale. The Universiti Teknologi Malaysia (UTM) public transportation service has been used as a case study. The population size in the case study is 190; therefore, according to the Morgan table, the sample size should be 123. We have collected and compared the responses from the pre-questionnaire and the post-questionnaire of the two data groups. As the two data groups are paired and have normal distribution, the paired T–Test method is the appropriate method for this comparison. The proposed method has been validated using the t–test analysis. The analysis analyzed these two hypotheses:

a. Hypothesis 1: “Is the proposed web-based application could improve the service quality of public transportation in UTM” and
b. Hypothesis 2: “Is the proposed web-based application could improve user satisfaction of public transportation in UTM”

We have measured the service quality of web-based application using five dimensions including usefulness of information, ease of use of web pages, quantity of information provided on the web, the interactive communication and feedback from the users. Next, we designed a questionnaire that asks users about these dimensions. The responses of the questionnaire have been analysed by multiple regression analysis. The analysis found correlation between the overall service quality and the five dimensions. The analysis also discovered strengths and weaknesses of these dimensions, so that we can use the analysis to improve the web application.
3.1. Web-based vehicle tracking system

The proposed web-based vehicle tracking system comprises three major components. The first component is to find real time position of public vehicle using a GPS (global positioning system) module and sends the information to a server using a GPRS module. The second module is to transfer the information to a windows application on the server. The third module is to show the position on GIS maps using a web application on the server. The hardware and software that work together according to the modules are shown in Figure 1.

3.2. Evaluation of the hypotheses using T-test analysis

According to the above sections, the research has two hypotheses:

a. Hypothesis 1: “Is the proposed web-based application could improve the service quality of public transportation in UTM” and

b. Hypothesis 2: “Is the proposed web-based application could improve user satisfaction of public transportation in UTM”

We have used T-test analysis to analyse the hypotheses. Responses from the 123 samples show that 55 persons use the public transport and 68 people do not use it. So, the responses from the 55 persons to the pre and post-questionnaire were analysed.

3.3. Analysis of the first hypothesis

This section analyses the amount of service quality improvement after using the proposed method. T-Test analysis defines the two hypotheses before proving or rejecting them:

a. $H_0$ (Null hypothesis): there is no significant difference between means of these two groups; in other words, the proposed method does not have any significant impact on service quality of the public transportation.

b. $H_1$ (Alternative hypothesis): there is a significant difference between means of these two groups; in other words, the proposed method has a significant impact on service quality of the public transportation.

Since the two samples are the same, the analysis is a dependent T-test analysis and we calculated the value of ‘t’ using the below formula:
\[
    t = \frac{\sum d}{\sqrt{n(\sum d^2)(\sum d)^2}} = -2.15933
\]  
(3)

d is the difference between the samples and n is the sample size.

The sign of the ‘t’ value is not important

After calculating the ‘t’ value, we determined the degree of freedom. Degree of freedom is calculated using the below formulas:

If \( n_1 = n_2 \) and \( s_1^2 = s_2^2 \) then \( d_f = n_1 + n_2 - 2 \)  
(4)

If \( n_1 = n_2 \) and \( s_1^2 \neq s_2^2 \) then \( d_f = n_1 - 1 \) or \( n_2 - 1 \)  
(5)

If \( n_1 \neq n_2 \) and \( s_1^2 \neq s_2^2 \) then \( d_f = \text{average of } n_1 - 1 \) and \( n_2 - 1 \)  
(6)

That

\( n_1 \) is number of subjects in sample1 = 55
\( n_2 \) is number of subjects in sample2 = 55
\( s_1^2 \) is variance of sample1 = 0.155406
\( s_2^2 \) is variance of sample2 = 0.59985

As \( n_1 = n_2 \) and \( s_1^2 \neq s_2^2 \) then \( d_f = n_1 - 1 = 55 - 1 = 54 \)

According to T-distribution table, if level of significant is 5% (0.05) and degree of freedom is 54, then critical value of ‘t’ equals to 2.0049. At the end, ‘t’ value and critical value of ‘t’ should be compared in order to prove or reject the hypotheses. If the ‘t’ value is greater than the critical value of ‘t’, then the null hypothesis is rejected, but if the ‘t’ value is less than the critical value of ‘t,’ then the null hypothesis is not rejected. Since 2.15933 (‘t’ value) > 2.0049 (critical value of ‘t’) in the analysis, the null hypothesis is rejected. So, there is a significant difference between means of these two groups. Mean1 (average of sample1) < Mean2 (average of sample2), so the analysis has shown that the proposed method has a significant positive impact on service quality of the case study.

3.4. Analysis of the second hypothesis

This section analyses the amount of user satisfaction improvement after using the proposed method. The hypotheses of this analysis are:

a. \( H_0 \) (Null hypothesis): there is no significant difference between means of these two groups; in other words, the proposed method does not have any significant impact on user satisfaction in the case study.

b. \( H_1 \) (Alternative hypothesis): there is a significant difference between means of these two groups; in other words, the proposed method has a significant impact on user satisfaction in the case study.
Table 1. Service quality dimensions and their items

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Items</th>
</tr>
</thead>
</table>
| Usefulness             | Relevant information to users  
|                        | The web application gives relevant information to you.  
|                        | Accurate information  
|                        | The web application gives accurate information to you.  
|                        | Up-to-date information  
|                        | Information provided by the web application is updated.  
|                        | Valuable tips on services  
|                        | The web application has valuable tips on how to find the required information.  |
| Ease of use            | Clear and well-organized content  
|                        | The web application has clear content.  
|                        | Well-organized hyperlinks  
|                        | Hyperlinks of the web application are well-organized.  
|                        | Ease of finding desired information  
|                        | Do you find the desired information in the web application?  
|                        | Logical layout  
|                        | The web application has a logical layout.  |
| Quantity of information| Complete service description  
|                        | The web application has complete description about its service.  
|                        | Diversified content  
|                        | The web application has a diversified content.  |
| Interactive communication| Quick responsiveness to users  
|                        | The web application has quick responsiveness to users.  
|                        | Empathy to customer problems  
|                        | The web application understands user problems.  |
| Technical adequacy     | High speed of accessing the Web  
|                        | The web application can be accessed quickly.  
|                        | High speed of page loading  
|                        | The web application pages load quickly.  
|                        | Proper use of fonts  
|                        | The web application uses proper fonts.  
|                        | Proper use of colours  
|                        | The web application uses proper colours.  
|                        | Accessibility of the site  
|                        | Accessibility of the web application is high.  |
| Overall service quality| Overall, the service has excellent quality  
|                        | Overall, the service of the web application has excellent quality.  
|                        | The service quality provided by this website matches my expectations  
|                        | Quality of the service provided by the web application matches your expectation.  
|                        | The website service offerings are very competitive  
|                        | The services provided by the web application are very competitive.  |

According to the formula that has been used to calculate ‘t’ value, the amount of ‘t’ value of this analysis equals to -2.33973 (the sign of the ‘t’ value is not important). Then, \( n_1 = n_2 = 55 \), \( s_1^2 = 0.150673 \) and \( s_2^2 = 0.388342 \) (\( n_1 = n_2 \) ands \( s_1^2 \neq s_2^2 \)), thus \( d = n_1 - 1 = 55 - 1 = 54 \). According to the previous section, the critical value of ‘t’ in this analysis equals to 2.0049. Since 2.33973 (‘t’ value) > 2.0049 (critical value of ‘t’) in the analysis, the null hypothesis is rejected. So, there is a significant difference between means of these two groups. Mean1 (average of sample1) < Mean2 (average of sample2), so the proposed method has a significant positive impact on user satisfaction in the case study.

4. Evaluation of service quality in the web application

According to the methodology, we have measured the service quality of web application based on five dimensions using multiple regression analysis. We assigned several items to each of the dimensions. Table 1 in the previous page maps the dimensions with the items. The items are from the
questions of the third questionnaire. The five dimensions are independent variables and the overall service quality of the web application is dependent variable in the multiple regression analysis. This analysis predicts the dependent variable using the independent variables. As there are five independent variables in this analysis, the regression equation of the analysis is:

\[ Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 \]  
(7)

where

\[ Y \]
- dependent variable (predicted by regression model)

\[ X_i \]
- \( i \)th independent variable from total set of \( k \) variables

\[ \beta_i \]
- \( i \)th coefficient corresponding to \( X_i \)

\( \beta_0 \)
- intercept (or constant)

\( i = 1, 2, \ldots, 5 \)
- independent variables’ index

### Table 2. Multiple regression analysis results between the overall service quality and the five service quality dimensions

<table>
<thead>
<tr>
<th>Variable</th>
<th>Standardized Coefficients (beta)</th>
<th>t-value</th>
<th>P-Value</th>
<th>Level of significance</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usefulness ((X_1))</td>
<td>-1.19243</td>
<td>-8.60874</td>
<td>2.27E-11</td>
<td>0.05</td>
<td>(H_0) rejected</td>
</tr>
<tr>
<td>Ease of use ((X_2))</td>
<td>-0.25767</td>
<td>-2.03299</td>
<td>0.04749</td>
<td>0.05</td>
<td>(H_0) rejected</td>
</tr>
<tr>
<td>Quantity of information ((X_3))</td>
<td>2.105578</td>
<td>8.175596</td>
<td>1.03E-10</td>
<td>0.05</td>
<td>(H_0) rejected</td>
</tr>
<tr>
<td>Interactive communication ((X_4))</td>
<td>1.16563</td>
<td>7.266833</td>
<td>2.56E-09</td>
<td>0.05</td>
<td>(H_0) rejected</td>
</tr>
<tr>
<td>Technical adequacy ((X_5))</td>
<td>0.246523</td>
<td>1.432631</td>
<td>0.158313</td>
<td>0.05</td>
<td>not rejected</td>
</tr>
</tbody>
</table>

Overall service quality = 3.63 - 1.19 * Usefulness - 0.26 * Ease of Use + 2.11 * Quantity of Information + 1.17 * Interactive Communication  
(8)

The regression analysis determines the impact of each of these independent variables on the dependent variable by their coefficients, so we have the below hypotheses for each of these independent variables:

- **a.** \(H_0\) (Null hypothesis): \(\beta_i = 0\), the independent variable, \(X_i\), is not important for predicting the dependent variable \(Y\)
- **b.** \(H_1\) (Alternative hypothesis): \(\beta_i \neq 0\), the independent variable, \(X_i\), is important for predicting the dependent variable \(Y\)

The coefficients show the impact of these independent variables on the dependent variable and the signs of these coefficients show the direction of the impacts (positive or negative). The P-value proves or rejects the null hypothesis. If P-Value of \(X_i\) is less than the level of significance (0.05), then the null hypothesis is rejected, but if P-Value of \(X_i\) is greater than the level of significance (0.05), then the null hypothesis is proved. Table 2 shows the decisions for the hypotheses. Since \(H_0\) for \(X_1, X_2, X_3, X_4\) is rejected, these variables are important for predicting the dependent variable \(Y\). As the coefficients of
$X_1, X_2$ are negative, these variables have negative impact on the $Y$ variable. Due to positive coefficients of $X_3, X_4$, these variables have positive impact on the $Y$ variable. However, $H_0$ for the $X_5$ is not rejected, thus the variable is not important for predicting the $Y$ variable; in other word, the impact of the variable on the dependent variable is insignificant.

5. Conclusion

Public transportation is an important service that can reduce the impacts of several problems. For example, using public transports instead of personal vehicles reduces traffic congestion and global warming. The improvement of public transportation facilities helps to increase public transportation usage rate. Some of the major problems in public transportation systems are long waiting time, dirty vehicles, and bad treatment given by drivers. This paper proposes a method for improving public transportation in which users can manage their time when using public transports. The proposed web-based application has been analysed and the performance of the proposed method has been measured based on its service quality and user satisfaction improvement. This paper has proved that the proposed method has a positive impact on user satisfaction and service quality of public transportation. Users use the proposed method via web application. We found out that the usefulness and ease of use have a negative impact on the overall service quality while quantity of information and interactive communication have a positive impact on the overall service quality.

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7. References


