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NLP-Based Decision Support System for PUV Management: Enhancing Services Through Passenger Feedback Analysis

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Abstract: This paper presents the development and evaluation of an NLP-Based Decision Support System for Public Utility Vehicle (PUV) Management, focusing on enhancing services through passenger feedback analysis. The study addresses the need for improved public transportation quality in the Philippines, where PUVs play a vital role in daily commuting. The proposed system aims to digitize the passenger feedback process and utilize Natural Language Processing (NLP) techniques to provide decision support for PUV operators. Methodologically, the study follows a phased approach based on the System Development Life Cycle (SDLC). Developed primarily using PHP as the programming language, with Vanilla JS, Bootstrap, and jQuery for backend development and frontend technologies including HTML5, CSS3, and JavaScript (ES6) for creating an interactive user interface, the system caters to the needs of its different users. The evaluation process incorporates the ISO 25010 standard for evaluating systems, and with the participation of 43 respondents from the province of Iloilo, the evaluation results revealed an overall mean score of 4.34, indicating an "Excellent" level of system functionality, reliability, portability, usability, performance efficiency, security, compatibility, and maintainability. This implies that PUV operators and management can use the developed system.

Keywords: Public Utility Vehicle, Feedback System, Transportation, Decision Support Systems, Natural Language Processing (NLP)

1. Introduction

Public Utility Vehicles (PUVs) are road-based motor vehicles (mostly with four wheels) that provide conveyance to the general public. These vehicles have dedicated routes and standard fares regulated by the government. Academicians, engineers, and even the government sector are involved continuously in PUV-related studies [1], aiming to maximize satisfaction while minimizing the perceived negative

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quality. One of the countries heavily congested by PUV is the Philippines [2]. Over the years, passengers in the Philippines have relied on Public Utility Buses (PUB) to reach their destinations [3].

There has been increased attention as to how to measure the impacts of service quality on travel demand and how to predict the impacts of specific service quality changes on transport elasticities [4]. Litman [5] studied the impact of service quality on urban rail transit. The study clearly emphasized the importance of service quality concerning customer satisfaction. Moreover, their study suggested that customer satisfaction directly affects the passenger's intention to reuse that mode of transportation.

Wang *et al.* [6] defined feedback as “information about a person’s performance or behavior, or the impact of performance or behavior, that is intentionally delivered to that person to change or improve.” More so, Huang *et al.* [7] described feedback as “actions taken by external agents to provide information regarding some aspects of one’s task performance”. Feedback systems have also been shown to improve safety performance in the workplace [8]. Kluger *et al.* [9] found that feedback helps drivers improve safety behavior and showed that individual feedback is an effective tool for positive behavior modifications toward collaborations.

This study emerged from the fact that it is needed to enhance the safety, efficiency, and quality of public transportation in the Philippines. With the growing concerns about the compliance of the PUVs, together with their safety, regulations, and the entire experiences of the passengers, we can say that there is a gap that has to be addressed. Currently, the traditional process of evaluating PUVs, which relies only on manual inspections and subjective feedback, is time-consuming, prone to errors, and always insufficient to provide accurate and comprehensive insights.

The proposed system aims to improve the current system by using the latest technologies to digitize the passenger feedback system and use this feedback to provide insights and decision support to PUV operators. By leveraging an expert system that can gather feedback from the passengers and analyze it, the system can offer a good approach to making sure that the PUV operators and management give great service to the passengers. This proposed system sees to it that the automated feedback process also assures transparency and accountability and gains the trust of the public transportation sector.

2. Literature Review

Public transportation is a form of travel offered locally that enables more people to travel together along designated routes. Typical examples of public transportation include buses, trains, and trams [10]. Stelzer *et al.* [11] show the necessity of standardized automated information exchange between travelers and transportation companies to improve the service quality of public transport. Therefore, the needs and expectations of transportation companies and travelers are defined, and the use of a novel approach for bidirectional information and communication systems in public transport is proposed. Studies also identify poor inter-government coordination among the various agencies handling transport and at different levels of government [12]. This literature review emphasizes the importance of standardized automated information exchange between travelers and transportation companies to enhance service quality in public transport, improve communication channels, and ultimately enhance the service quality of public transportation systems.

Huang *et al.* [7] explored the potential uses of feedback systems in the trucking industry as a means of improving safety. Applying information to cause system variables to conform to desired values called the reference. Feedback control is a deeply embedded network: interaction with physical environments [13]. These findings underscore the use of feedback systems in the industry to improve quality service.

A Decision Support System (DSS) is an imperative tool that helps businesses make decisions. In most cases, this means providing decision-makers with meaningful information that's relevant to a given decision [14]. DSS is extensively used in business and management [15]. At present, data analysis is of increasing importance. Data analysis was mentioned for the first time at the beginning of the 1990s, together with the concept of data mining in databases. The first data analysis experiments began with data from databases filled with customer, product, and transaction information [16]. From this viewpoint, we can understand data analysis as a process of selecting, exploring, modeling, and visualizing a large amount of data with the aim of discovering patterns or relationships that are not yet known. This way, it is possible to get clearer and more obvious results and use them to improve the analysis process. The new technologies and data mining tools provide organizations with new insights from previously unused data sources [17]. This review shows the importance of a DSS and analysis in an organization or business.

The review collectively focuses on enhancing public transportation service quality through improved communication, coordination, and feedback mechanisms. They highlight the need for standardized automated information exchange between travelers and transportation companies to meet expectations and improve service, address poor inter-government coordination among transport agencies, and explore feedback systems to boost safety and quality in the industry. Additionally, the importance of Decision Support Systems (DSS) and advanced data analysis in making informed decisions and discovering new insights is emphasized, showcasing their critical role in optimizing operations and improving organizational outcomes.

3. Methodology

3.1 Research Design

A developmental methodology was employed in the design and creation of the system. This approach involves devising, building, and evaluating systems, processes, and applications to ensure they meet various standards of acceptability, efficacy, and consistency. In the educational context, this method is often used as a “systematic approach for designing, developing, and evaluating instructional programs, processes, and products that must meet the criteria of internal consistency and effectiveness” [18].

The study employed the ISO 25010 standard, a leading model for evaluating software quality, as a framework to assess the system's effectiveness across eight key characteristics [19][20]. Descriptive research methods were employed to examine the system's functionality, reliability, portability, usability, performance efficiency, security, compatibility, and maintainability.

3.2 Research Respondents

The study was conducted at selected terminals in Iloilo Province and offices of PUVs that are commonly used by passengers as their mode of transportation. The study participants were the clerks of specific PUV companies, several drivers and conductors, and random passengers.

3.3 Initial Pre-Survey Results

The researcher used a variety of methods to collect data for the study. These methods included an initial pre-survey (both physical and online), interviews, and a research questionnaire based on the ISO 25010 standard.

The pre-survey, which was completed by 51 random passengers, revealed that most passengers found it difficult to provide feedback using the existing manual system. Many respondents also expressed a desire for automation of the feedback process.

Interviews were conducted with five drivers, five conductors, and three office clerks. All of those interviewed stated that assessing passenger needs and concerns was challenging due to the lack of an automated feedback system, emphasizing the potential benefits of such a system.

3.4 The Conceptual Framework

Figure 1 reflects the conceptual representation of the proposed system. It is based on the IPO, or Input, Process, Output (IPO) model. It depicts that the passenger scans the QR code displayed within the PUV, then accesses the feedback website and provides feedback, ratings, comments, and suggestions. The process shows feedback validation, feedback dissemination, and management reporting. In Feedback Validation, the validator verifies the authenticity and relevance of the feedback; feedback with multiple validations (*e.g.*, from passengers during a fast trip) is prioritized for validation.

In feedback dissemination, validated feedback is transmitted to the management system, driver's dashboard, and conductor's dashboard. Also, recommendations and compliance reports are generated based on the validated feedback and sent to drivers and conductors. Lastly, in management reporting, management utilizes the accumulated feedback data to generate weekly reports; thus, reports serve as decision-support tools for assessing the performances of drivers and conductors. In the output, validated feedback is disseminated to relevant stakeholders (management, drivers, and conductors). Recommendations and compliance reports are delivered to drivers and conductors, and weekly performance reports are generated for management decision-making.

In this conceptual framework depicted in Figure 1, the IPO model outlines the flow of inputs (passenger feedback), processes (validation, dissemination, and reporting), and outputs (validated feedback, recommendations, and compliance reports).

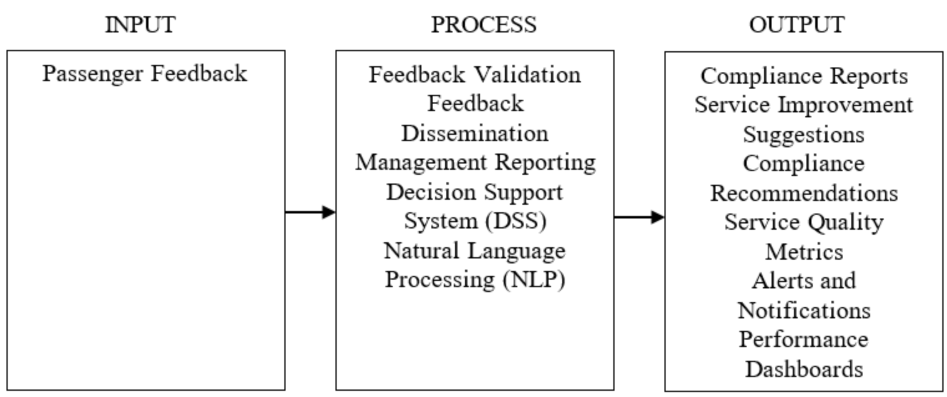

Figure 1. The Conceptual Framework of the Proposed System

3.5 The Proposed System

The proposed system was developed in response to the absence of an automated passenger feedback mechanism. Its primary purpose is to leverage advanced digital technologies to gather and analyze passenger feedback efficiently. By employing an expert system, the solution ensures that PUV operators and management can consistently provide excellent service. Additionally, this automated process enhances transparency and accountability, fostering greater trust within the public transportation sector.

3.5.1 The Use Case Diagram of the Proposed System

The use case diagram in Figure 2 illustrates the systematic interaction between passengers and the QR Code-based Passenger Feedback System. It begins with passengers initiating the feedback process by scanning the QR code displayed within the vehicle, granting them access to the feedback interface. Within this interface, passengers can provide feedback, including optional personal details, specify the recipient (driver, conductor, or management), and articulate their comments or concerns. Once submitted, the feedback is automatically stored in the system's database, ensuring secure and organized data management.

Before feedback is disseminated, it undergoes validation by a designated validator to ensure accuracy and relevance. Validation includes assessing feedback against predefined criteria to ensure its validity and effectiveness. Feedback must meet a predetermined threshold of occurrences for the same issue or concern to be considered valid, ensuring that only substantiated issues are addressed. Once validated, feedback reports are forwarded to the appropriate recipients based on their nature. Reports intended for drivers or conductors are routed to their respective sides, while management receives all validated feedback automatically.

Moreover, the system generates reports highlighting specific violations or compliance issues observed during PUV operations. These reports are tailored to the respective recipients (drivers or conductors) to facilitate targeted remedial actions and performance improvement initiatives. This structured and efficient process ensures that feedback is captured, validated, and disseminated effectively, leading to continuous improvement in service quality and passenger satisfaction within the PUV ecosystem.

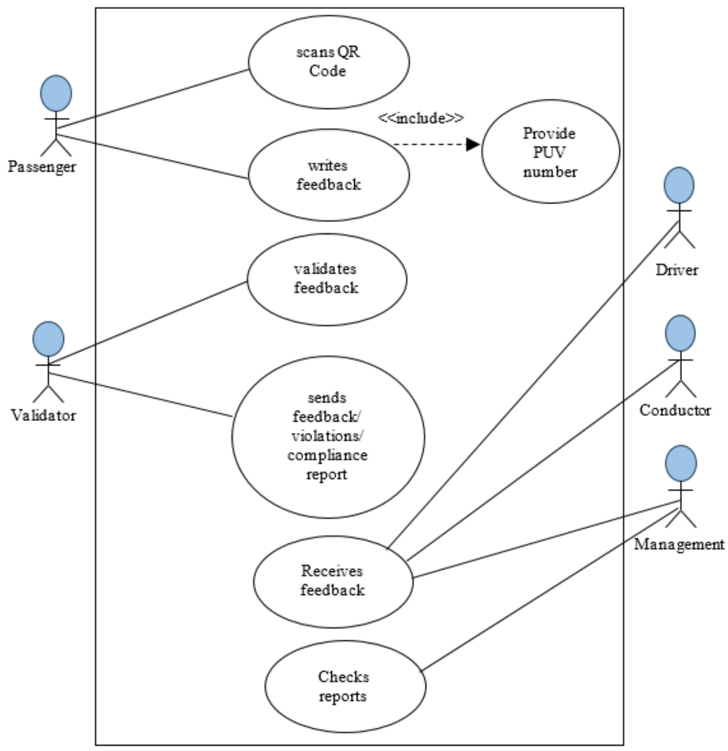

Figure 2. The Use Case Diagram of the Proposed System

3.5.2 User Interface Design

Figure 3 illustrates the feedback form utilized by passengers to convey their travel experiences. Through this interface, passengers can input details such as personal information and journey feedback, facilitating their contribution to the improvement of public transportation services. The passenger just must be connected to the internet so he can access the form.

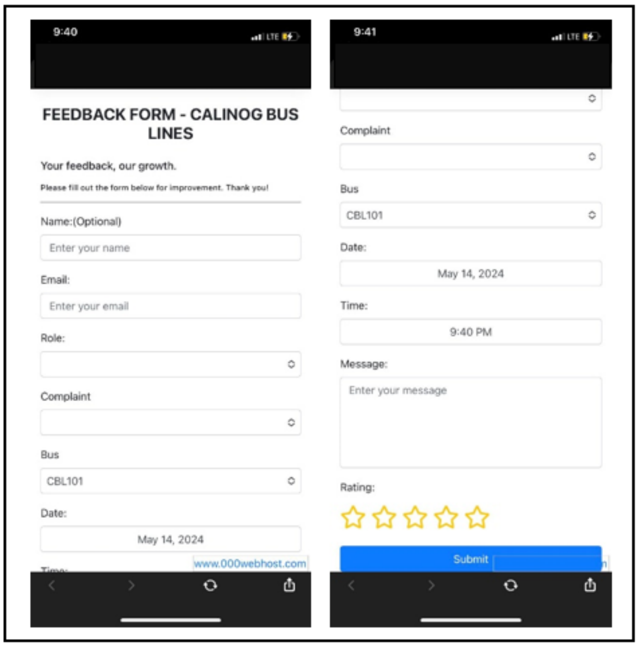

Figure 3. The Feedback Form of the Passenger

Figure 4 displays the Validator’s dashboard, providing access to reports on passenger feedback regarding drivers, conductors, and equipment, along with a summary of complaints. The dashboard allows the validator to review feedback and decide whether to file a report. Notifications are triggered upon reaching the feedback threshold, indicating widespread passenger concerns about a specific bus and prompting further investigation or report filing.

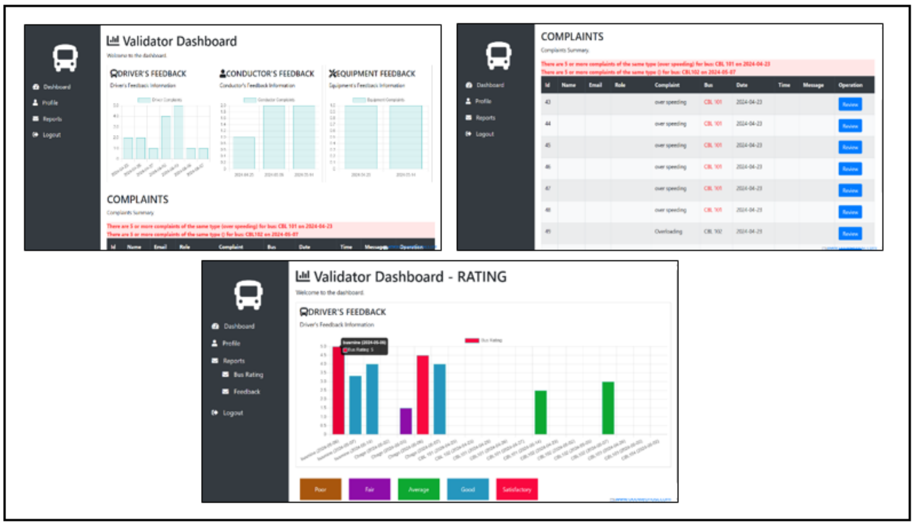

Figure 4. The Validator’s Dashboard with Data Visualization

Figure 5 presents the driver's dashboard, featuring a graph depicting daily passenger feedback. Additionally, it includes a profile page where the driver can view their profile details and a feedback page to review validated feedback or complaints filed by the validator. This dashboard provides drivers with valuable insights into passenger satisfaction and facilitates communication regarding feedback and complaints. This is the same on the conductor’s side.

Figure 5. Dashboard of the Driver Showing the Graph of the Feedback of the Passengers

3.6 Operation and Testing Procedure

During this phase, the system underwent pilot testing. The researcher went to PUV terminals and asked random passengers who were willing to participate in the study to do the pilot testing. The phase transition occurred after the system was tested and approved by selected people who were technically capable. Deployment into a live environment ensued, with program testing conducted systematically to ensure adherence to specifications. Functionality and reliability served as the test parameters, with errors rectified following each executed test case.

3.7 System Evaluation

The system was evaluated using the eight quality parameters described in the ISO 25010 standard in terms of functional suitability, reliability, portability, usability, performance efficiency, security compatibility, and maintainability.

A total of 43 participants were involved in this research, divided into three groups. The first group consisted of thirty passengers who own smartphones with internet connectivity, regardless of brand or operating system. The second group included five (5) drivers and five (5) conductors who also possess smartphones with internet access. The third group comprised three (3) PUV management clerks who likewise have internet-capable smartphones.

To interpret the data, the weighted arithmetic mean, a statistical technique, was used. This method determined the average responses across five rating options: excellent (5), very good (4), satisfactory (3), fair (2), and poor (1). After data collection and tabulation, the weighted mean for each criterion and the overall grand mean were calculated.

Table 1. Likert Scales for System Evaluation

Rating	Mean Range	Verbal Interpretation
5	4.21-5.00	Excellent
4	3.31-4.20	Very Good
3	2.61-3.30	Satisfactory
2	1.81-2.60	Fair
1	1.00-1.80	Poor

The respondents assessed the system by completing a questionnaire utilizing a 5-point Likert scale. This scale measured various characteristics aligned with ISO criteria for establishing standard software development. Table 1 illustrates the verbal interpretation corresponding to the Likert scores.

4. Results and Discussion

Table 2 presents the evaluation of the system based on the ISO 25010 standard, revealing significant strengths and areas for improvement. With an overall mean score of 4.34 from the evaluation of 43 respondents, the system excels in most assessed categories, particularly functional suitability, portability, and usability, indicating that it effectively meets user needs, adapts well to various environments, and is user-friendly.

Table 2. Summary of Evaluation

Characteristics	Mean			Grand Mean	Description
	Passengers	*Drivers /Conductors*	*Clerks*		
A. Functional Suitability					
Completeness	4.61	4.60	4.40	4.54	Excellent
Correctness	4.61	4.15	4.33	4.36	Excellent
Appropriateness	4.71	4.45	3.90	4.35	Excellent
B. Reliability					
Maturity	4.73	4.55	4.67	4.65	Excellent
Availability	4.55	4.27	4.35	4.39	Excellent
Fault Tolerance	4.43	4.01	3.67	4.03	Very Good
Recoverability	4.65	3.86	3.33	3.94	Very Good
C. Portability					
Adaptability	4.77	4.35	4.33	4.48	Excellent
Durability	4.58	4.42	4.33	4.44	Excellent
Installability	4.60	4.45	4.67	4.57	Excellent
Affordability	4.82	4.29	4.33	4.48	Excellent
D. Usability					
Appropriateness Recognizability	4.74	4.39	3.67	4.27	Excellent
Learnability	4.87	4.86	4.50	4.74	Excellent
Operability	4.74	4.58	4.17	4.49	Excellent
User error protection	4.97	3.93	4.67	4.52	Excellent
User interface aesthetics	4.81	4.80	5.00	4.87	Excellent
Accessibility	4.97	4.30	4.67	4.64	Excellent
E. Performance Efficiency					
Time behavior	4.87	4.19	4.00	4.35	Excellent
Resource utilization	4.77	3.99	4.67	4.47	Excellent
Capacity	4.84	4.25	3.00	4.03	Very Good
F. Security					
Confidentiality	4.58	3.70	3.67	3.98	Very Good
Integrity	4.77	4.10	4.00	4.29	Excellent
Non-repudiation	4.35	3.40	3.67	3.81	Very Good
Accountability	4.63	4.10	3.67	4.13	Very Good
Authenticity	4.65	3.50	4.00	4.05	Very Good
G. Compatibility					
Co-existence	4.68	4.50	4.17	4.45	Excellent
Interoperability	4.93	4.00	3.83	4.25	Excellent
H. Maintainability					
Modularity	4.77	4.30	4.17	4.41	Excellent
Reusability	4.40	4.20	3.83	4.14	Very Good
Analyzability	4.35	4.00	4.00	4.11	Very Good
Modifiability	4.77	4.10	4.17	4.34	Excellent
Testability	4.52	4.20	4.50	4.40	Excellent
		Overall Mean		**4.34**	**Excellent**

Reliability and security, though rated highly overall, show potential for enhancement in fault tolerance, recoverability, and specific security aspects such as confidentiality and non-repudiation. These areas, while still performing well, could benefit from targeted improvements to bolster the system's robustness and security.

Overall, the system's strong performance demonstrates its capability to provide high-quality service, with excellence in functionality, ease of use, and adaptability. Future developments should focus on addressing the identified areas for improvement to further enhance the system's reliability and security.

5. Conclusion

The development of the NLP-Based Decision Support System for PUV Management: Enhancing Services Through Passenger Feedback Analysis has been a success. The evaluation of the system, utilizing the ISO 25010 standard, has demonstrated exemplary performance across multiple dimensions, reflected in the commendable grand mean score of 4.34, signifying an "Excellent" level of functionality and reliability. These results affirm the system's robustness, usability, and effectiveness in meeting the defined criteria for software development standards. However, to sustain this high level of performance and address potential areas for improvement, several key recommendations emerge.

Firstly, it is imperative to establish a framework for continuous monitoring and improvement, ensuring that the system remains responsive to evolving user needs and industry standards. Regular assessments and updates will help maintain its relevance and effectiveness over time. Additionally, investing in comprehensive training programs and user support mechanisms will empower users to fully leverage the system's capabilities, minimizing errors and maximizing efficiency.

Furthermore, proactive efforts to address any identified areas for improvement, based on user feedback and further analysis, will be essential. Timely enhancements and refinements will optimize the system's performance and enhance user satisfaction. Moreover, exploring opportunities to integrate emerging technologies such as artificial intelligence or machine learning can further augment the system's capabilities and future-proof its functionality. By fostering stakeholder engagement and collaboration, including feedback sessions and collaborative initiatives, the organization can ensure that the system continues to evolve in alignment with user needs and organizational objectives. These concerted efforts will contribute to the sustained success and value of the system, ultimately enhancing organizational efficiency and effectiveness in achieving its mission.

References

[1] J. Kim, J. D. Schmöcker, J. W. Yu, J. Y. Choi, "*Service Quality Evaluation for Urban Rail Transfer Facilities with Rasch Analysis*," Travel Behaviour and Society, vol. 13, January 2018, pp. 26-35, https://doi.org/10.1016/j.tbs.2018.05.002.

[2] Mateo-Babiano, R. B. Recio, D. P. Ashmore, M. D. Guillen, S. M. Gaspay, "*Formalizing the Jeepney Industry in the Philippines – A Confirmatory Thematic Analysis of Key Transitionary Issues*", Research in Transportation Economics, vol. 83, March 2020, pp. 100839, https://doi.org/10.1016/j.retrec.2020.100839.

[3] M. M. Cahigas, Y. T. Prasetyo, S. F. Persada, A. K. S. Ong, R. Nadlifatin, "*Understanding the Perceived Behavior of Public Utility Bus Passengers During the Era of COVID-19 Pandemic in the Philippines: Application of Social Exchange Theory and Theory of Planned Behavior*", Research in Transportation Business & Management, vol. 45, part C, March 2022, pp. 100840, https://doi.org/10.1016/j.rtbm.2022.100840.

[4] A. Anburuvel, W. U. L. D. P. Perera, R. D. S. S. Randeniya, "*A Demand Responsive Public Transport for a Spatially Scattered Population in a Developing Country*", Case Studies on Transport Policy, vol. 10, no. 1, February 2022, pp. 187-197, https://doi.org/10.1016/j.cstp.2021.12.001.

[5] T. Litman, "*Valuing Transit Service Quality Improvements*", Journal of Public Transportation, vol. 11, no. 2, 2008, pp. 43-63, https://doi.org/10.5038/2375-0901.11.2.3.

[6] Y. Wang, Z. Zhang, M. Zhu, H. Wang, "*The Impact of Service Quality and Customer Satisfaction on Reuse Intention in Urban Rail Transit in Tianjin, China*," SAGE Open, vol. 10, no. 1, January 2020, pp. 1-10, https://doi.org/10.1177/2158244019898803.

[7] Y. H. Huang, M. Roetting, J. R. McDevitt, D. Melton, G. S. Smith, "*Feedback by technology: Attitudes and opinions of truck drivers*," Transportation Research Part F: Traffic Psychology and Behaviour, vol. 8, no. 4–5, July-September 2005, pp. 277-297, https://doi.org/10.1016/j.trf.2005.04.005.

[8] K. A. Hutton, C. G. Sibley, D. N. Harper, M. J. Hunt, "*Modifying Driver Behaviour with Passenger Feedback*," Transportation Research Part F: Traffic Psychology and Behaviour, vol. 4, no. 4, December 2001, pp. 257-269, https://doi.org/10.1016/S1369-8478(01)00027-4.

[9] A. N. Kluger, A. DeNisi, "*The Effects of Feedback Interventions on Performance: A Historical Review, A Meta-analysis, and A Preliminary Feedback Intervention Theory*," Psychological Bulletin, vol. 119, no. 2, February 1996, pp. 254-284, https://doi.org/10.1037/0033-2909.119.2.254.

[10] T. Chuenyindee, A. K. S. Ong, J. P. Ramos, Y. T. Prasetyo, R. Nadlifatin, Y. B. Kurata, T. Sittiwatethanasiri, "*Public Utility Vehicle Service Quality and Customer Satisfaction in the Philippines During the COVID-19 Pandemic*," Utility Policy, vol. 75, April 2022, https://doi.org/10.1016/j.jup.2022.101336.

[11] A. Stelzer, F. Englert, S. Hörold, C. Mayas, "*Improving Service Quality in Public Transportation Systems Using Automated Customer Feedback*," Transportation Research Part E: Logistics and Transportation Review, vol. 89, May 2016, pp. 259-271, https://doi.org/10.1016/j.tre.2015.05.010.

[12] N. A. Rahman, Y. A. Abdullah, "*Theorizing the Concept of Urban Public Transportation Institutional Framework in Malaysia*," MATEC Web of Conferences, vol. 66, July 2016, https://doi.org/10.1051/matecconf/20166600043.

[13] J. Doyle, B. Francis, A. Tannenbaum, "*Feedback Control Theory*," Macmillan Publishing Co., January 2009, https://doi.org/10.1007/978-0-387-85460-1_1.

[14] J. Spacey, "*Decision Support Techniques*," Simplicable, https://simplicable.com/IT/decision-support.

[15] R. Armacost, "*Decision Support Systems*," I Know LLC, https://www.iknow.us/technologies/decision-support-systems.

[16] M. Smallcombe, "*A Brief History of Data Analysis*," Integrate.io, https://www.integrate.io/blog/a-brief-history-of-data-analysis/.

[17] U. Fayyad, R. Uthurusamy, "*Evolving Data into Mining Solutions for Insights*," Communications of the ACM, vol. 45, no. 8, August 2002, pp. 28-31, https://doi.org/10.1145/545151.545174.

[18] R. C. Richey, "*The Pursuit of Useable Knowledge in Instructional Technology*," Educational Technology Research and Development, vol. 46, December 1998, pp. 7-22, https://doi.org/10.1007/BF02299670.

[19] R. S. Mission, "*Online Support Management System for University of Antique*", Journal of Innovative Technology Convergence, vol. 2, no. 2, December 2020, pp. 39-52, https://doi.org/10.69478/JITC2020v2n2a05.

[20] International Organization for Standardization, "*ISO/IEC 25010:2011 Systems and software engineering - System and software Quality Requirements and Evaluation (SQRE) - Part 1: Quality models*," https://iso25000.com/index.php/en/iso-25000-standards/iso-25010.