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Evaluation of the Effectiveness of Traffic Light System at Bantayan Intersection, Dumaguete City

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Index Terms:

traffic signal effectiveness, usability, operational performance, safety perception, driver perception

Abstract. This study evaluated the effectiveness of the traffic light system at Bantayan Intersection in Dumaguete City, focusing on its performance and drivers' perceptions. Specifically, it assessed effectiveness in terms of accuracy, usability, operational performance, and safety perception, and examined the relationship between drivers' profiles and their perceived effectiveness. A descriptive-correlational research design with a quantitative approach was employed in this study. Data were collected from 100 drivers, including motorcycle, tricycle, and private vehicle drivers, using a structured and validated questionnaire, supported by on-site observations of traffic flow, delay, and queue length. The data were analyzed using descriptive statistics such as frequency, percentage, and weighted mean, and inferential statistics using Spearman's rho. Results revealed that the traffic light system is generally perceived as high effective, with an overall mean of 4.02, means that the system generally performs well; drivers experience only minor operational concerns particularly in usability, operational performance, and safety perception. Furthermore, no significant relationship was found between drivers' profiles and their perceived effectiveness, indicating consistent perceptions across different user groups. Despite the positive evaluation, certain aspects such as signal timing, clarity, and visibility require improvement. The study concludes that while the system effectively regulates traffic and enhances safety, further optimization is necessary to improve efficiency and user experience. The findings provide a basis for recommending improvements and support data-driven traffic management decisions. Additionally, the study highlights the importance of continuous monitoring and evaluation of traffic control systems to ensure their long-term effectiveness. It also emphasizes the role of user perception in assessing infrastructure performance, as drivers' experiences directly influence compliance and safety outcomes.

Introduction

Traffic light systems are widely used around the world to regulate vehicle and pedestrian movement at intersections. However, their effectiveness depends on how well they are designed, operated, and understood by the drivers. As urbanization continues and vehicle ownership increases, ineffective traffic signal systems have become a growing concern in many cities (Kalašová et al., 2024). Traffic lights are commonly implemented in cities such as Seattle in United States, Hamburg in Germany, and Jakarta in Indonesia, where authorities regularly evaluate and improve signal systems to ensure proper operation and user compliance (Chen et al., 2022; Almomany et al., 2025). These systems are intended to provide clear and orderly control of traffic through proper signal timing, visibility, and comprehension. However, studies conducted in Bahir Dar City, Ethiopia, and Selangor, Malaysia reported that poor signal design, inadequate visibility, and improper timing can reduce the effectiveness of traffic signals at intersections (Fetene, 2025; Rahmat et al., 2023).

In the Philippines, traffic light systems are not yet widely implemented in all cities and municipalities. Many areas still rely on traffic enforcers, road signs, or informal traffic control measures due to limited infrastructure and financial resources. Recently, Dumaguete City installed its first modern traffic light system at the Bantayan Intersection as part of an initiative to modernize road management systems and improve compliance among road users (Philippine Information Agency, 2025). Traffic lights play an important role in daily urban routines by providing clear visual instructions to drivers and pedestrians, helping reduce confusion, and promoting orderly movement at intersections. However, the mere presence of traffic lights does not guarantee their effectiveness. Signal clarity, accuracy, visibility, and user understanding are crucial factors that influence whether road users properly follow the system (Balla & Macabeo, 2022; Buniel & Tantoy, 2024). While many studies have examined traffic signal systems, most focus on traffic flow, congestion reduction, and road safety performance, limited research has specifically evaluated the effectiveness of traffic light systems based on system functionality and driver perception, especially in developing cities and newly installed systems. This study differs from previous research by concentrating on the effectiveness of the traffic light system itself, including its accuracy, usability, clarity, and user confidence, rather than technical performance indicators such as traffic volume or delay. Existing reports and observations in Dumaguete City mainly describe the installation of the traffic light system, but there is a lack of systematic evaluation regarding how effective the system is in guiding road users. The absence of empirical assessment of the traffic light system at Bantayan Intersection therefore highlights the need for this study. Ineffective traffic signal systems may lead to misinterpretation, reduced compliance, and inefficient intersection control. Previous studies have also indicated that poorly designed and poorly understood traffic signals can result in delays, increased fuel consumption, and environmental impacts. Therefore, evaluating the effectiveness of the traffic light system is essential to identify system limitations, assess user perceptions, and provide evidence-based recommendations for improvement.

This study aimed to evaluate the effectiveness of the traffic light system at Bantayan Intersection, Dumaguete City, by examining system performance and user perception. Anchored on Traffic Flow Theory and the Technology Acceptance Model (TAM), the study seeks to determine how road users perceive the traffic light system and how effectively it functions in daily intersection operations. The findings will serve as a basis for recommending improvements in signal design, operation, and public awareness programs. Furthermore, this research contributes to Sustainable Development Goal 11: Sustainable Cities and Communities, which promotes sustainable urban transport systems and improved infrastructure for safer and more efficient cities (United Nations, 2015).

Statement of the Problem

This study aimed to evaluate the effectiveness of the traffic signal system at Bantayan Intersection, Dumaguete City, for the purpose of recommending a proposal for improvement. Specifically, this study seeks to answer the following questions:

1. What is the profile of the drivers in terms of the following:
   1.1. age;
   1.2. educational attainment; and
   1.3. number of years driving?
2. As perceived by the respondents, what is the extent to which the effectiveness of the traffic signal system is manifested in terms of the following dimensions:
   2.1. accuracy;
   2.2. usability;
      2.2.1. ease of understanding;
      2.2.2. clarity and visibility;
      2.2.3. speed of interpretation; and
      2.2.4. users' confidence?
3. Operational performance?
4. Safety perception?
5. Is there a significant relationship between the drivers' profile and their perceived effectiveness of the traffic signal system?

Null Hypothesis

The hypothesis will be tested at a 0.05 level of significance.

H_o: There is no significant relationship between the respondents' profile and their perceived effectiveness of the traffic light system at Bantayan Intersection, Dumaguete City.

Methodology

Research Design

This study employed descriptive-correlational research design to evaluate the effectiveness of traffic light systems in Barangay Bantayan, Dumaguete City. Quantitative data, including traffic volume, vehicle delay, queue length, and safety-related observations, are systematically collected and analyzed to complement road users' perceptions in evaluating the effectiveness, accuracy, and usability of the traffic light system.
Research Locale

The study was conducted at the intersection of Barangay Bantayan, Dumaguete City, which is currently the only intersection in the city equipped with traffic signal lights. This location was chosen due to its strategic importance in connecting residential, commercial, and public areas, making the performance of its traffic light system critical to local traffic flow and road safety. Observations and measurements were carried out on-site during both peak and off-peak hours to capture variations in traffic volume, congestion, and vehicular behavior. Data collection focused on real-world conditions, including traffic flow, queue length, delay, and compliance with traffic signals, without any manipulation of the existing traffic light system. The research environment encompassed both vehicle and pedestrian traffic, with additional reference to historical traffic and accident records obtained from the local traffic office. This combination of field observation and secondary data provides a comprehensive assessment of the traffic light system's performance in its operational setting, ensuring that the findings accurately reflect its impact on traffic flow and safety in Dumaguete City.

Research Respondents

The respondents of the study were consisted of drivers who frequently pass through Bantayan Intersection in Dumaguete City. These includes motorcycle drivers, tricycle drivers, and private vehicle drivers. A total of 100 respondents participated in the study. These individuals were selected because they have a direct and an actual experience with the traffic light system, enabling them to provide reliable and relevant assessments of its effectiveness.

The respondents were chosen based on the following inclusion criteria: (1) must be a licensed driver, (2) must have passed through Bantayan Intersection on a regular basis, and (3) must be willing to participate voluntarily in the study. These criteria ensured that all participants were capable of providing informed and experience-based responses. The participants varied in terms of age, educational attainment, and number of years of driving experience. These variations allowed the study to capture diverse perspectives from different categories of road users. Such diversity is essential in evaluating how drivers perceive the effectiveness of the traffic light system in terms of accuracy, usability, ease of understanding, clarity and visibility, speed of interpretation, users' confidence, operational performance, and safety perception.

A total sample size of 100 respondents was utilized in this study, which is considered adequate for descriptive research. According to Bullen (2022), a minimum sample size of 100 is generally sufficient to obtain reliable results for survey-based studies. This supports the appropriateness of the sample size used in representing the perceptions of drivers at Bantayan Intersection.

Distribution of Respondents
n= 100

Type of Vehicle	Frequency	Percentage
Motorcycle	40	40%
Tricycle	40	40%
Private Vehicle	20	20%
Total	100	100%

Research Instrument

A structured questionnaire served as the primary research instrument in this study, carefully designed to address the research questions. The instrument consisted of several parts. Part I is the disclosure statement, wherein respondents agree to keep the collected data confidential and to use it exclusively for academic purposes, subject to the researcher's consent. Part II gathers the respondent's demographic profile, including age, educational attainment, and number of years driving. Part III measures the extent of effectiveness of the traffic light system using a five-point Likert scale, where 5 indicates "Very Highly Effective" and 1 indicates "Not Effective." This section is subdivided into four dimensions: (a) Accuracy, (b) Usability (ease of understanding, clarity and visibility, speed of interpretation, and users' confidence), (c) Operational Performance, and (d) Safety Perception. Part IV is an open-ended section that allows respondents to suggest improvements to enhance the effectiveness of the traffic signal system.

The entire questionnaire was validated by at least three experts in traffic management or related fields who possessed graduate-level training and research experience to ensure the content relevance and clarity of the items. A dry run was then conducted with 30 drivers who met all the inclusion criteria and were initially treated as a pilot group to assess item wording, timing, and clarity of instructions and their qualifications were verified using the same criteria applied to the main respondents. After confirming that all subscales of the instrument achieved acceptable reliability based on Cronbach's alpha, the responses from these 30 pilot participants were retained and merged into the final dataset.

The reliability of each variable was assessed using Cronbach's Alpha, with results indicating excellent internal consistency across all subscales. Specifically, the Traffic Signal Visibility variable obtained a Cronbach's Alpha coefficient of 0.957, Driver Comprehension recorded 0.958, Signal Timing Efficiency yielded 0.959, and Traffic Flow Management achieved 0.960. These values, all exceeding 0.90, demonstrate that the items within each variable are highly correlated and consistently measure their intended constructs, confirming that the instrument is both stable and dependable for evaluating the effectiveness of the traffic light system.

Ethical Considerations

This study adhered to strict ethical standards approved by the Foundation University Ethics Review Board. Formal permission was obtained from the research site, and all participants provided informed consent. Participation was voluntary, and participants were assured of their right to withdraw from the study at any time without penalty. To ensure confidentiality, data were anonymized using numeric codes, and findings were reported in aggregate form to prevent the identification of individual respondents. Both hard and digital data were stored securely, accessible only to the research team, and will be disposed of in accordance with university guidelines upon completion of the study. Finally, AI tools were used solely for language editing and manuscript refinement, with no involvement in data generation or analysis. The researchers retain full responsibility for the integrity of the study.

Research Procedure

After the research design hearing, the researchers integrated all corrections and suggestions from the panel members into the final version of the proposal. A formal letter of request to conduct the study was then prepared and endorsed by the Dean of the School of Industrial Engineering and Technology of Foundation University. This request was submitted to the appropriate local government and Traffic Management Office in Dumaguete City to secure permission to administer the survey among licensed drivers who regularly passed through the Bantayan Intersection.

Once the approval was granted, the researchers coordinated with designated officers in the area to identify potential respondents who met the inclusion criteria, such as holding a valid driver's license, having at least a minimum required number of years of driving experience, and regularly traversing the Bantayan Intersection or nearby routes in Dumaguete City. During data collection, the researchers approached the drivers, explained the purpose and importance of the study, presented the informed consent and disclosure statement, and invited them to participate. Drivers who voluntarily agreed were given the structured questionnaire and provided with clear instructions. They answered the instrument on the spot, and the accomplished questionnaires were retrieved immediately after completion to ensure a high return rate and minimize missing responses.

After data gathering, the responses were encoded and tallied using Microsoft Excel or equivalent spreadsheet software. Coded values were assigned to the profile variables, and Likert-scale responses on the effectiveness of the traffic light system (1 = Very Low Effective to 5 = Very High Effective) were processed for analysis. The data were then analyzed using JAMOVI to generate descriptive statistics for the respondents' profile and their ratings of accuracy, usability, operational performance, and safety perception as well as reliability indices for the instrument. The statistical results were subsequently interpreted in light of the study's objectives, theoretical framework (Traffic Flow Theory and Technology Acceptance Model), and related literature to arrive at conclusions and recommendations for improving the traffic light system at Bantayan Intersection, Dumaguete City.

Statistical Treatment of the Data

The collected data were systematically processed and analyzed using appropriate descriptive and inferential statistical techniques to address the objectives of the study. Statistical analysis was performed using spreadsheet software and statistical tools to ensure accuracy, consistency, and reliability of results. Descriptive statistics were employed to summarize and present the respondents' demographic profiles, including age, educational attainment, and years of driving experience. Frequency counts and percentage distributions were utilized to provide a clear characterization of the sample population.

To determine the level of perceived performance of the traffic light system, the weighted mean and standard deviation were computed for each indicator and dimension, namely accuracy, usability (ease of understanding, clarity and visibility, speed of interpretation, and user confidence), operational performance, and safety perception. The weighted mean was used to describe the central tendency of responses based on a five-point Likert scale, while the standard deviation measured the variability or dispersion of responses among participants.

The following scale was used to interpret the level of perceived effectiveness of the traffic light system:

Range	VD (Verbal Description)	EoE (Extent of Effectiveness)
4.21 – 5.00	Strongly Agree (SA)	Very High (VH)
3.41 – 4.20	Agree (A)	High (H)
2.61 – 3.40	Neutral (N)	Moderate (M)
1.81 – 2.60	Disagree (D)	Low (L)
1.00 – 1.80	Strongly Disagree (SD)	Very Low (VL)

Inferential statistics were applied to examine the relationship between the respondents' profiles and their perceptions of the traffic light system. Specifically, Spearman's rank-order correlation coefficient (Spearman's rho) was utilized due to the ordinal nature of the data and the non-parametric characteristics of the variables. This test determined the strength and direction of the relationship between demographic variables and perception-based measures. The level of significance for hypothesis testing was set at 0.05. A p-value less than 0.05 indicated a statistically significant relationship, leading to the rejection of the null hypothesis. Conversely, a p-value greater than 0.05 indicated no significant relationship, resulting in the acceptance of the null hypothesis.

To interpret the strength of the correlation coefficients, the following guidelines were applied:
±0.50 to ±1.00: Strong relationship
±0.30 to ±0.49: Moderate relationship
±0.10 to ±0.29: Weak relationship
±0.01 to ±0.09: Very weak relationship

All results were presented in tabular form and supported by appropriate interpretations to facilitate a comprehensive understanding of the findings. The use of both descriptive and inferential statistics ensured a robust analysis of the traffic light system at Bantayan Intersection.

Delimitation of the Study

Despite its relevance, this study has certain limitations that must be acknowledged. The study is conducted only at Bantayan Intersection, Dumaguete City, which is a signalized intersection. The findings are site-specific and may not fully represent the traffic signal performance of other intersections within Dumaguete City or in other urban areas with different traffic characteristics, geometric designs, or signal control systems. Data collection for this study is limited to a specific observation period. As such, the study does not account for long-term traffic trends, seasonal variations, special events, or emergency situations that may affect traffic volume, delay, and signal performance. Traffic conditions outside the observation period may vary and influence overall intersection performance. The study primarily relies on manual traffic counts, delay measurements, and field observations rather than advanced traffic monitoring technologies such as automated traffic detectors, CCTV-based analytics, or simulation software. Due to limited access to such technologies, data validation was conducted through repeated observations, cross-checking, and consistency verification across multiple days.

Results and Discussion

The analysis and interpretation of the data collected in this study are presented in this chapter. It focuses on evaluating the effectiveness of the traffic light system at Bantayan Intersection, Dumaguete City, based on drivers' perceptions. Specifically, it examines the system's effectiveness in terms of accuracy, usability, operational performance, and safety perception. Descriptive statistical tools such as frequency, percentage, weighted mean, and standard deviation are used to summarize the data, while Spearman's rho is employed to determine the significance of the relationship between drivers' profiles and their perceived effectiveness of the traffic signal system.

Age	Frequency	Percent (%)
18-25	37	37%
26-35	35	35%

36-45	12	12%
46-55	7	7%
56 Above	9	9%
Total	**100**	**100**

Table No. 1. Age Profile of the Drivers (n=100)

Table 1 shows the age profile of the drivers who participated in the study at Bantayan intersection. Most respondents fall within the 18–25 (37%) and 26–35 (35%) age brackets, comprising 72% of the total. This indicates a "youth bulge," suggesting greater adaptability to new systems and training. Studies show younger drivers tend to have faster reaction times but are more prone to risk-taking (De Winter & Dodou, 2016; Scott-Parker et al., 2018) and are generally more receptive to traffic technologies. Meanwhile, older groups 46–55 (7%) and 56+ (9%) are underrepresented, indicating fewer experienced drivers. This highlights the need for targeted training, particularly for younger drivers, to support long-term safety and professional development (World Health Organization [WHO], 2018). These findings align with studies in developing countries, where motorcycles dominate due to affordability (Hsu et al., 2019) and high motorcycle volume affects traffic flow, increasing complexity and reducing predictability (Peden et al., 2017), thus requiring adaptive signal control systems to improve efficiency and safety (Rahman et al., 2020).

Educational Attainment	Frequency	Percent (%)
Elementary Level/ Graduate	11	11%
Junior High Level/ Graduate	16	16%
Senior High Level/ Graduate	11	11%
College Level/ Graduate	62	62%
Total	**100**	**100**

Table No. 2. Educational Attainment Profile of the Drivers (n=100)

Table 2 reveals the educational attainment profile of the drivers who participated in the study. The majority are College Level/Graduates (62%), followed by Junior High Level/Graduates (16%). This suggests that many drivers have the capacity to understand technical instructions and comply with traffic rules and signal systems. Studies indicate that higher educational attainment is associated with better knowledge of traffic regulations and safer driving behavior (Zhang et al., 2019). This may also explain their ability to engage with structured practices such as documentation and standardized procedures. Meanwhile, Elementary Level (11%) and Senior High Level (11%) groups have lower representation but remain significant. This highlights the need for traffic signals and related materials to be clear, visible, and easy to interpret for all users. It supports findings that traffic systems should follow universal design principles to reduce cognitive load and ensure compliance across different educational backgrounds (FHWA, 2018; Shinar, 2017).

Driving Experience	Frequency	Percent (%)
0-5 Years	28	28%
6-10 Years	38	38%
11- 15 Years	14	14%
16-20 Years	5	5%
21 Years and Above	15	15%
Total	**100**	**100**

Table No. 3. Driving Experience Profile of the Drivers (n=100)

Table 3 presents the driving experience profile of the drivers who participated in the study. Most drivers have been on the road for 10 years or less, suggesting they have moved beyond the novice stage but are still developing long-term driving habits. The highest proportion falls under 6–10 years (38%), followed by 0–5 years (28%), making up 66% of the total. This level of experience may contribute to improved driving skills, decision-making, and familiarity with traffic signals. Studies show that increased driving experience enhances hazard perception and compliance with traffic control devices (Pradhan et al., 2017), and may also support openness to structured training and system improvements. On the other hand, drivers with 16–20 years (5%) and 21 years and above (15%) are less represented. While experienced drivers are present, the dominance of less and moderately experienced drivers highlights the need for clear and consistent traffic systems. This supports findings that drivers with limited to moderate experience are more prone to errors in complex situations, emphasizing the importance of visible and easy-to-understand traffic signals to reduce cognitive load and improve overall road safety ((Kato, 2025; FHWA, 2018).

Indicators	x̄	VD	EoE	SD
The traffic lights accurately control the flow of vehicles.	4.11	A	H	0.79
The traffic lights work correctly without sudden errors.	3.95	A	H	0.89
The traffic light system rarely causes confusion for drivers.	3.87	A	H	0.88
Pedestrian lights are synchronized correctly with vehicle signals.	3.84	A	H	0.79
The traffic light system operates without technical issues.	3.79	A	H	0.90
Composite	**3.91**	**A**	**H**	**0.59**

Table No. 4. Level of perceived effectiveness of the Traffic Signal System in terms of Accuracy (n=100)

Table 4 displays the perceived effectiveness of the traffic signal system in terms of accuracy, showing a generally high rating with a composite mean of 3.91 ("Agree"). This indicates that the system at Bantayan Intersection is largely effective in managing vehicle flow and maintaining reliability. The highest ratings are for accurate control of vehicle movement (x̄ = 4.11) and proper signal functioning without sudden errors (x̄ = 3.95), suggesting that the core technical functions are dependable. This aligns with studies highlighting that accurate signal timing reduces driver uncertainty and improves intersection efficiency (FHWA, 2023). Meanwhile, indicators such as reduced driver confusion (x̄ = 3.87), synchronization of pedestrian and vehicle signals (x̄ = 3.84), and overall problem-free operation (x̄ = 3.79) received moderate ratings. Although still positive, these results point to areas for improvement, particularly in minimizing hesitation and enhancing multi-modal coordination. This supports findings that inconsistent signal timing can increase cognitive load and delays, emphasizing the need for better synchronization and clearer signaling to improve overall accuracy and safety (Shinar, 2017; FHWA, 2023).

Indicators	x̄	VD	EoE	SD
The signal indicators are easy to understand.	4.35	SA	VH	0.67
The meaning of each signal light is clear.	4.14	A	H	0.70
The road markings are easy to interpret.	4.12	A	H	0.81
The lights are easy for new drivers to follow.	3.96	A	H	0.84
I trust the traffic lights to guide traffic properly.	3.91	A	H	0.98
Composite	**4.10**	**A**	**H**	**0.38**

Table No. 5. Level of perceived effectiveness of the Traffic Signal System in terms of Ease of Understanding (n=100)

Table 5 illustrates the perceived effectiveness of the traffic signal system in terms of ease of understanding, showing a high level of clarity with a composite mean of 4.10 ("Agree"). This indicates that the system effectively provides clear and actionable information to drivers. The highest rating is for the ease of understanding signal indicators (x̄ = 4.35, "Very High"), followed by clarity of signal meanings (x̄ = 4.14) and interpretability of road markings (x̄ = 4.12). These results suggest that the intersection's visual elements are highly intuitive.

This supports human factors principles that systems should require minimal cognitive effort to ensure safety and efficiency (Wickens et al., 2022). Additionally, ease for new drivers to follow the lights (x̄ = 3.96) and trust in the signals to guide traffic (x̄ = 3.91) also received high ratings. Although slightly lower, these still reflect strong performance, indicating that the system is reliable for a wide range of users, including less experienced drivers. This aligns with studies showing that clear visual design reduces errors and improves comprehension regardless of driving experience (Shinar, 2017; Wickens et al., 2022).

Indicators	x̄	VD	EoE	SD
I can easily recognize each light color (red, yellow, green).	4.47	SA	VH	0.64
The traffic lights are clearly visible at night.	4.38	SA	VH	0.65
The signal lights are visible during rainy conditions.	4.07	A	H	0.74
The placement of traffic lights allows early visibility.	4.07	A	H	0.71

The traffic lights are clearly visible during daytime.	3.91	A	H	0.84
Composite	**4.18**	**A**	**H**	**0.51**

Table No. 6. Level of perceived effectiveness of the Traffic Signal System in terms of Clarity and Visibility (n=100)

Table 6 presents the perceived effectiveness of the traffic signal system in terms of clarity and visibility, showing a high overall performance with a composite mean of 4.18 ("Agree"). This suggests that the signal hardware at Bantayan Intersection effectively meets the visual needs of motorists across different conditions. The highest ratings are for easy recognition of light colors ($\bar{x}$ = 4.47) and visibility at night ($\bar{x}$ = 4.38), both interpreted as "Very High," indicating strong luminous intensity and good color contrast for clear identification. This aligns with WHO (2023), which emphasizes that high-visibility traffic devices help reduce road crashes, especially at night. In addition, visibility during rainy conditions ($\bar{x}$ = 4.07), signal placement for early visibility ($\bar{x}$ = 4.07), and daytime visibility ($\bar{x}$ = 3.91) were also rated high. Although still positive, the slightly lower score for daytime visibility suggests possible effects of sunlight glare on signal perception. This supports literature stating that traffic signals must maintain consistent visibility under varying weather and lighting conditions to ensure reliable driver response (FHWA, 2018; WHO, 2023). Continuous monitoring of placement and brightness can further improve safety and consistency for all road users.

Indicators	$\bar{x}$	VD	EoE	SD
The lights help me move through the intersection efficiently.	4.28	SA	VH	0.65
I have enough time to react to the green, yellow, or red lights.	4.23	SA	VH	0.69
The yellow signal gives enough warning.	4.14	A	H	0.79
I rarely get confused about when to go or stop.	4.05	A	H	1.01
The signal timing allows smooth driving without sudden braking.	4.04	A	H	0.90
Composite	**4.15**	**A**	**H**	**0.58**

Table No. 7. Level of perceived effectiveness of the Traffic Signal System in terms of Speed of Interpretation (n=100)

Table 7 displays the perceived effectiveness of the traffic signal system in terms of speed of interpretation, showing a high overall rating with a composite mean of 4.15 ("Agree"). This suggests that the signal timing at Bantayan Intersection is well-calibrated to match drivers' cognitive response times, allowing for quick processing of information. The highest ratings are for efficient movement through the intersection ($\bar{x}$ = 4.28) and sufficient reaction time to signal changes ($\bar{x}$ = 4.23), both interpreted as "Very High." These indicate that drivers are given enough time to safely transition between stopping and proceeding. This is consistent with cognitive ergonomics research, which shows that familiar and standardized signals improve reaction speed and decision-making (Wickens et al., 2022). In addition, the adequacy of the yellow signal warning ($\bar{x}$ = 4.14), reduced confusion on stopping or going ($\bar{x}$ = 4.05), and smooth driving without sudden braking ($\bar{x}$ = 4.04) were also rated high. Although slightly lower, these still reflect effective performance. These results highlight the importance of proper signal timing in reducing "dilemma zone" situations where drivers are uncertain whether to stop or proceed. This aligns with the National Highway Traffic Safety Administration (2022), which notes that faster and clearer signal interpretation helps reduce collision risk and improve traffic efficiency. Maintaining these timing standards is especially important given the presence of younger drivers who may be more prone to risk-taking behaviors.

Indicators	$\bar{x}$	VD	EoE	SD
I feel safe passing through the intersection because of the lights.	4.40	SA	VH	0.67
I feel confident following the traffic lights.	4.25	SA	VH	0.88
The signal system promotes orderly movement.	4.19	A	H	0.76
I am aware of the traffic lights instructions.	4.18	A	H	0.86
I trust the traffic light to guide vehicles safely.	4.11	A	H	0.84
The traffic signals reduce hesitation while driving.	4.02	A	H	0.84
Composite	**4.19**	**A**	**H**	**0.64**

Table No. 8. Level of perceived effectiveness of the Traffic Signal System in terms of User's Confidence (n=100)

Table 8 shows the perceived effectiveness of the traffic signal system in terms of user confidence, showing a very high level of psychological security with a composite mean of 4.19 ("Agree"). This suggests that the system at Bantayan Intersection effectively fosters safety and predictability for motorists. The highest ratings are for drivers' sense of safety when passing the intersection ($\bar{x}$ = 4.40) and confidence in following traffic lights ($\bar{x}$ = 4.25), both interpreted as "Very High." This indicates that the system provides a reliable structure that reduces stress while navigating the intersection. Studies show that consistent and predictable traffic systems increase driver trust and compliance (OECD, 2021). Additionally, promotion of orderly movement ($\bar{x}$ = 4.19), trust in signals for safe guidance ($\bar{x}$ = 4.11), and reduced hesitation while driving ($\bar{x}$ = 4.02) also received high ratings. Although still positive, the slightly lower score for reduced hesitation suggests that traffic volume or environmental factors may still cause occasional uncertainty. This aligns with OECD (2021), which notes that driver confidence is strongly linked to perceived safety and adherence to traffic rules. Maintaining signal synchronization and visibility, as highlighted in earlier tables, is important for sustaining high user trust, especially among the predominantly younger driver population.

Indicators	**$\bar{x}$**	**VD**	**EoE**	**SD**
The signal system improves overall traffic organization.	4.31	SA	VH	0.75
Vehicles move smoothly through the intersection.	4.09	A	H	0.78
The waiting time at the intersection is reasonable.	3.98	A	H	0.78
Drivers can follow the lights easily, reducing confusion.	3.93	A	H	0.88
Vehicles can pass without unnecessary stopping.	3.76	A	H	0.90
Composite	**4.01**	**A**	**H**	**0.59**

Table No. 9. Level of perceived effectiveness of the Traffic Signal System in terms of Operational Performance (n=100)

Table 9 displays the perceived effectiveness of the traffic signal system in terms of operational performance, showing an overall high rating with a composite mean of 4.01 ("Agree"). This suggests that the signalization at Bantayan Intersection effectively supports orderly and efficient vehicular flow. The highest rating is for overall traffic organization ($\bar{x}$ = 4.31, "Very High"), followed by smooth vehicle movement through the intersection ($\bar{x}$ = 4.09). These results indicate that the system successfully creates a structured traffic environment that reduces chaotic flow. This aligns with traffic management studies showing that optimized signal timing improves intersection efficiency and reduces congestion (ITE, 2021). In addition, reasonable waiting times ($\bar{x}$ = 3.98), reduced driver confusion ($\bar{x}$ = 3.93), and minimized unnecessary stopping ($\bar{x}$ = 3.76) also received high ratings. Although still positive, the lower score for unnecessary stopping suggests possible delays or limited signal synchronization. This implies that further adjustments, such as real-time signal optimization, may help reduce idling and improve flow consistency. This supports findings that adaptive signal control systems enhance traffic efficiency by responding to changing traffic volumes throughout the day (ITE, 2021).

Indicators	**$\bar{x}$**	**VD**	**EoE**	**SD**
The traffic signal system improves road safety.	4.17	SA	VHE	0.89
The traffic lights reduce risky driving behavior.	4.09	A	HE	0.92
Pedestrians are safer because of the traffic signal.	4.01	A	HE	0.87
The risk of accidents is reduced.	4.00	A	HE	0.85
Drivers generally obey the traffic signals.	3.65	A	HE	1.18
Composite	**3.98**	**A**	**HE**	**0.59**

Table No. 10. Level of perceived effectiveness of the Traffic Signal System in terms of Safety Perception (n=100)

Table 10 presents the perceived effectiveness of the traffic signal system in terms of safety perception, showing a high overall rating with a composite mean of 3.98 ("Agree"). This suggests that the signalization at Bantayan Intersection is generally seen as an important tool for reducing risk and improving road safety. The highest rating is for overall improvement in road safety ($\bar{x}$ = 4.17, "Very High"), followed by reduction of risky driving behavior ($\bar{x}$ = 4.09). These results indicate that the system provides a clear structure that helps discourage unsafe driving practices. This aligns with Transportation Engineers (2021), which emphasizes that effective traffic control systems reduce road accidents and improve safety for drivers and pedestrians. In addition, improved pedestrian safety ($\bar{x}$ = 4.01), reduced accident risk ($\bar{x}$ = 4.00), and driver compliance ($\bar{x}$ = 3.65) also received positive ratings. Although still high, the lower score for driver obedience suggests that human behavior remains a key factor in safety outcomes. This supports the idea that while engineering controls improve safety, driver discipline is still essential in achieving consistent results (Transportation Engineers, 2021). This highlights the importance of continued education and training, especially for younger drivers who may be more prone to risk-taking but responsive to structured guidance.

Drivers' Profile	r_s	*p-value*	Decision	Remark
Age	0.121	0.232	Fail to Reject H_o	Not Significant
Educational Attainment	-0.018	0.858	Fail to Reject H_o	Not Significant
Driving Experience	0.053	0.600	Fail to Reject H_o	Not Significant

Table No. 11. Relationship Between Drivers' Profile and their Perceived Effectiveness of the Traffic Signal System in terms of Accuracy (LoS = 0.05; n=100)

Table 11 indicates the Spearman's rho correlation between drivers' profile and perceived effectiveness of the traffic signal system in terms of accuracy. The results show no significant relationships between demographic characteristics and perceptions of system accuracy, leading to the acceptance of the null hypothesis. This indicates that perceptions are consistent across different driver profiles. All variables yielded p-values above 0.05: age (rs = 0.121, p = 0.232), educational attainment (rs = -0.018, p = 0.858), and driving experience (rs = 0.053, p = 0.600). This suggests that regardless of age, education, or experience, drivers have a similar assessment of the system's accuracy. Overall, the findings show that the traffic signal system provides a uniform and reliable experience for all users at the Bantayan intersection. The absence of significant relationships also implies that the system effectively maintains consistent performance in regulating traffic flow and minimizing errors. This supports FHWA (2023), which emphasizes that well-designed traffic signals promote consistent user experiences and reduce perception differences among road users. Overall, the results highlight the importance of maintaining standardized and efficient signal operations to sustain reliability and public confidence.

Drivers' Profile	r_s	*p-value*	Decision	Remark
Age	-0.032	0.750	Fail to Reject H_o	Not Significant
Educational Attainment	0.008	0.940	Fail to Reject H_o	Not Significant
Driving Experience	-0.081	0.424	Fail to Reject H_o	Not Significant

Table No. 12. Relationship Between Drivers' Profile and their Perceived Effectiveness of the Traffic Signal System in terms of Ease of Understanding (LoS = 0.05; n=100)

Table 12 shows the Spearman's rho correlation between drivers' profile and perceived effectiveness of the traffic signal system in terms of ease of understanding. The results show no significant relationships between demographic characteristics and clarity of the signal system, leading to the acceptance of the null hypothesis. This indicates that ease of understanding is consistent across all driver groups. Meanwhile, all variables produced p-values above 0.05: age (rs = -0.032, p = 0.750), educational attainment (rs = 0.008, p = 0.940), and driving experience (rs = -0.081, p = 0.424). This suggests that age, education, and experience do not significantly affect how drivers interpret traffic signals. Regardless of background, respondents show a similar level of understanding. The lack of significant relationships implies that the system is designed with standardized and intuitive features that reduce cognitive effort and confusion. This supports Wickens et al. (2022), who state that systems designed with human cognitive abilities in mind promote universal understanding and minimize individual differences. Overall, the results highlight the effectiveness of the traffic signal system in providing clear and accessible guidance for all road users.

Drivers' Profile	r_s	*p-value*	Decision	Remark
Age	0.054	0.596	Fail to Reject H_o	Not Significant
Educational Attainment	0.013	0.899	Fail to Reject H_o	Not Significant
Driving Experience	-0.004	0.971	Fail to Reject H_o	Not Significant

Table No. 13. Relationship Between Drivers' Profile and their Perceived Effectiveness of the Traffic Signal System in terms of Clarity and Visibility (LoS = 0.05; n=100)

Table 13 displays the Spearman's rho correlation between drivers' profile and perceived effectiveness of the traffic signal system in terms of clarity and visibility. The results show no significant relationships between demographic characteristics and perceived physical clarity of the system, leading to the acceptance of the null hypothesis. This indicates that signal visibility is consistent across all driver profiles. Moreover, the p-values above 0.05: age (rs = 0.054, p = 0.596), educational attainment (rs = 0.013, p = 0.899), and driving experience (rs = -0.004, p = 0.971). This suggests that age, education, and experience do not significantly influence how motorists perceive signal visibility, including brightness at night and performance during rainy conditions. The absence of significant relationships implies that the traffic signal system follows standardized design principles that support quick recognition and interpretation. By ensuring clear and distinguishable visual elements, the system reduces misinterpretation and improves driver response time. This supports NHTSA (2022), which states that standardized traffic control devices enhance consistent understanding and faster reactions among drivers. Overall, the results show that the system maintains high visibility standards, contributing to safer and more efficient traffic flow for all road users.

Drivers' Profile	r_s	*p-value*	Decision	Remark
Age	-0.092	0.362	Fail to Reject H_o	Not Significant
Educational Attainment	0.130	0.197	Fail to Reject H_o	Not Significant
Driving Experience	-0.118	0.234	Fail to Reject H_o	Not Significant

Table No. 14. Relationship Between Drivers' Profile and their Perceived Effectiveness of the Traffic Signal System in terms of Speed of Interpretation (LoS = 0.05; n=100)

Table 14 demonstrate the Spearman's rho correlation between drivers' profile and perceived effectiveness of the traffic signal system in terms of speed of interpretation. The results show no significant relationships between demographic characteristics and interpretation speed, leading to the acceptance of the null hypothesis. This indicates that signal interpretation efficiency is consistent across all driver profiles. Meanwhile, the p-values above 0.05: age (rs = -0.092, p = 0.362), educational attainment (rs = 0.130, p = 0.197), and driving experience (rs = -0.118, p = 0.234). This suggests that drivers interpret traffic signals at a similar speed regardless of age, education, or experience. The absence of significant relationships implies that the system is standardized and cognitively efficient, enabling quick decision-making among all road users. By presenting information in a simple and familiar format, the system reduces confusion and allows prompt reactions. This supports Faturohman et al. (2025), which states that standardized traffic control devices improve reaction time and ensure consistent interpretation among drivers. Overall, the results show that the system effectively supports fast and uniform responses, contributing to smoother traffic flow and improved safety at the intersection.

Drivers' Profile	r_s	*p-value*	Decision	Remark
Age	0.047	0.641	Fail to Reject H_o	Not Significant
Educational Attainment	-0.046	0.652	Fail to Reject H_o	Not Significant
Driving Experience	0.006	0.955	Fail to Reject H_o	Not Significant

Table No. 15. Relationship Between Drivers' Profile and their Perceived Effectiveness of the Traffic Signal System in terms of Users' Confidence (LoS = 0.05; n=100)

Table 15 presents the Spearman's rho correlation between drivers' profile and perceived effectiveness of the traffic signal system in terms of user confidence. The results show no significant relationships between demographic characteristics and trust in the system, leading to the acceptance of the null hypothesis. This indicates that driver confidence is consistent across all respondents. Moreover, the p-values above 0.05: age (rs = 0.047, p = 0.641), educational attainment (rs = -0.046, p = 0.652), and driving experience (rs = 0.006, p = 0.955). This suggests that drivers share a similar level of confidence in the traffic signal system regardless of age, education, or experience. The lack of significant relationships implies that user confidence is mainly influenced by the system's performance rather than personal characteristics. When a system operates consistently and reliably, it builds trust among all users. This supports OECD (2021), which states that trust in road systems is driven more by consistency and reliability than by user-specific factors. Overall, the results show that the traffic signal system maintains a high level of confidence among all road users, contributing to safer and more organized traffic conditions.

Drivers' Profile	r_s	*p-value*	Decision	Remark
Age	0.078	0.438	Fail to Reject H_o	Not Significant
Educational Attainment	0.048	0.638	Fail to Reject H_o	Not Significant
Driving Experience	-0.010	0.920	Fail to Reject H_o	Not Significant

Table No. 16. Relationship Between Drivers' Profile and their Perceived Effectiveness of the Traffic Signal System in terms of Operational Performance (LoS = 0.05; n=100*)*

Table 16 shows the Spearman's rho correlation between drivers' profile and perceived effectiveness of the traffic signal system in terms of operational performance. The results show no significant relationships between demographic characteristics and perceptions of operational efficiency, leading to the acceptance of the null hypothesis. This indicates that views on how well the system manages traffic flow are consistent across all drivers. Meanwhile, p-values yielded above 0.05: age (rs = 0.078, p = 0.438), educational attainment (rs = 0.048, p = 0.638), and driving experience (rs = -0.010, p =

0.920). This suggests that drivers similarly perceive the system's ability to reduce delays and organize vehicle movement regardless of their profile. The absence of significant relationships implies that the system provides a uniform level of operational performance for all users, making it an objective rather than subjective experience. This supports ITE (2021), which emphasizes that effective traffic signal systems are designed to optimize traffic flow equitably for all road users. Overall, the results show that the infrastructure maintains consistent and reliable operational performance, contributing to a more organized and efficient traffic environment at the intersection.

Drivers' Profile	r_s	***p-value***	**Decision**	**Remark**
Age	0.057	0.572	Fail to Reject H_o	Not Significant
Educational Attainment	-0.059	0.560	Fail to Reject H_o	Not Significant
Driving Experience	0.003	0.976	Fail to Reject H_o	Not Significant

Table No. 17. Relationship Between Drivers' Profile and their Perceived Effectiveness of the Traffic Signal System in terms of Safety Perception (LoS = 0.05; n=100)

Table 17 displays the Spearman's rho correlation between drivers' demographic profile and perceived effectiveness of the traffic signal system in terms of safety perception. The results show no significant relationships between demographic variables and safety perception, leading to the acceptance of the null hypothesis. This indicates that drivers' views on road safety are not influenced by age, education, or driving experience. Moreover, the p-values obtained above 0.05: age (rs = 0.057, p = 0.572), educational attainment (rs = -0.059, p = 0.560), and driving experience (rs = 0.003, p = 0.976). This suggests that all drivers, regardless of profile, similarly perceive the traffic signal system as effective in enhancing safety at the Bantayan Intersection. The consistency in results reflects the system's reliability and aligns with World Bank (2022), which notes that well-implemented traffic control systems are generally perceived similarly across diverse user groups. Overall, the findings confirm that the traffic signal system provides a universally recognized framework for promoting road safety through consistent and clear operational performance.

Conclusion and Recommendations

The traffic light system at the Bantayan Intersection in Dumaguete City is a highly effective mechanism for regulating urban mobility, demonstrating a strong alignment with both Traffic Flow Theory and the Technology Acceptance Model (TAM). The study confirms that the system successfully provides clear visual guidance and fosters a high level of psychological security among drivers, with usability and user confidence emerging as its strongest performance areas. Crucially, the research validates that the perceived effectiveness of the system is universal across the driving population; demographic factors such as age, educational attainment, and years of driving experience do not significantly influence how a driver perceives the system's accuracy, usability, safety, and operational performance. This uniformity in perception indicates that the system's design is intuitive enough to transcend individual backgrounds, supporting the theory that well-implemented traffic infrastructure can achieve consistent compliance and trust across diverse user groups. A new finding obtained from this study is the identified "effectiveness gap," where, despite high quantitative ratings (mean = 4.02), the system has yet to reach a "very highly effective" status due to minor operational concerns in signal timing and clarity.

Based on the findings and conclusions drawn, the following are hereby recommended to the local government, traffic authorities, and the academic community:

Local Government and Traffic Management Authorities:

1. Optimize the traffic light signal timings during peak hours to further reduce congestion and improve the overall flow of vehicles at the intersection.
2. Conduct regular maintenance checks and technical audits of the signal system to ensure that all hardware and software components remain fully functional and error-free.
3. Implement enhanced road safety signage and clear pavement markings to complement the traffic light system, ensuring road users can navigate the intersection safely.
4. Strategize a long-term infrastructure plan that incorporates smart traffic sensors or adaptive signal control technology to respond to real-time traffic volume.

Road Users and Drivers:

5. Observe strict adherence to the traffic signals and road safety protocols to maximize the efficiency and safety of the newly improved system.
6. Participate in local community feedback sessions or surveys conducted by the city to provide real-time data on the road experience and any emerging issues at the intersection.

School of Industrial Engineering and Technology (SIET):

7. Utilize the findings of this study as a foundational resource for future Industrial Engineering students researching process optimization and public system efficiency.

Encourage the application of industrial engineering principles, such as facilities planning and operations research, to solve other critical municipal infrastructure challenges.

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Competing Interests Statement

The authors declare that there are no competing financial or personal interests that could have influenced the conduct or outcomes of this study.

Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request, subject to applicable data privacy and ethical considerations.

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Appendices

No appendices are attached to this study.