User Interaction and Perceived Effectiveness of S-VoCTF for Traffic Volume Count Studies

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Abstract. Traffic volume count studies play a critical role in urban planning, transportation infrastructure development, and traffic management. While traditionally centered on quantitative data, the influence of user interaction ranging from data collection to result application remains underexplored. This research introduces the Smart Volume Counter Of Traffic Flow (S-VoCTF), an innovative tool designed to enhance student learning and field data collection, particularly in the Highway & Traffic Engineering course. S-VoCTF facilitates the assessment of traffic flow and intersection performance using Passenger Car Unit (PCU) data.The study investigates how stakeholders such as city planners, engineers, and civil engineering students interact with S-VoCTF and how these interactions affect the perceived effectiveness of traffic volume studies. Using a mixed-methods approach, including surveys, interviews, and case studies, the research identifies key factors influencing user trust, data usability, and the integration of findings into real-world decision making. Findings reveal that 92% of respondents view S-VoCTF as innovative, effective, and well-designed for field application. Moreover, 91% found it user-friendly, intuitive, market-relevant, and cost-effective. Additionally, 90% acknowledged its positive impact on users, while 89% agreed it aligns with user and industry needs in terms of value and cost. The study concludes that transparency in methodology, real-time data access, and effective visualization significantly enhance the credibility and utility of traffic volume data. Recommendations are provided to improve user engagement and maximize the influence of such technologies on urban mobility and infrastructure planning.

Keywords: volume study, level of service, passenger car unit, traffic study

INTRODUCTION

Traffic studies involve complex investigations and detailed analyses within a specific area's transportation system. This method is supported by extensive data collection aimed at determining the number, movement patterns, and classification of road vehicles at designated locations, with the goal of estimating CO_2 emission rates. In Malaysia, traffic studies are typically conducted by government agencies, particularly the Road Planning Unit (UPJ) under the Public Works Department (JKR), or by consulting engineers appointed by JKR.

Traditionally, vehicle volume analysts relied on manual methods, which required the use of traffic volume count forms. Although traffic detection systems using cameras are now available in the market, these typically involve the use of costly specialized equipment. To address this, the innovative Smart Volume Counter of Traffic Flow (S- VoCTF) has been developed, incorporating two integrated innovations: the Electronic Vehicle Count (E-VeC), which utilizes mobile applications such as smartphones, and the Digital Vehicle Count (D-VeC), a digital device. This tool is designed to assist Civil Engineering students or Technical Department personnel in efficiently counting vehicles based on direction and type whether at intersections or on straight roads to determine traffic flow volumes.

Problem Statement

The current methods of traffic counting face significant challenges that hinder their effectiveness in transportation planning and management. Traditional manual counting methods are prone to errors, while automated systems may suffer from reliability issues and limited coverage. According to Gonzalez et al. (2019), traffic congestion remains a critical issue that must be addressed, as it leads to time delays, energy waste, environmental pollution, stress, and ultimately reduces societal productivity. Therefore, analyzing traffic volume is essential to identify the level of congestion before implementing measures to resolve these challenges.

This innovation also aims to address a key problem faced by Polytechnic students enrolled in Highway and Traffic Engineering courses, who still rely on outdated manual methods to count vehicles. Manual techniques are increasingly obsolete in the context of today's rapid technological advancements. Furthermore, data collected manually cannot be stored in digital databases for future analysis. If such data is lost, there will be no reference for the traffic volume previously recorded.

This innovative product offers a solution by enabling automated traffic flow volume calculations. It transfers data electronically and stores it in an online database system, significantly enhancing efficiency and ensuring data reliability for future research and planning.

1.0 Objectives of Study

The objectives of this study are as follows:

i) To evaluate the user interaction and perceived effectiveness of the mobile application tools, Electronic Vehicle Count (E-VeC) and Digital Vehicle Count (D-VeC for Traffic Volume Count Studies.

ii) To determine traffic flow volume and intersection performance levels based on data measured in Passenger Car Units (PCU).

LITERATURE REVIEWS

Traffic Survey

A traffic survey involves systematically recording the movement of vehicles or pedestrians at various distinct locations such as roads, intersections, or pathways over a set period. This can be done manually or with the help of automated systems (Salisu et al., 2020). Such surveys are essential for capturing real-time traffic dynamics, including the volume, flow patterns, timing, and categorization of movement. The collected data plays a vital role in the planning and management of road transportation systems.

Concept of Traffic Volumes & Classification

Traffic volume surveys aim to gather information regarding the quantity and categories of vehicles that pass a specific location whether along a road segment, route, or intersection during a defined time frame. According to Salisu et al. (2020), traffic flow is typically quantified as the number of vehicles moving past a point within an hour (vehicles/hour) or across an entire day (vehicles/day). These figures, when recorded over a twelve-month period, are commonly used to calculate metrics such as Average Daily Traffic (ADT) and Annual Average Daily Traffic (AADT).

a) Manual Traffic Count

Manual traffic counting involves a person known as a surveyor standing by the roadside, counting and identifying vehicles according to their types as they pass during set time periods. This method is usually used when only a small amount of data is needed or when automated equipment is too costly or not available. Surveyors can record the counts using tally sheets, mechanical clickers, or electronic counters.

b) Automatic Traffic Count

The automatic traffic count method helps to collect a large amount of traffic data without needing people to monitor it manually. It usually records data every hour throughout the day and can be used over longer periods using tools such as portable counters, permanent counters, or video recordings. According to Kand et al. (2021), past research on automatic traffic counting generally falls into three main types: those that use sensors, those that analyse images, and those that use deep learning (AI-based) methods. In one study, Kamkar & Safabakhsh (2016) used image analysis to recognize vehicles by breaking them into parts and looking at features like shape, texture, colour, and surface area.

Intersection Volume Count

The intersection volume count involves calculating the number of vehicles using the intersection from all approaching roads as follows:

1. Counting the number of vehicles for each direction of movement.
2. Counting the number of vehicles within a specific time period.
3. Classifying the types of vehicles and converting them to passenger car unit (PCU).

TABLE 1. Shows the Passenger Car Unit (PCU) values used for the purpose of volume calculation at intersections or roundabouts.

TABLE 1. Passenger Car Unit (PCU) Equivalency Values

Vehicle Type	**Type Of Vehicle Equivalency in P.C.U**			
	Rural Areas	**Urban Areas**	**Roundabout**	**Traffic signal**
Car	1.00	1.0	1.00	1.00
Motorcycle	1.00	0.75	0.75	0.33
Light Vehicle (Van)	2.00	2.00	2.00	2.00
Medium Truck	2.50	2.50	2.50	1.75
Heavy Vehicle (Truck)	3.00	3.00	2.80	2.25
Bus	3.00	3.00	2.80	2.25

Source: Road Engineering Guidelines ATJ 11/87

The literature review encompasses three studies highlighting the critical role of traffic volume research, intelligent transportation systems (ITS), and computer vision in enhancing traffic management and urban planning. Nishant Singh et al. (2021) emphasize the importance of understanding peak flow periods and addressing challenges in heterogeneous traffic flows through the introduction of the Passenger Car Unit (PCU). Dinh et al. (2021) underscore the significance of ITS in smart city development, particularly in public transport planning and management, advocating for AI-based traffic counting systems using edge computing to improve traffic efficiency. Lastly, Tituana et al (2022) survey on vehicle counting using computer vision stresses the necessity of accurate data, especially traffic density, for effective road planning and management within cities, highlighting its role in preserving transit capacity and enhancing road safety and reliability.

METHODOLOGY

To develop the digital device and application software, the initial stage involved creating a 3D model and design layout to conceptualize the structure and functionality of the product. The effectiveness of this innovation was further enhanced through the integration of an electronic database system. **FIGURE 1.** and **FIGURE 2.** illustrates the detailed planning and implementation methodology of the project.

The developed product focuses on calculating traffic volume and classifying vehicle types. Subsequently, field data collection is conducted, and the information obtained is stored and processed digitally using a computer system, enabling the generation and printing of reports. The resulting graphs allow for clearer data analysis, making it easier to interpret traffic flow patterns, particularly during peak hours. Additionally, the data reveals the most frequently occurring vehicle types at the intersection, allowing for more informed evaluations.

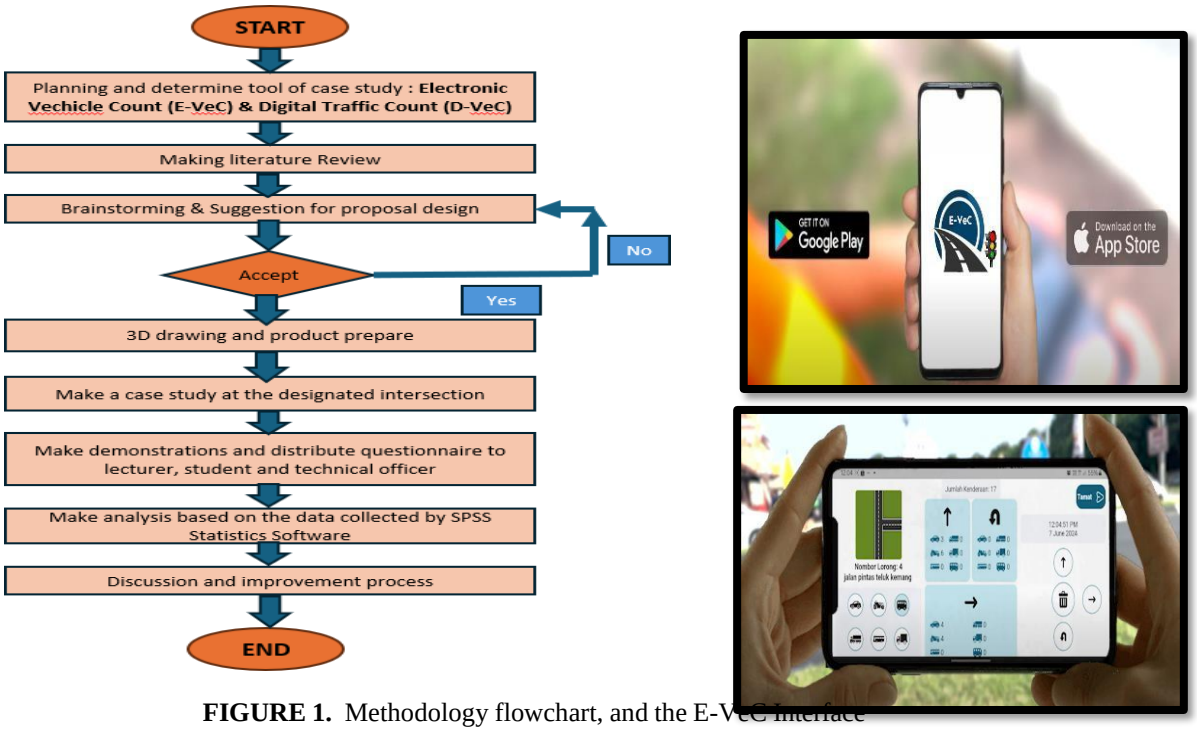

FIGURE 1. Methodology flowchart, and the E-VeC Interface

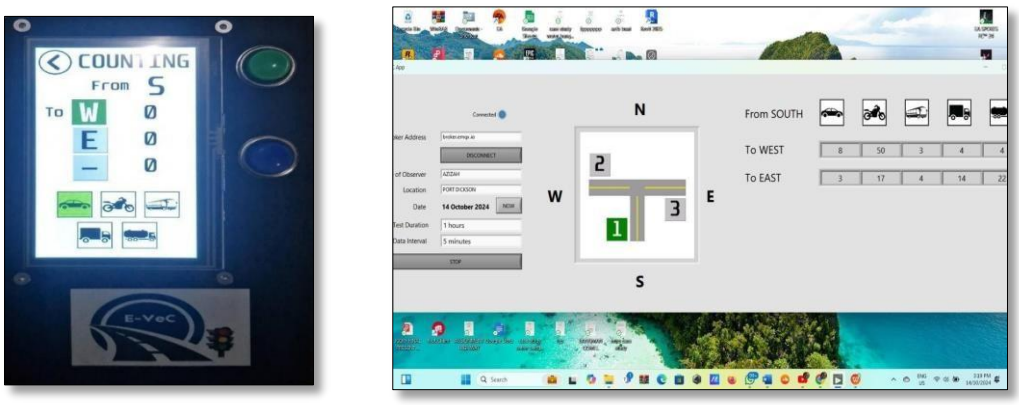

FIGURE 2. Digital device D-Vec

This study uses a quantitative research design, with a questionnaire as the primary tool for data collection. The questionnaire was designed to evaluate user interaction and the perceived effectiveness of the S-VoCTF system in supporting students during fieldwork and data observation sessions. The respondents included Semester 3 students from the Highway and Traffic Engineering course at Politeknik Port Dickson, as well as lecturers from the Civil Engineering Department who were able and willing to complete the survey. The questionnaire was distributed using Google Forms via email, WhatsApp group messages, and QR codes.

A preliminary study was carried out to evaluate the questionnaire's clarity, consistency, and validity prior to its full- scale implementation. The data survey was analyse by SPSS to get the mean and percentage of respondent feedback. **TABLE 3. S**hows the Reliability Statistics, Cronbach's Alpha is 0.959.

RESULT AND DISCUSSION

The User Interaction and Perceived Effectiveness of E-Vec And D-Vec for Traffic Volume Count

The implementation of teaching and learning (T&L) using the mobile application (E-VeC) and digital device (D-VeC) has significantly simplified the process for students to efficiently count vehicles entering and exiting intersections or traveling on straight roads without the need for manual tools such as pen and paper. This innovation allows data to be processed accurately, minimizing the risk of counting errors made by students.

To evaluate the effectiveness of this innovation, demonstration sessions were conducted alongside the distribution of questionnaires. The survey findings and respondents' feedback were analyzed to assess how well the mobile application and digital device enhanced the T&L experience, as well as their overall impact on the Highway & Traffic Engineering course.

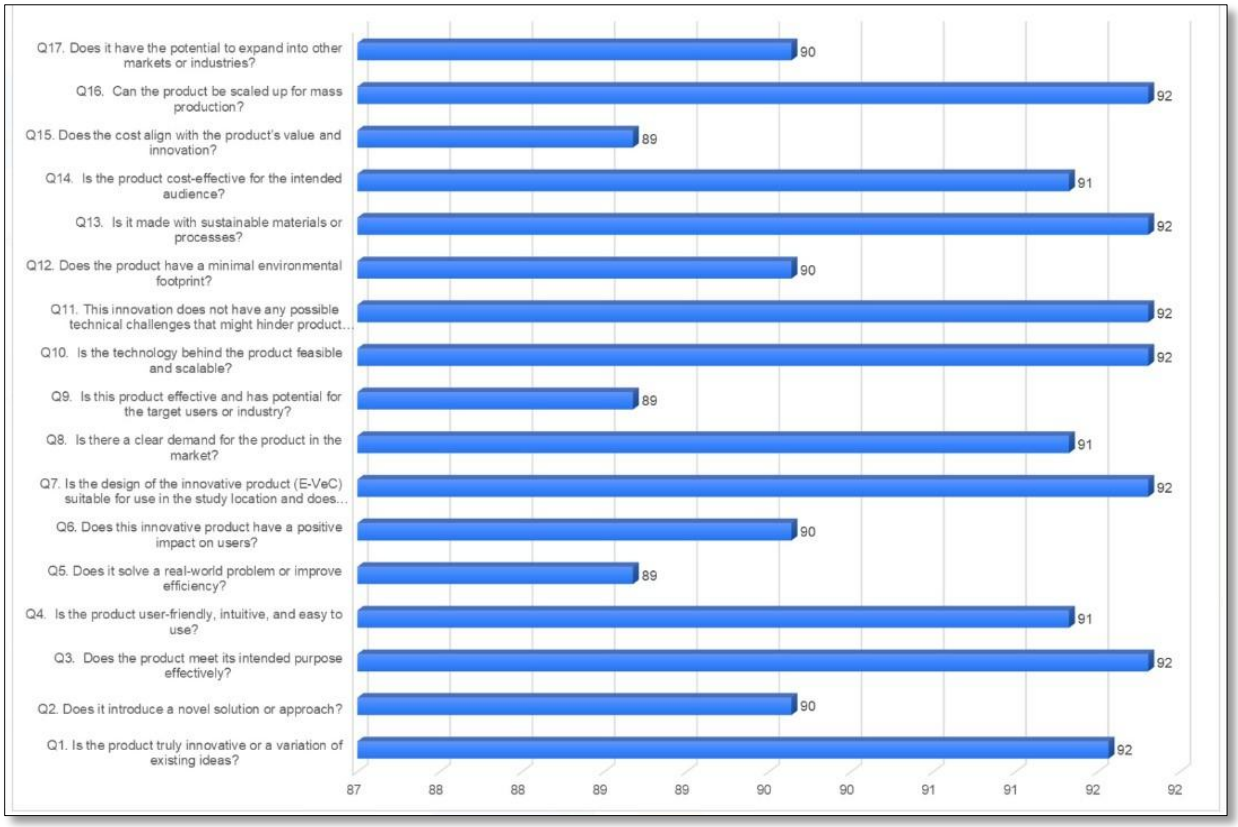

FIGURE 3. Mean score % of respondents' feedback

TABLE 2. SPSS Analysis for respondents' feedback

Item Statistics	Mean	%	Std. Deviation	N
truly innovative	4.58	92	.665	83
introduce a novel solution	4.48	90	.612	83
meet its intended purpose	4.59	92	.585	83
user-friendly, intuitive, and easy to use	4.57	91	.648	83
solve a real-world problem or improve efficiency	4.43	89	.666	83
have a positive impact on users	4.48	90	.625	83
suitable for use and meet the study criteria	4.59	92	.583	83
clear demand for the product in the market	4.57	91	.669	83
effective and has potential for the target users or industry	4.43	89	.648	83
feasible and scalable	4.59	92	.631	83
not have any possible technical challenges	4.59	92	.715	83
have a minimal environmental footprint	4.48	90	.612	83
made with sustainable materials	4.59	92	.650	83
cost-effective for the intended audience	4.57	91	.628	83
cost align with the product's value	4.43	89	.588	83
scaled up for mass production	4.59	92	.687	83
potential to expand into other markets	4.48	90	.612	83

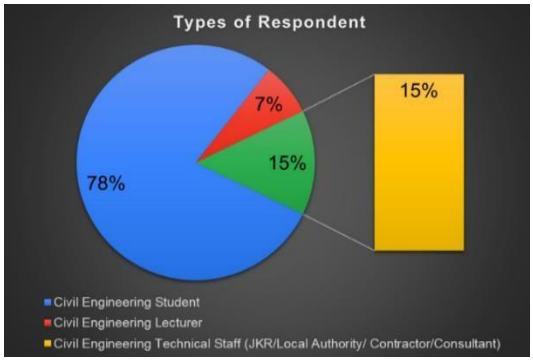

FIGURE 4. Types of respondent

TABLE 3. Reliability Statistics

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.959	.959	17

Based on the analysis, as illustrated in **FIGURE 3**., **FIGURE 4.** and summarized in **TABLE 2.** and **TABLE 3**.:

- 92% of respondents agreed that the E-VeC is highly innovative, effectively meets its intended purpose, and features a design suitable for use in real field locations.
- 91% agreed that the product is user-friendly, intuitive, easy to operate, clearly in demand within the market, and cost-effective.
- 90% of respondents felt that it delivers a positive impact for users.
- 89% agreed that the product has strong market potential for both individual users and industry, and that the cost is appropriate in relation to its value.

Traffic Flow Volume and Intersection Performance Levels Based on Data Measured in PCU

The use of the mobile application (E-VeC) and digital device (D-VeC) in the field has successfully generated

Passenger Car Unit (PCU) data based on peak-hour traffic volume observations at the Jalan Dataran Pahlawan intersection in Port Dickson.

From **FIGURE 5.** and **FIGURE 6.,** it was found that cars recorded the highest PCU values on both weekdays and weekends, followed by motorcycles. This innovation also has the capability to produce printed outputs (hard copies) in the form of tables, forms, reports, or digital formats, containing vehicle count data and PCU information. These features assist students in preparing experiment reports for the Highway & Traffic Engineering course. Moreover, peak traffic flow patterns can be clearly identified, and students are able to interpret the most frequently occurring vehicle types passing through the intersection.

0	Car	motocycle	Van	Heavy Lorry	Small Lorry	Bus
PCU (MORNING)	1952	159.06	17.5	33.75	8.75	**4.5**
PCU (AFTRENOON)	1694	103.62	12.25	20.25	15.75	**0**
PCU (EVERNING)	**2046**	**149.16**	**24.5**	**38.25**	**24.5**	**0**

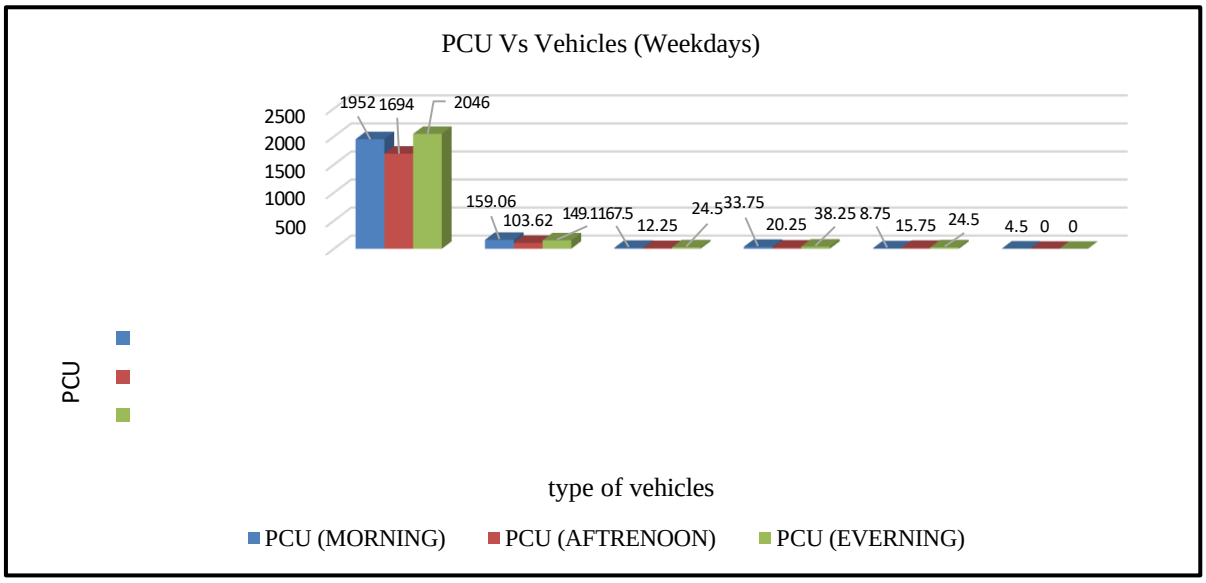

FIGURE 5. Graph PCU Vs Vehicles (Weekdays)

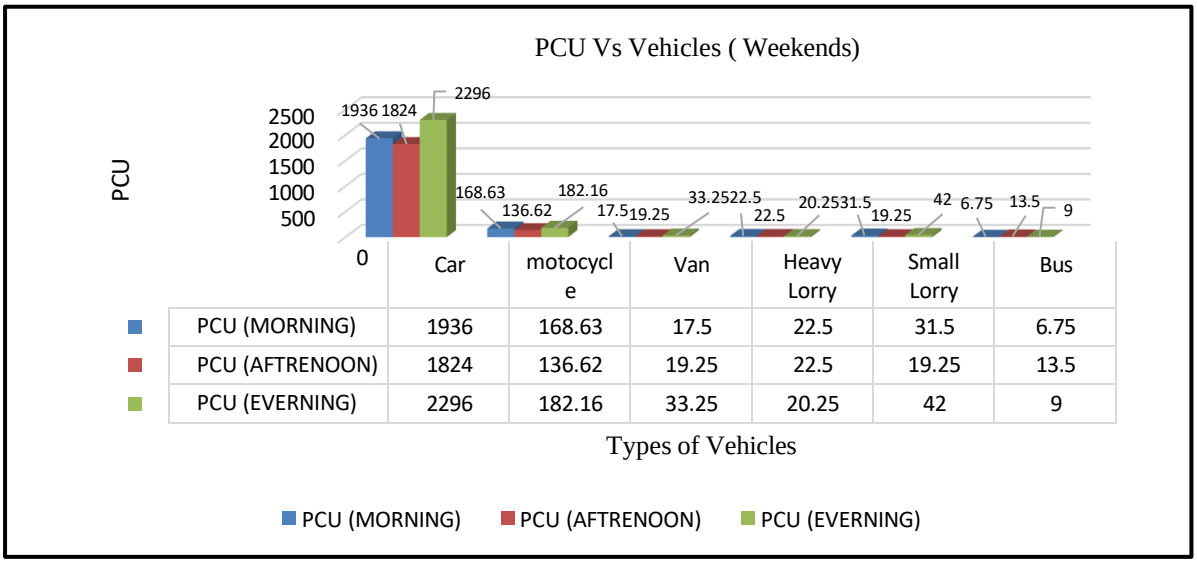

FIGURE 6. Graph PCU Vs Vehicles (Weekends)

Traffic counting is important because the data collected can be used for various purposes, such as designing road rehabilitation projects, conducting traffic studies at intersections, planning traffic control systems, forecasting traffic volumes, analysing traffic accidents, and carrying out cost-benefit analyses for highway projects.

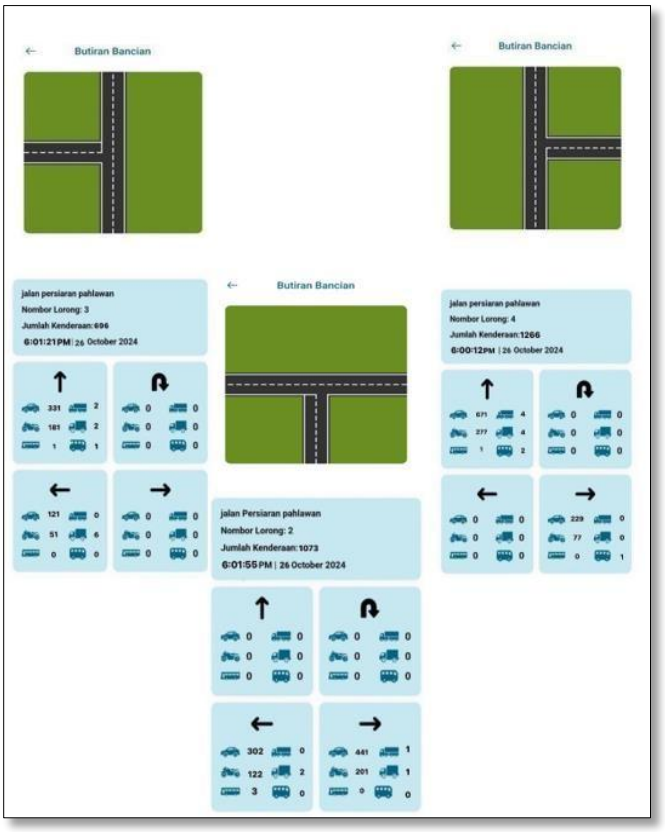

FIGURE 7. A Sample of Vehicles Recorded During an Evening Counting Session

CONCLUSION & RECOMMENDATION

In conclusion, this innovation has received positive feedback and demonstrates strong potential for commercialization and marketability, both within institutions of higher education and technical departments. Additionally, the product has proven to enhance employability outcomes when compared to traditional manual methods. However, several improvements are recommended to further optimize its efficiency and functionality in the future, including:

i. Enhance the system's capability for real-time, simultaneous online data collection before data is printed or stored.
ii. Upgrade the system by integrating solar-powered devices for conducting on-site traffic volume counts.

It is hoped that the findings and insights from this research will serve as a valuable reference for future studies aimed at developing a more functional and cost-effective S-VoCTF system.

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