SMART ZEBRA CROSS

Aneziatun Aqmal Puteh Ahmad[1], Rusatika Abdullah[1]

[1]Politeknik Ungku Omar
anezaqmal@gmail.com
rusatikq@gmail.com

ABSTRACT

The problem faced by pedestrians in using the existing zebra crossing can be summarized in three main issues which are poor marking and signage, carelessness of road users and less sensitivity to the signals given and also the lack of confidence to use zebra crossing during night time. The performance of smart zebra crossing occupied with the motion sensor and LED light using the Arduino Uno approach was presented in the study. This study was focused on the existing zebra crossing on the main road of Politeknik Ungku Omar (PUO) and Sekolah Menengah Kebangsaan Raja Chulan Ipoh. The objectives of the study are to identify problems that pedestrian has regarding the existing zebra crossing, to design a modern, user-friendly and build a prototype of the new zebra crossing and also to identify the satisfactions of road user regarding the new design of zebra cross. A modern and user-friendly smart zebra cross has been built by using AutoCAD 3D software and has been realized through the prototype model making. The overall prototype model design meets the objectives which were using the Arduino technology and a user-friendly by using the sensor to detect the movement which is easier to use for all stages of age. The level of product satisfaction and effectiveness were determined by questionnaire and functionality testing and have been analysed using SPSS software packages. Based on the respondents, there are 100% agreed that the smart zebra crossing more effective compared to the existing zebra cross located in the main road of Politeknik Ungku Omar. This study was intended in contributing to mitigate accidents among students and reducing the congestion especially during peak hours such as 8.00 am and 5.00 pm.

Keywords: Arduino Uno, zebra crossing

1. Introduction

Everyone can be categorized as pedestrians. A pedestrian is a person traveling on foot, whether walking or running. In some communities, those traveling using tiny wheels such as roller skates, skateboards, and scooters, as well as wheelchair users are also included as pedestrians. In the urban context, pedestrians are one of the most important elements that leverage urban activities by fulfilling the inner space of cities for various purposes such as work, business, shopping, sightseeing and so on.
Pedestrians not only rely solely on the routes provided. Pedestrian movement is unlimited and difficult to control. Each pedestrian has different levels and abilities. This depends on the person's physical factors, including gender, age, and endurance respectively. The type of pedestrian crossing that used all over the world is zebra crossing. The efficiency of zebra crossing affecting the road traffic smooth in avoiding the undesirable events occurs in the carriageway.

Therefore, the provision of pedestrian facilities is important as one of the measures to improve and create social interactions among the community as well as to control the quality of the environment. In addition, it also helps in generating and stimulating economic activities of a city. This is because the city is a centre of attention. Hence, the city that can attract visitors is a rapidly developing city.

The Malaysian Institute of Road Safety Research (MIROS) was established in 2007 as an agency under the Ministry of Transport Malaysia to serve as a central repository of knowledge and information on road safety. The findings derived from research and evidence-based intervention programs provide the basis for the formulation of new strategies, legislation, policies, and enforcement measures, governing road safety at the national level. Principally engaged in research, MIROS collaborates closely with local and international government agencies and private bodies to further the cause of road safety.

For instance, the 20th ASEAN Transport Ministers Meeting (ATM) on 27 November 2014 in Mandalay, Myanmar welcomed the appointment of the Malaysian Institute of Road Safety Research (MIROS) as the ASEAN Road Safety Centre (ARSC). The roles of this centre are to help and guide the ASEAN countries to reach a higher level of road safety performance on road safety issues which includes road traffic laws and regulations, data management, standards development, road safety awareness and education programs and also to evaluate and validate road safety performance for member countries, combine and harmonize regional comparisons so as to represent regional road safety condition

MIROS has conducted an observation on pedestrians and drivers' behaviour at the signalized and un-signalized zebra crossings. Findings from the observation found that around 74% of the drivers do not give way to pedestrians at zebra crossings especially at un-signalized junctions. For signalized junctions, only 8.2% of them disobeyed the traffic rules (run red light) at the zebra crossing. Meanwhile, 95.4% of pedestrians used the crosswalk in a proper way at un-signalized junctions and 83.1% at signalized junctions. The MIROS chairman, Tan Sri Lee Lam Thye has identified a need to equip zebra crossings with traffic signals in order to ensure that approaching vehicles to stop for pedestrians crossing the road. Summonses or a demerit points system was recommended to be implemented to the drivers who have not given the right of way to pedestrians at crossings (The Sun Daily, 2018).

According to Road Transport Act 1987, duty of pedestrians to comply with traffic directions subjected to a police officer in uniform or a traffic warden in uniform is for the time being engaged in regulating vehicular traffic on a road, any pedestrian who proceeds across or along the carriageway in contravention of a direction to stop given by the officer in the execution of his duty, either to pedestrians or to pedestrians and other traffic, shall be guilty of an offence and shall on conviction be liable to a fine not exceeding five hundred ringgit in accordance to Part III Section 75.

2. Literature Review

Over a million people worldwide died each year due to road traffic injuries and more than 10 million sustain permanent disabilities. Many of these victims are pedestrians. The present retrospective study by Pfortmueller et.al. (2014) were analyses the severity and mortality of injuries suffered by adult pedestrians, depending on whether they used a zebra crosswalk. The study showed that the accidents on zebra crosswalks are more common than those not on zebra crosswalks. The injury severity of non-zebra crosswalk accidents is significantly higher than in patients with zebra crosswalk accidents. Accidents involving large vehicles are associated with increased risk of severe injury. Further prospective studies are needed, with a detailed assessment of motor vehicle types and speed.

As the number of the pedestrian accident is increasing, this problem needs to be addressed urgently. One of the main reasons that attributed to the high number of pedestrian accidents is due to a careless crossing. This may be due to insufficient time to cross safely, crossing speed or other unexpected factors. To tackle this problem, one of the alternatives is to consider zebra crossing speed in roadway design and operation. According to Goh et al (2012), crosswalk type, age, and gender significantly contribute to pedestrian speed in Malaysia. Pedestrian at the non-signalised crosswalk has significantly faster-crossing speed than at a signalized crosswalk.

According to research reported by MIROS, the pedestrian can be categorized into two (2); pedestrians who will wait at the roadside before crossing; and the pedestrian who will immediately cross the intersection after arrived at the roadside. However, through the observations made, both of these situations involve pedestrians that comply and also failed to comply with pedestrian signals. Supposedly, the pedestrian has to wait for the green-man phase before crossing and that green-man phase is related to traffic signal cycle length. However, the results show that most of the pedestrian did not follow the pedestrian signals. Therefore, it can be concluded that the traffic situation is one of the factors that influence the behaviour of pedestrians before deciding to cross. Long waiting times at signalized intersections will cause pedestrians to be impatient and tend to violate pedestrian signals.

Furthermore, road traffic crashes result from a combination of factors related to the road layout, the vehicles, the road users and the way they interact. The main causes of pedestrian fatalities and the safety effects of road measures (traffic lights, roundabouts and refuge islands) at pedestrian crossings before and after implementation were investigated. The results indicate that there is strong evidence for the positive effect of these measures especially on the number of pedestrian-related accidents. Advanced safety measures involving vehicles, infrastructure, and its environment, protective systems, training and development of behavioural knowledge are the main tools to reduce the number and severity of accidents involving vulnerable road users (Mako and Szakonyi, 2016).

Aqbal Hafeez et.al. (2010) investigates traffic accidents involving elderly pedestrians aged 66-70 contributed the highest number of deaths than any other age group. The majority of types of injuries sustained by pedestrians were at head/face and legs/hips. The highest pedestrian deaths and killed and seriously injured (KSI) casualties had occurred at night between 8 pm and 9 pm. Seventy percent of pedestrian casualties were attributed to unsafe behaviour such as careless and illegal crossing. A fatal outcome of the pedestrian was more likely on a single collision event with either HGV or bus. Pedestrian-motorcycle accident is a significant concern in the country considering the motorcycle population on Malaysian roads which attributed to more than 50% of all traffic distributions. The findings provide useful information for interventions and safety control measures to prevent and reduce pedestrian casualties in road accidents. Further in-depth and focused research pertaining to pedestrian safety should be carried out to better understanding the situation.

Additionally, pedestrian crashes are a critical problem in Latin American countries. A study has been published by Poo, Ledesma, and Trujilla (2018) about pedestrians and even less about their behaviours in a naturalistic context. A high proportion of risky behaviours were observed among pedestrians. The majority of pedestrian waited in the street (as opposed to on the sidewalk) before crossing, did not comply with traffic lights, or crossed outside the crosswalk. A large number of pedestrians were distracted while crossing. Men presented higher scores on risky behaviours than women.

Based on the study done by Basile, Persia, and Usami (2010), the safety level of a pedestrian crossing is affected by infrastructure characteristics and vehicular and pedestrian traffic levels. A summary of results has been developed and analysis with the proposed methodology highlighted some common issues present at the European level such as the absence of pedestrian refuge islands, improper traffic light timing, car parking blocking visibility and frequent accessibility problems due to obstacles on the pedestrian crossing.

Figliozzi and Tipagornwong (2016) stated that since pedestrians are the most vulnerable road users, safe and comfortable crosswalks are essential to ensure that pedestrian travel becomes an appealing alternative. The results of the research provided new insights into the relationships between traffic conditions, vehicle trajectory, and compliance rates. Results indicate that vehicle origin, vehicle type, stopping at upstream traffic lights, and changes in vehicle speed and headways are key factors to predict pedestrian crosswalk law compliance and stopping the behaviour; changes in vehicle speed and headways have the highest explanatory power.

A shared zone is an implementation of a living street in Australia and New Zealand, where pedestrians, cyclists and motorized traffic share the same road space. Shared zones are characterized by an absence of traditional markers that segregate the road and footpath. Negotiation of a shared zone relies on an individual's ability to perceive, assess and respond to environmental cues according to Earl et.al (2018). This ability may be impacted by impairments in cognitive processing, which may lead to individuals experiencing increased anxiety when negotiating a shared zone. Overall, participants in the study would not avoid shared zones. Pedestrians with intellectual disabilities were, however, not well represented by either viewpoint, suggesting that shared zones may pose a potential barrier to participation for this group.

3. Methodology

The study was carried out in PUO in order to upgrade the existing zebra crossing at the main road. The location was selected due to its rapid population corresponding pedestrian activities and high capacity of the pedestrian crossing of Sekolah Menengah Kebangsaan Raja Chulan Ipoh and PUO residential college especially during peak hour at 8.00 am and 5.00 pm. The existing zebra crossing is categorized as a signalized crosswalk.

3.1 Research flow

The objectives of the study were achieved by several work procedures. It also discussed what are the materials used, the function of each component, method on how to build a prototype in order to evaluate this study. The methodology was based on four stages which are preliminary study, data collection, and data analysis and results and also discussion and conclusion. Prototype testing was done for the satisfaction level and effectiveness of the prototype. Figure 1 shows the research flow which consists of four stages from the preliminary to the final stage in determining the conclusions and findings of this study.

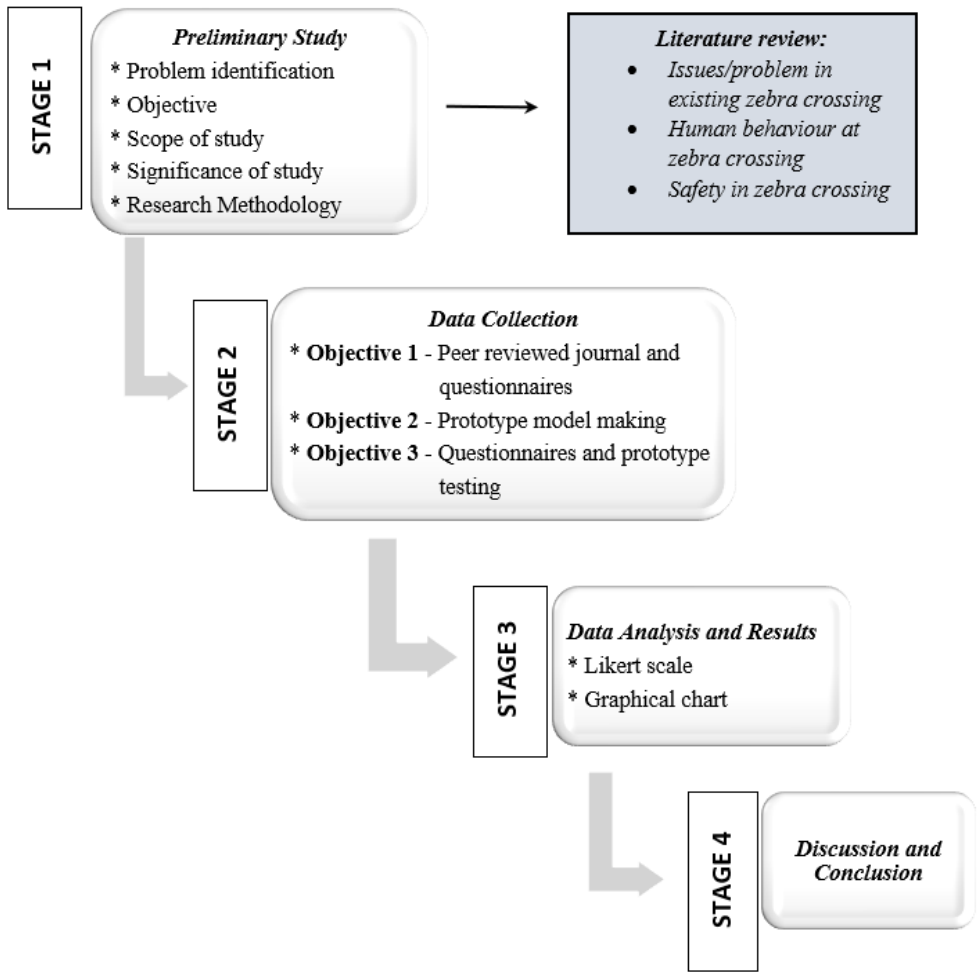

Figure 1. Research flow

During the data collection process, characteristics of respondents have a very significant role to play in expressing and giving the responses about the problem. In this study, a set of personal characteristics namely age, gender, education level, occupation, transportation used has been collected and analysed. About 100 respondents have been selected and participated in questionnaire distribution where it was among the students of Politeknik Ungku Omar, Sekolah Menengah Kebangsaan Raja Chulan Ipoh and the road users who use roadways near the area. The data were analysed through SPSS software and presented in a graphical chart.

3.2. Materials and Prototype Model Preparation

In prototype making process, the main components used are LED Strips, LCD/ 7SEG, Arduino Uno, PIR Sensor, USB Cable and a wooden board with the supportive materials such as clear glass Perspex, black mounting board and glue. The components are used to detect the movement of the pedestrian when crossing the Smart Zebra Cross.

Light emitting diodes, commonly called LEDs (Figure 2) are just tiny light bulbs that fit easily into an electrical circuit. LEDs have many advantages over incandescent light sources, including lower energy consumption, longer lifetime, improved physical robustness, smaller size, and faster switching. LEDs are used as a traffic light simulator in the prototype model.

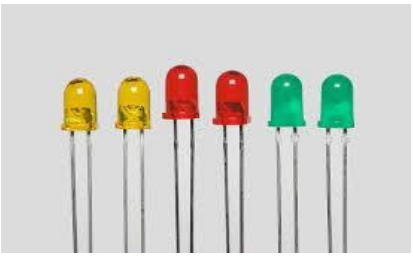

Figure 2. Light Emitting Diode

LED Strip Light (also known as an LED tape or ribbon light) is a flexible circuit board populated by surface mounted light-emitting diodes (SMD LEDs) and other components that usually comes with an adhesive backing as in Figure 3. Traditionally, strip lights had been used solely in accent lighting, backlighting, task lighting, and decorative lighting applications. LED strip lights are their flexibility. Unlike bulbs, they can be attached to curved surfaces, corners or moulded into almost any shape. Although the initial cost of LED lights is more than their counterparts, their long-life, durability, and energy-efficiency make them more cost-effective.

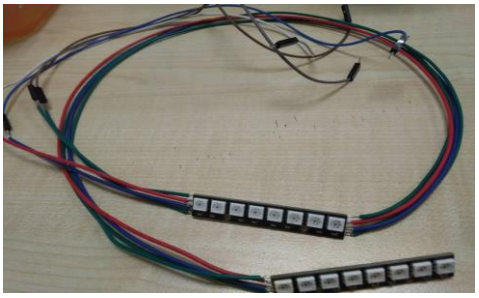

Figure 3. LED stripes

Figure 4 shows a seven-segment display (SSD), or seven-segment indicator, which is a form of the electronic display device for displaying decimal numerals that is an alternative to the more complex dot matrix displays. In this study, it showed the countdown timer. The seven segments display are the oldest yet one of the efficient types of display used in embedded applications. It is a widely used electronic display device for displaying decimal numbers from 0 to 9. They are most commonly used in electronic devices like digital clocks, timers, and calculators to display numeric information.

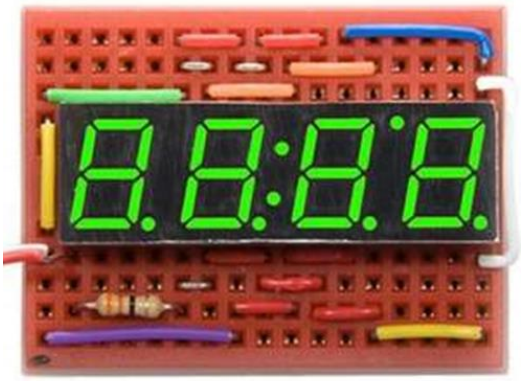

Figure 4: Seven-segment Display (SSD)

The Arduino UNO is a widely used open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced with various expansion boards (shields) and other circuits. The board features 14 Digital pins and 6 Analog pins. It is programmable with the Arduino IDE (Integrated Development Environment) via a type B USB cable. It can be powered by a USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts. Arduino boards are relatively inexpensive compared to other microcontroller platforms. Arduino boards are relatively inexpensive compared to other microcontroller platforms. Arduino programming environment is easy-to-use for beginners, yet flexible enough for advanced users to take advantage of as well. There is a built-in LED driven by digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off. The Arduino UNO is generally considered the most user-friendly and popular board of the Arduino board series as in Figure 5.

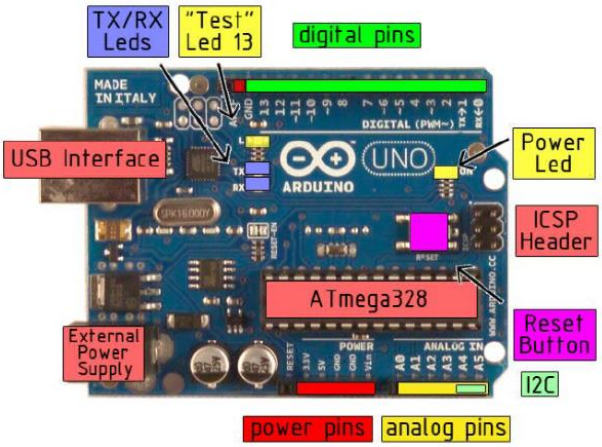

Figure 5: Arduino Uno components

PIR sensor detects a human movement around within approximately 10 m from the sensor. This is an average value, as the actual detection range is between 5 m and 12 m. PIR is fundamentally made of a pyroelectric sensor, which can detect levels of infrared radiation PIR sensors that are incredible. They are flat control and minimal effort, have a wide lens range, and are simple to interface with. Most PIR sensors have a 3-pin connection at the side or bottom. One pin will be ground, another will be signal and the last pin will be power. Power is usually up to 5V. Figure 6 shows the PIR sensor installed in the prototype model.

Figure 6. PIR sensor

Subsequently, to build the electronic system for the prototype model, the component for the electronic circuits was chosen carefully to make sure that it can work very well during the daytime or night time. The outer body for this prototype model was made from a wooden board which represents the roadway itself. The wooden board was cut into 0.57 m x 0.57 m in size and make sure all electronics parts are ready.

The electric circuit flow was installed according to the correct circuit flow such as LEDs, LCD/7SEG, Arduino and PIR sensor. The LED lights were being soldered on the PCB board before all the component was glued on the wooden board. The installation process can be referred to in Figure 7. The finishing process was done to give the prototype more presentable and neat.

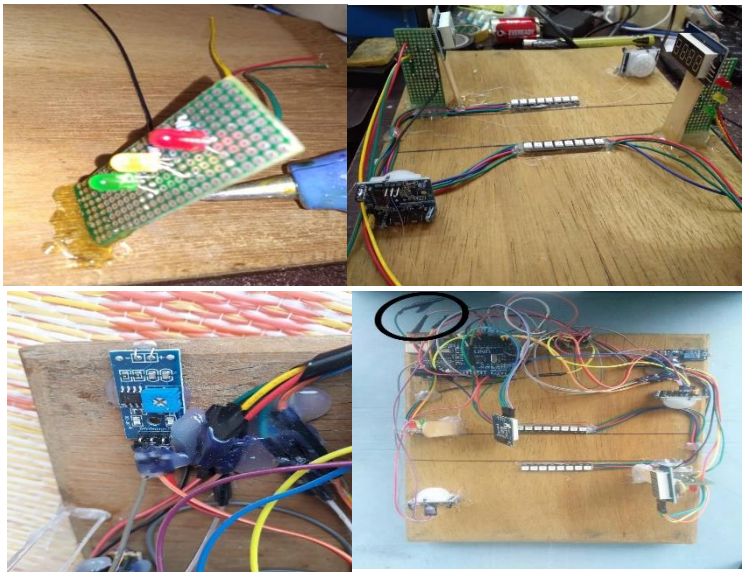

Figure 7. Electronics component installation

3.3. Prototype Model Testing

The functionality testing will be carried out and recorded to check the effectiveness in achieving the objectives. The testing process is carried out to test the effectiveness of the prototype model works during day and night. It is rated based on the motion sensor's ability to detect pedestrian movement when approaching the crosswalk area and so that the STOP figure signal appearing with a LED light up.

3. Result and Discussion

From the questionnaires data collection, the main problems faced in using existing zebra crossing are as follows:

i. The poor marking and signage of the existing zebra crossing.
ii. The carelessness of road users and less sensitive to the signals given by existing zebra crossing when passing through the roadways.
iii. The pedestrians are afraid to cross the zebra crossing during the night due to less visibility of road users.

The data that has been collected was used to create the prototype model in order to reduce the problems having by the respondents. In the process of designing the prototype model, it involved AutoCAD 3D software to illustrate the ideas into drawing according to the size and scale as illustrated in Figure 8 and meanwhile, Figure 9 presented the final look of the prototype model.

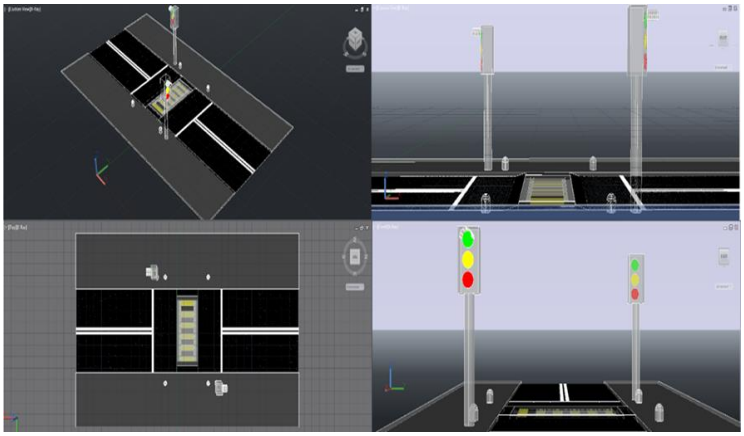

Figure 8. AutoCAD 3D illustration of Smart Zebra Cross

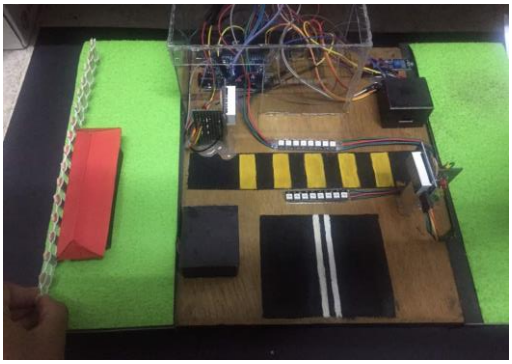

Figure 9. The Smart Zebra Cross prototype model

The functionality testing has been carried out and recorded to check the effectiveness in achieving the objectives. The functionality was summarized in Table 1. Figure 10 showed that the countdown timer will appear every time when it detected the movement near the crosswalk. Meanwhile, the LED lighting will light up when it detected a movement across the prototype during the night only as in Figure 11. Based on the testing, we can have concluded that it can minimize the problem faced by pedestrians when using zebra crossing by increasing the road user's level of sight, especially at night.

Table 1. Functionality test result

Functionality Testing		
Day	Daytime	Night
Led Lighting	No	Light Up
Timer	Yes	Yes

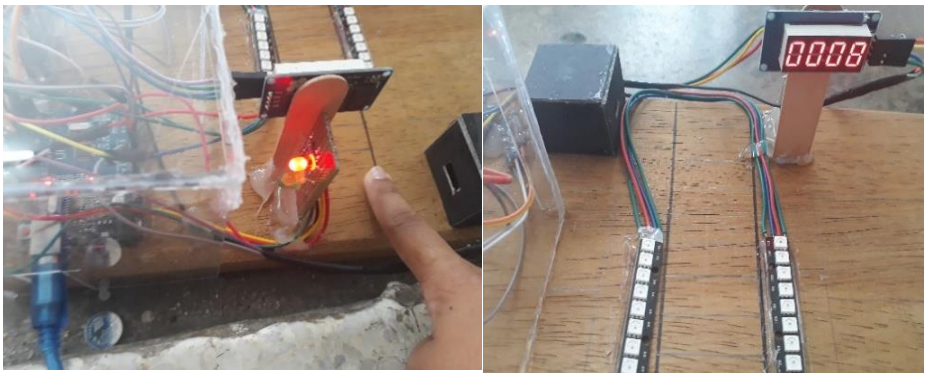

Figure 10. Smart Zebra Cross during daytime

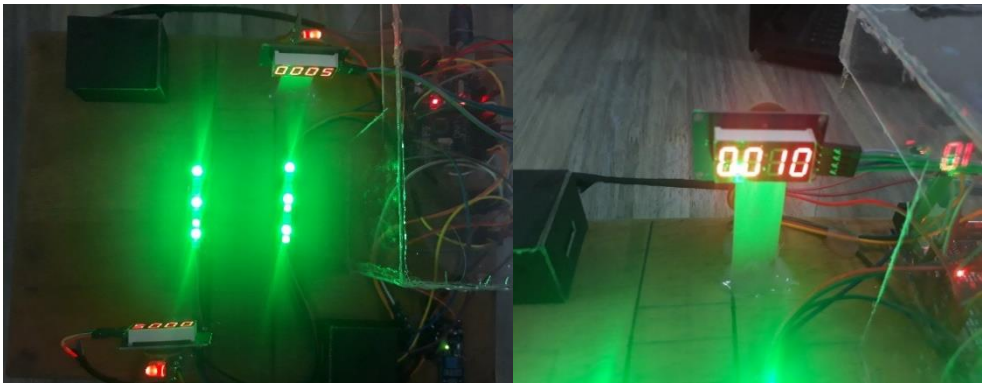

Figure 11. Smart Zebra Cross during night time

The results obtained from the study showed that Smart Zebra Cross is a good idea and a suitable approach. The total of the respondent gave a positive response regarding the application of Smart Zebra Cross in upgrading the existing zebra crossing located at the main road of Politeknik Ungku Omar and Sekolah Menengah Kebangsaan Raja Chulan Ipoh as in Figure 12. From the analysis, most respondents were among the students where it is because the location of the study was located near the institution. This study was intended in contributing to mitigate accidents among students and reducing the congestion especially during peak hours such as 8.00 am and 5.00 pm.

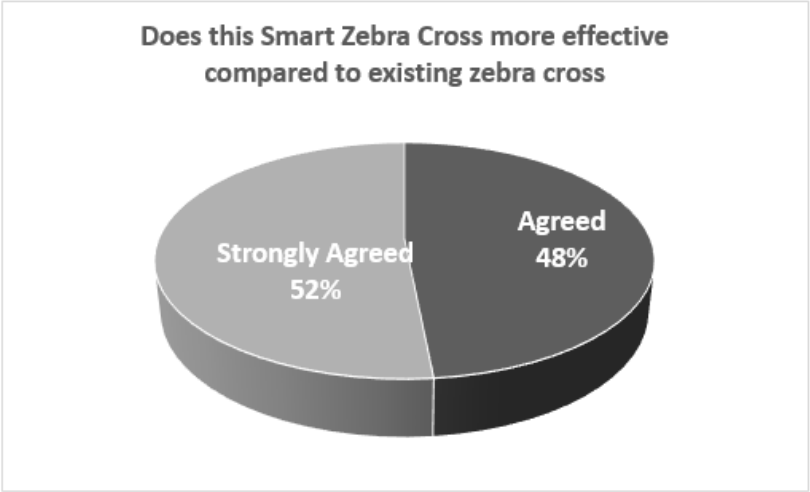

Figure 12. Responses in effectiveness of Smart Zebra Cross

Some recommendation obtains from the respondents on how to improve the quality of the product in the future are:

i. The countdown timer for the pedestrian to cross the roadway should be longer, to make sure that the pedestrians have enough time to cross.
ii. The increment of the length of LED lights installed along the crosswalk so that the road users would see even from a distance.
iii. The crosswalk paint can be also in glow in the dark to realize the existence of road users during night.
iv. The solar-powered pedestrian crosswalks can be implemented in LED light and stop signs for less energy usage.

Several comparisons made between the existing zebra crossing and the smart zebra crossing are as follows:

Existing zebra cross	Smart zebra cross
Pedestrians need to push the button to stop the vehicles and wait in several seconds before the signal shows green figure.	Pedestrians only have to wait for a very short period of time before the signal shows green figure by motion sensor approach
Minimal usage of energy due to minimal design and operation	Level of visibility increasing by LEDs light installation along the crosswalk especially during night time.
Pedestrians are exposed to accidents due to negligence by road users	Accidents are expected to be mitigated with improvements in terms of design and operation

4. Conclusion

These study achievements at exploring the motion sensor and LEDs light along the crosswalk in Smart Zebra crossing and several conclusions can be drawn as follows:

i. The problem faced by pedestrians in using the existing zebra crossing can be summarized in three main problems which are poor marking and signage, carelessness of road users and less sensitivity to the signals given and the lack of confidence to use zebra crossing during night time.
ii. A modern and user-friendly of smart zebra cross prototype has been built to give the road user a sense of its function and operation.
iii. The functionality testing of the prototype shows the satisfaction to respondents as well as the road users with improvements through the use of motion sensors and LED lights installed on the roadways.

References

Aqbal Hafeez Ariffin, Zulhaidi Mohd Jawi, Mohd Hafzi Md Isa, Khairil Anwar Abu Kassim and Wong Shaw Voon (2010). *Pedestrian Casualties in Road Accidents – Malaysia Perspective*. 1st MIROS Road Safety Conference. Pp 280-289

Earl R., Falkmer T., Girdler S. Morris S.L. and Falkmer M. (2018). *Viewpoints of Pedestrians with and Without Cognitive Impairment On Shared Zones and Zebra Crossings*. PLoS ONE Volume 13. Issue 9. doi: 10.1371/journal.pone.0203765

Figliozzi M.A. and Tipagornwong C. (2016). *Pedestrian Crosswalk Law: A Study of Traffic and Trajectory Factors That Affect Non-Compliance and Stopping Distance*. Accident Analysis and Prevention. Volume 96. Pp 169-179. doi: 10.1016/j.aap.2016.08.011

Goh B.H., Kulanthayan S., Yeong T.W and Abdullahi Ali Mohamed. (2012). *Pedestrian Crossing Speed: The Case of Malaysia*. International Journal for Traffic and Transport Engineering. doi: 10.7708/ijtte.2012.2(4).03

Malaysia (2013) *Act 333 Road Transport Act 1987*. Laws of Malaysia

Mako E. and Szakonyi P. (2016). *Evaluation of Human Behaviour at Pedestrian Crossings*. Transportation Research Procedia. Volume 14. pp 2121-2128. doi: 10.1016/j.trpro.2016.05.227

Basile O., Persia L. and Usami D. S. (2010). *A Methodology to Assess Pedestrian Crossing Safety*. European Transport Research Review. Volume 2. Issue 3. pp 129-137. doi: 10.1007/s12544-010-0036-z

Nur Zafirah H., Azzuhana R., Rizati H., Siti Zaharah I., Akmalia S. and Wong Shaw Voon (2017). *The Impact of Waiting Time towards Pedestrian Crossing Behaviour at Signalised Intersection*. MRR No. 244. Malaysian Institute of Road Safety Research (MIROS)

Pfortmueller C.A., Marti M., Kunz M., Lindner G. and Exadaktylos A.K. (2014). *Injury Severity and Mortality of Adult Zebra Crosswalk and Non-Zebra Crosswalk Road Crossing Accidents: A Cross-Sectional Analysis*. PLoS ONE Volume 9. Issue 3. doi: 10.1371/journal.pone.0090835

Poó F.M., Ledesma R.D., Trujillo R. (2017). *Pedestrian Crossing Behaviour, an Observational Study in The City of Ushuaia, Argentina*. Traffic Injury Prevention. doi: 10.1080/15389588.2017.1391380

Traffic Signal Needed at Zebra Crossing for Pedestrians' Safety: Miros (2018, January 31) *The Sun Daily*. Retrieved 10 Jun, 2018, from https://www.thesundaily.my/archive/traffic-signal-needed-zebra-crossing-pedestrians-safety-miros-HUARCH523008