Pedestrian Behaviour at Unsignalized Zebra Crossing: A Case Study in UMP Gambang Campus

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Abstract. The interest toward promoting walking culture has been increased dramatically especially in many cities across the nation. This is also included universities worldwide that have started seeking ways to increase pedestrian activities. Hence, campus planners must address the mobility and accessibility needs of pedestrian in their communities to ensure safety, functionality and conducive living and learning environment. This study was conducted to evaluate the pedestrian perception and behaviour towards the unsignalized zebra crossing in campus environment. To achieve the objective of this study, the unsignalized zebra crossing in UMP Gambang campus was selected as study location. This study was conducted using a quantitative study by means of questionnaires distribution and pedestrian movement data collection. Then Average Index Method was performed to indicate the pedestrian perception towards the crossing facility performances. The result shows that the zebra crossing was efficient and safe from the respondent's perspective. Other than that, gender and platoon significantly influenced the crossing speeds. The outcomes from this study were hoped to bring some understanding to the university on the pedestrian's behaviour for future planning and pedestrian safety.

1. Introduction

The transportation systems and its technology continue to evolve over time to meet the challenges towards fulfilling the aspirations of the people. The rapid developments of the transport system are of concern, due to its significant effects on the congestion, environment, safety issues and so on. As all these issues are becoming growing problems worldwide, the interest toward promoting non-motorized travel options by means of walking has been increased dramatically especially in many cities across the nation. This is also including Universities worldwide that are pledging to provide conducive living and learning environments for their communities. University can be seen as small town where movements of goods and peoples inside the campus are massive [1,2]. Good transportation system within a university not only can help in managing the university's daily activities but also contribute to support the aims of sustainability.

Walking is a key non-motorized mode of transport used by pedestrians that are beneficial to the environment, economy as well as promoting the health of users [3]. Accordingly, most universities around the globe have looking for ways to encourage pedestrian activities and discourage automobile dependency, specifically for short trips in campus settings as part to create sustainable campuses. According to [4,5], campus walkability is an important component of campus mobility because these users need to have access to a connected network that linking the hostel, faculties, bus stops and other facilities that will enhance healthy social life and reduces economic problems which is based on safety, functionality, pleasure, and learning. Therefore, campus planners must address the mobility and accessibility needs of these communities. When these facilities are incorrectly designed, issues such as accident, congestion, physical deteriorating, and increase in travel times might occur. This is supported by [6,7] where several issues accounted in campus physical development planning that has led to failure in creating a conducive environment for learning and living.

Moreover, as pedestrian is the most vulnerable road user, the exposure to vehicular traffic is considered as risky as compared to the other transportation network user especially when involve crossing activities. As reported in the Malaysian Road Safety Plan for 2014-2020, the pedestrians' death and injuries in 2013 were recorded at the third place after motorcyclists and passenger car road users. This is alarming especially with the increasing number of vehicles is growing rapidly everywhere nowadays including in university campuses. According to [8] most of pedestrian accidents mainly involved private vehicles and motorcycles at which the vehicular drivers fail to acknowledge the rights of pedestrians at the crossing facilities. Meanwhile as stated by [9,10] the vehicle- pedestrians' accidents was influenced by the total traffic volume, speed limit and land use activities. Since universities environment can be comparable with a small city, therefore substantial amounts that involves traffic activities by pedestrians and vehicles can be expected.

Several types of engineering options available to improve pedestrian safety and ensure destination accessibility. In Malaysia regardless in urban or sub urban setting development the most commonly types of pedestrian crossing facilities include zebra crossing, signalized crossing, and pedestrian bridge. These crossing facilities is also commonly found in campus environment [7]. Recognising the fact that the crossing facilities provides abundant benefits for students, there is a need to carefully evaluated these facilities and their potential value for future application.

2. Literature Review

A safe walking environment is key to provide comfort, friendliness and protect pedestrians as well as fostering social and physical activity [11]. Pedestrians' facilities serve as a protection to pedestrians from conflicts with motorized vehicles. The pedestrian crossing facility is part of road which marks by difference textures, difference surface or different colours to make it contrast so it can be easily recognized by pedestrians and drivers. Generally, pedestrian crossing facilities can be divided into several types such as signalized pedestrian crossing, marked pedestrian crossing or pedestrian bridge. The option of pedestrian crossing facilities should take into account the pedestrian needs that covered the background of the pedestrians such as age, gender, willingness to use pedestrian facilities and others [12]. The pedestrian crossings should be supply at where traffic volumes, pedestrian volumes, capacity of intersection and other conditions favour their use. These facilities are warranted in areas having heavy pedestrian movements for example at schools, campus, central business districts or any other's location that necessary. Characteristics such as walking speed, waiting time, pedestrian platoon, and accessibility concerns, are all important factors considered for pedestrian facilities.

A zebra crossing is one type of pedestrian crossing facility commonly used in many countries. The zebra-crossing often characterizes a crossing, which provides a safe area for pedestrians to cross the road and assist drivers to reduce their speed when approaching the crossing. Researchers claimed that most pedestrian fatalities occurred at unsignalized zebra crossing [13,14]. According to [15] several action could be made at such facilities to ensure safety of the pedestrian and drivers. Among the action include provide signages, reduce vehicle speeds, provide street lighting or any other suitable traffic control devices and many more.

Although, the location of the unsignalized zebra crossing is prone to high frequencies and severities of crashes, pedestrians' behaviour also plays a substantial role on the crash outcomes Understanding the behaviours of pedestrian while crossing a road section is part of a road safety challenge. Pedestrian behaviour cannot be assumed to be consistent. There are several of studies conducted in many ways about pedestrian crossing behaviour. The study approaches usually used discreet observation or simulation According to [16] different demographic characteristics (e.g; age and gender), type of crossing facility provided, traffic environment condition and different culture would affect the behaviour of pedestrians that provide significant insights into understanding pedestrian safety. For example, male and female drivers is known to have different behaviour and attitude while driving at which male drivers is more aggressive compared to female. In the case of pedestrians crossing behaviour, male pedestrians are prone to adopt risky situation when crossing the roadway. Similar to gender, age characteristics is another factor that could influence pedestrian performance. Looking at groups of children, adults, and older pedestrians for example on their walking speed and the reaction in

accepting the gap to cross the roadway, these may vary and needs detail understanding to ensure the safety and effectiveness of the traffic systems.

A study conducted by [17] and [18] found that of pedestrian's accident occurred because they not paying attention. These days, it is common to see pedestrians are distracted in other activities while crossing the roads such as talking or browsing on a mobile phone, smoking, eating, drinking and listen to music via headphone and many more. [14] found that pedestrians' behaviour in terms of crossing speed waiting time and size of gap acceptance while crossing at marked crosswalks was significantly influenced by distraction in many ways. According to [19] and [20] distracted pedestrians with multiple tasks usually at high risk since they were failed to demonstrate cautionary behaviours and motor coordination judgment for example in accepting or rejecting an available gap while crossing the road and crossing with inappropriate walking speed. Finding by [21] in his study on pedestrians with mobile phone usage claimed that crossing with low speed and changing lane will increase exposure to risk. This is consistent with the result presented by [22] that mobile phone distraction led to a significant effect in term of crossing time to which average time to cross was 14.77 second in Kuala Lumpur Malaysia. Other than that, based on [23] pedestrian waiting time is another essential variable to study because pedestrians generally become impatient while waiting to cross the street. When this situation occurred, the pedestrians normally attempt to cross the roadway in risky situation such as stopping, stepping back, or running if they had the chance. Likewise, pedestrians who crossing outside the available crossing infrastructure are also more likely expose to risky situations [24].

Considering that pedestrians crossing behaviour offering valuable insights about pedestrian safety, therefore it is important to assess on its characteristics and performance. With the best knowledge of author, in Malaysia most of the research on pedestrians crossing behaviour conducted was focusing on urban street in city environment such as in Kuala Lumpur and very few studies were conducted on campus street environment. Given the differences of both environment in terms of pedestrian's background, traffic flow condition, built environment characteristics, enforcement practices and many more, the study outcomes may vary and should not be generalised. This study is initiated to evaluate pedestrian behaviour on unsignalized zebra crossing in campus environment as to provide understanding in improving pedestrians' safety as well as to pave the way in achieving the goals of sustainable campus environment.

3. Methodology

A series of tasks were developed to complete research objectives successfully. This chapter presents site study location, method of data collection and data analysis conducted. The following sections describe in detail the methodology in conducting the study.

3.1 Study sites

To achieve study objectives, an unsignalized zebra crossing was selected in UMP Gambang campus. The selection criteria of the pedestrian crossing were: (a) selected sites must on level terrain; (b) moderate traffic volumes; and (c) presence of high pedestrian movement to reduce time taken for data collection. Figure 1 below show the layout of the study location of uncontrolled pedestrian crossing in UMP Gambang campus.

Figure 1. Uncontrolled pedestrian crossing in UMP Gambang

3.2 Data collection

This research employed quantitative approaches to achieve the study's aim. A survey to identify pedestrians' level of perception towards pedestrian crossing facility in the university's campus were conducted. This activity was done by distributing the questionnaires randomly to the respondents consisted primarily of undergraduate and graduate students who frequently used pedestrian facilities. A group of enumerators shall be engaged in completing this survey.

Meanwhile, in analysing the pedestrians crossing behaviour the data will be collected through visual observation of pedestrian and vehicular activities using video recorder. The spot speed study also will be performed to obtain speed distribution of pedestrian when crossing the uncontrolled zebra crossing.

3.2.1 Questionnaire

The questionnaire consists of questions that divided into two parts as follows; (Part A) was on the pedestrian's background; (Part B) was measured on performance of the pedestrian crosswalk (crossing location, effectiveness, compliance, safety); Part B was designed in the form of likert scale to obtain insight of user perceptions with the statement in the questionnaire. The likert scale was developed in ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). In this study, Average Index (AI) that has been proposed by [25] were used to understand better on the level of perception of the users towards the unsignalized zebra crossing facility in UMP. Table 1 shows the indicator for the average index and their attributes.

Table 1. Average Index and attributes

Likert Scale	Attributes	Average Index
5	Strongly Agree	4.5 < Average index < 5.0
4	Agree	3.5 < Average index < 4.5
3	Neutral	2.5 < Average index < 3.5
2	Disagree	1.5 < Average index < 2.5
1	Strongly Disagree	1.0 < Average index < 1.5

3.2.2 Movement data collection

For the pedestrians crossing behaviour the data was collected through visual observation with the aids of video recorder and by performing spot speed study. The video camera was set up on the sidewalks at the study location as shown in Figure 2 below. In this study, the data collection only measured one way direction of pedestrian movement from residential college to academic block for further analysis. The final data set offered from this video recording included pedestrian crossing volumes, crossing mode (walking, running, jaywalking etc), crossing speed, pedestrian platoon and waiting time

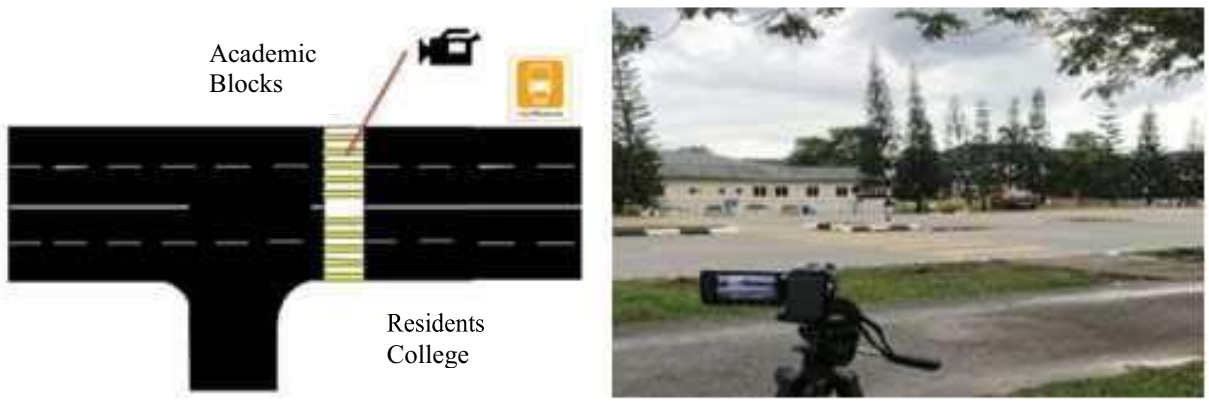

Figure 2. Video recorder location and setting up

4. Results and Discussion

The findings of this study are divided into two main sections. The first section presents the survey results from the questionnaire to obtain pedestrian perception as the users on the performance of the pedestrian crossing facility. Meanwhile, in the second part discusses the pedestrian behaviour at the study site.

4.1 Pedestrian perception

A total of 100 survey questionnaires were distributed to the respondents with the split of 50% for both male and female. All respondents are on campus residents. The majority respondents for both groups were in the age of 20-25 years old and followed by the group of 26-30 years old. Figure 3 summarize the average index from the questionnaire analysis to identify the perception level of the pedestrians towards the unsignalized zebra crossing compliance in the campus. Based on Figure 3, both male and female users in UMP have a consistent agreement towards question given. It can be concluded that most respondents agree that the unsignalized zebra crossing in Universiti Malaysia Pahang Gambang campus has adequately meet the functional aspects in terms of its utilisation, safety, connectivity, and the effectiveness towards them as a user's. This is shown from the results obtained that majority of the respondents were on agreeable side with the average index score that lies within the range of 3.50 to 4.50.

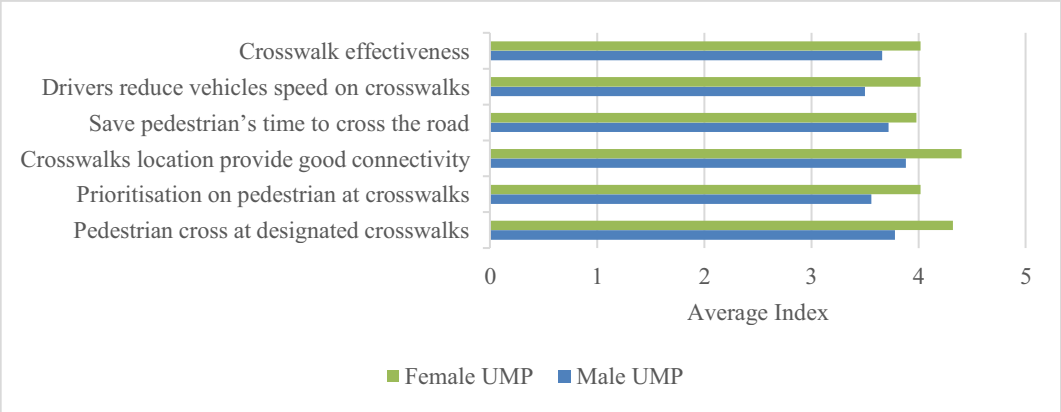

Figure 3. Respondents' perception on pedestrian crosswalk

From the survey, the respondents ranked highest average index score on the aspects of pedestrian compliance at which they agree that pedestrians cross at the designated crossing facility. Other than that, the aspects of crossing location also scored the highest average index for both male and female groups. This has brought to an assumption that the campus layout plays an important role in promoting walkability in campus environment. The layout of UMP Gambang campus is divided into two significant zones which are academic, library, health centre and recreational zone on one side and mainly residents' college on the other side. These two zones are separated by main circulation road of dual carriageway 2 lane roads in each direction. To ensure good connectivity and mobility between these two zones, the main access road is equipped with pedestrians' facilities such as sidewalk and pedestrian crossing. This is in line with the concern highlighted by [26] that to ensure walkability the land use pattern, streetscape layout, social safety and building accessibility must be considered. This is also supported by [27] stated that walkability must focus on accessibility, connectivity, liveability, safety, streetscape features and pedestrian activity.

4.2 Pedestrian crossing behaviour

In this section the pedestrian crossing behaviour data was gathered through video recording technique as illustrated in Figure 2 above. This recording was conducted during peak hour period at which a crowd of students will walk from colleges to academic blocks on three consecutive weekdays (Tuesday, Wednesday, and Thursday). The parameters of crossing behaviour that have been collected such as pedestrian counts, pedestrian crossing mode, pedestrian crossing speed, pedestrian platoon, and waiting time.

As shown in Figure 4 was the average of pedestrian count data that using the unsignalized zebra crossing. The data was analysed for every 10 minutes interval of morning and evening peak period to see closely the level of utilisation of the crosswalk. In UMP the class are generally scheduled base on 'time block' for straight two hours at which the first slot begins at 8.00am and the last slot begin at 4.00pm. Based on this figure, it shows that the pedestrian crossing utilisation will be increased at 10 to 20 minutes prior to class begin at 8.00 am, 10.00 am, 2.00 pm and 4.00 pm.

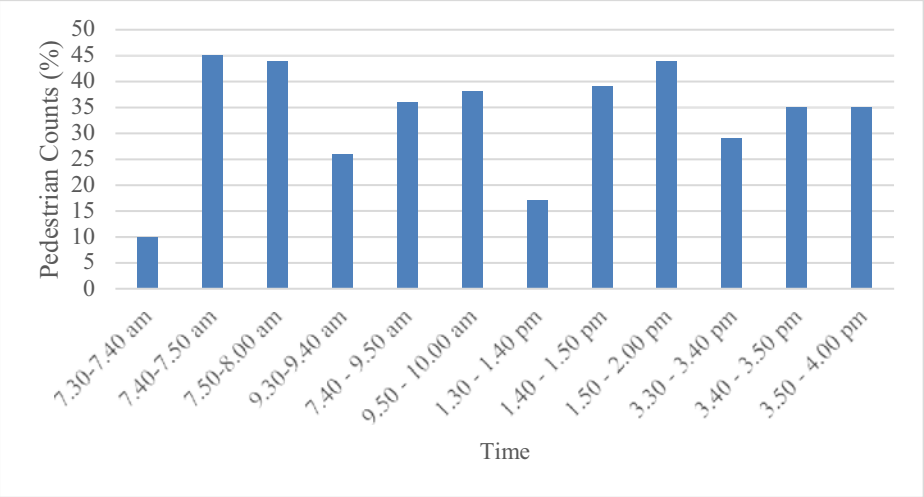

Figure 4. Pedestrian count on the crosswalk

The pedestrian crossing behaviour in this study was further assessed to identify the pedestrian crossing mode on the designated crosswalk. Figure 5a shows the illustration of the crossing mode that been analysed in this study. Pedestrian who crossed away from the crossing facility is known as jaywalking. This crossing behaviour indicates pedestrian do not comply with rules and regulation of the crosswalk. The arrow in orange colour indicates the mode of partial jaywalking. Partial jaywalking means those pedestrians whom crossing the road partially on the crosswalk. Meanwhile the arrow in purple colour is the pedestrian crossing on crosswalk.

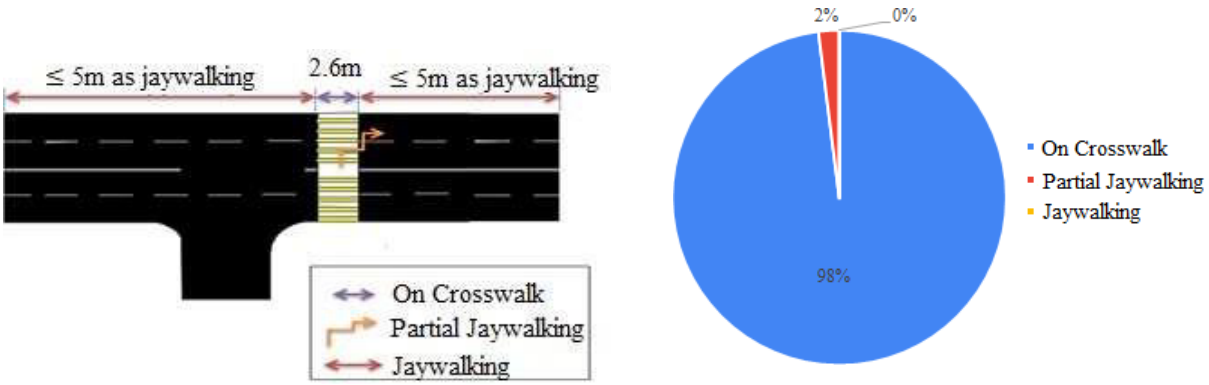

Figure 5. (a). Illustration of pedestrian crossing mode; (b). Statistic of pedestrian crossing mode

Meanwhile in Figure 5b provide the statistic of pedestrian crossing mode while crossing the road on the designated zebra crossing. Based on this figure it shows that 98 % of the pedestrians typically cross on the crosswalk. Meanwhile the remaining 2 % pedestrian crossing mode as partial jaywalker and none of jaywalking mode found during the observation. It can be concluded that the crossing compliance rate of the crosswalk are very high. This finding might reflect to the location of the crosswalk that provide good accessibility and connectivity between residents' college zone and the academic blocks zone. This is consistent with claimed made by [5] and [28] that accessibility and connectivity are among the significant factors that complement each other to make the street walkable. Hence greater attention

should be made by the campus planner to ensure the sustainability of street function. According to research done by [29] suggested that intensive measures should be made when pedestrian facilities are intended mainly for the use of pedestrian. For instance, to prevent pedestrians from crossing at non-designated locations due to risk pose between pedestrians and vehicles. This also may lead to unfavourable disruptions of traffic flow.

Next the pedestrian crossing speed was analysed as shown in Figure 6. The crossing speed was measured by taking the length of the crosswalk over the time when starts crossing until the end of pedestrian crosswalks. Referring to Figure 6, collectively it shows that majority pedestrian walks at speed of 1.45 m/s. This is supported by [15] stated that the average walking speed was 4.8 ft./s (1.46 m/s). The finding also clearly shows that the male pedestrian walks at higher speed compared to female pedestrian on the crosswalk. A study by [14] indicated that male pedestrians average crossing speed was 8.96% higher compared to female pedestrians.

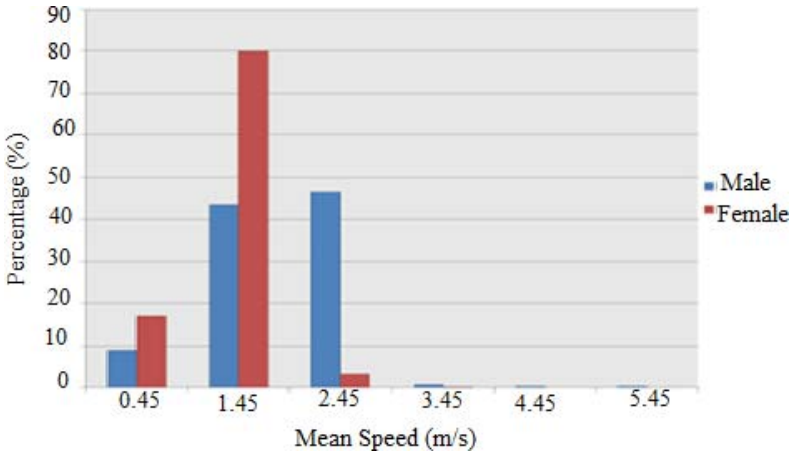

Figure 6. Walking speed on the pedestrian crosswalks

Meanwhile in Figure 7 shows the data on pedestrian platoon at the study site. As shown in figure 7, at speed rate of 1.45 m/s and 2.45 m/s it was observed that pedestrian crossing alone about 88 % and 12 % respectively. With the same speed rate, it was found that the trend of pedestrian crossing in group of two, three, four and five members to be decreasing. Hence it can be concluded that walking in group significantly impact pedestrian walking speed. The speed of crossing individually is higher compared to crossing in the group. This finding is consistent with research done by [15] and [30] stated that the mean walking speed of an individual is significantly higher than speed of pedestrian walking in group.

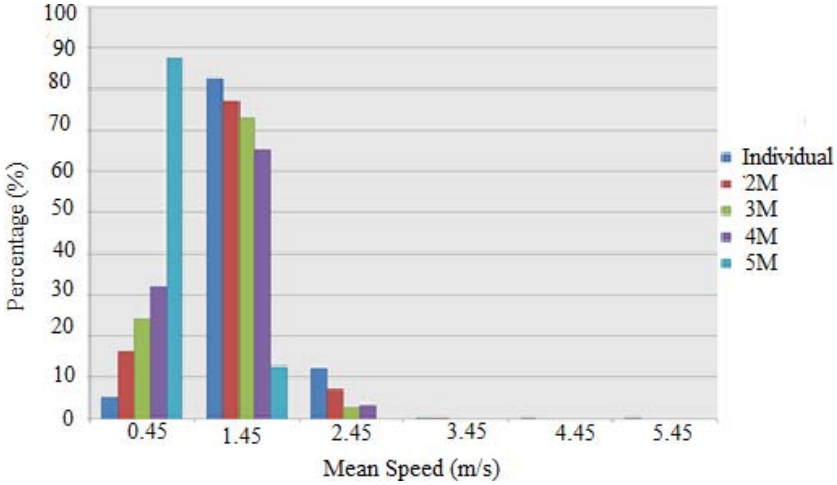

Figure 7. Pedestrian platoon on the crosswalk

Finally, this study also analysed on the waiting time. The waiting time is the time elapsed between the pedestrians reach the designated pedestrian crosswalks and the point when she/he starts crossing. The average pedestrian waiting times were analysed as shown in Figure 8 below. Most pedestrian (26%) took about 2 seconds of waiting time to start crossing. This shows that the conditions of traffic flow in Gambang campuses were not seriously congested. It is found that more than 80% pedestrians waiting time less than 7 seconds. The longer waiting time seen from the analysis was about 18 seconds.

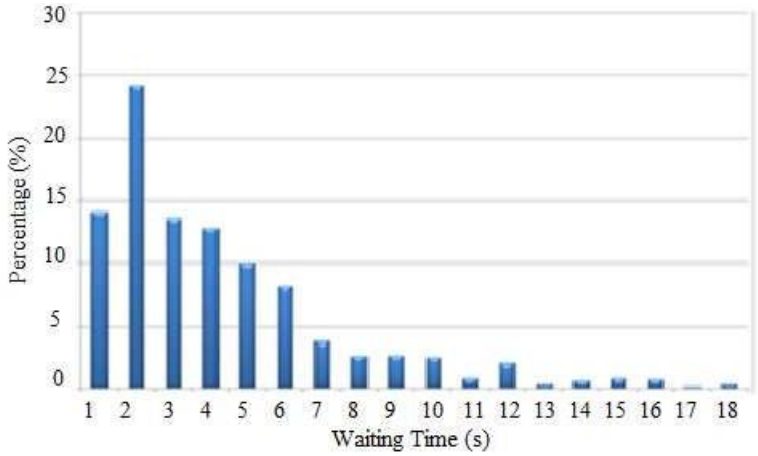

Figure 8. Waiting time at the pedestrian crosswalk

5. Conclusion

This study was conducted to analyse pedestrian behaviours on the unsignalized zebra crossing in campus environment. Besides, this study also provide insight into pedestrian perception towards the effectiveness of the crossing facility. Finding from this study reveals that provision of the unsignalized zebra crossing in UMP Gambang campus is satisfactory. Most respondents were agreed that the crossing facility has adequately serve the functional aspects in terms of its effectiveness, safety, and connectivity. This finding provides relatively consistent agreement between the user's responses and their actual crossing behaviour. From the analysis of pedestrian crossing behaviour, it is found that 98 % of the pedestrian cross on the designated zebra crossing. It can be concluded that the pedestrians show very high compliance at this facility. This might be due to the properly design and suitable location of the pedestrian crossing that encourage users to fully utilize the facility. Other than that, it is also noted that the gender and platoon size while crossing do greatly affect the crossing speed on the crosswalk. According to [15] distracted walking activities pose safety risk to the pedestrian especially at zebra crossings. The finding from this study is hoped to bring some understanding on pedestrian behaviour at unsignalized zebra crossing in campus environment. This is useful to comprehend the strategies to improve pedestrian safety at crossing location specifically in terms of engineering measures.

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