

Study on Traffic Safety Security System at the Entrance of Middle and Primary School



Fengchun Han and Yifan Jiang

Abstract As a focal point of traffic safety, school area has received extensive attention. Especially in the peripheral areas of primary schools. During the period of schooling, motorcades, motorcycles, and non-motor vehicles are accumulating at school gates, and a large number of pedestrians are mixed there too, which cause traffic disorder. In addition, primary and secondary school students have their own characteristic of crossing the street, so the security of the elementary school area needs more targeted measures. This article starts with the analysis of road traffic characteristics and the traffic accident characteristics in front of primary and secondary schools. Combining typical real cases, this paper proposes security protection measures from traffic organization, traffic enforcement, and transportation facilities. Further constructing a traffic safety guarantee system provides an important guideline for ensuring the safety of traffic in front of primary and secondary schools.

Keywords Traffic characteristics · Traffic organizations · Pedestrian sections · Safety guarantees

1 Introduction

The transportation safety at the entrance of the school is the focus on the transportation safety management work. The continuous increase for parents to travel by vehicles, incomplete facility of the surrounding road on the campus and the incompetent enforcement management leads to the phenomena of mixed people and vehicles. Coupled with the small age of primary school students, poor safety awareness and varied course of travel, chaotic traffic orders pose a great threat to the safety of teachers and students in school. The traffic accidents of primary school students mainly occur on the way to and from school. Therefore, the significance of the

F. Han (✉) · Y. Jiang
School of Traffic Management, People's Public Security University of China,
Beijing 100038, China
e-mail: hfc1966@163.com

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research on the safety protection measures in front of the school is becoming more and more important.

There are not many foreign studies on the safety and security of traffic around schools. Nakitto [1] thinks that the setting more safety routes, strengthening the monitor of non-motor vehicle and road transportation safety education for the children can reduce the accident surrounding the campus. The related study of domestic, from the perspective of transportation structure and traveling time, analyzes the transportation characteristics and generally to put forward the suggestion or strengthen transportation safety from increasing transportation facility. Sun et al. [2] categorizes the middle and primary school into three types, putting forward the overall propositions to set the proper decrease facility, reasonable bus stop and facility for pedestrians, etc. Zhao et al. [3] puts forward preferred organized scheme for the traffic safety facility at the entrance of different type of school and provides the basis for traffic safety. Chang [4] studies the solutions and appraisals of traffic organization to establish the model of network appraisals and puts forward the suggestions of facility and education for the pupils.

This paper analyzes road traffic characteristics, accidental features and the factors of influencing traffic safety around the regions of middle and primary school. With the example of typical cases, it proposes the solutions of traffic safety aiming at summarizing the system of traffic safety guarantee system and has guiding value for improving the level of traffic safety around schools.

2 Traffic Characteristics at the Entrance of School

2.1 Transportation Characteristics

(1) Large quantity of transportation at the peak

The vehicles at the entrance of school are mixed and disordered. The flows of vehicles are saturated at the peak of school times.

(2) Complex traffic constitution

The pick-up vehicles is mainly based on cars. It is mixed with electric vehicles, motorcycles and bicycles. The traffic composition is complicated and the mutual interference is large.

(3) Parking problems

During the period of schooling, there is a large demand for parking around the schoolyard, and it is difficult for the existing parking spaces to meet the parking demand, resulting in significant problems in the school gates.

(4) Disordered transportation

A large number of motorized vehicles, non-motor vehicles and pedestrians gathered near the school gate during the period of schooling. Without the isolation barrier and other traffic management facilities, the phenomena of non-convergence and pedestrians crossing the street are prominent, which makes the traffic chaotic.

(5) Fast speed

The gates of urban primary and secondary schools are generally facing the trunk roads, which are in good condition with speed limits of 30 km. In the absence of a complete speed-limiting transport facility or electronic police, the speed of the vehicle will be higher than the safe speed, and the accidents can easily lead to serious consequences.

2.2 Characteristics of Transportation Participants

- (1) The driving of motor vehicles is generally for middle-aged parents, who have rich driving experience and therefore drive at fast speed. They will stop at the school gate for a short time.
- (2) Non-motorized drivers are generally secondary school students or parents. Parents tend to ride safely, whereas the middle school students have a strong psychological risk, such as chase racing.
- (3) Pedestrians are mainly composed of primary school students and elderly parents. The seniors are poor in their ability to respond and act, and primary schools are active and have a weak sense of safety.

3 School Traffic Safety Analysis

3.1 Characteristics Analysis of Traffic Accidents

The main factors influencing the traffic safety at the entrance of middle and primary school include traffic participants, traffic management facility, illegal traffic action and environment and management, etc.

(1) Pattern of traffic accidents

According to statistic, student-related traffic accidents are mostly caused by sudden crossing of roads and disorderly walking when vehicles approaching. The accidental collision and side collision accidents caused by motor vehicles to pedestrians and non-motor vehicles are the main types of accidents.

(2) The happening time of traffic accidents

Accident occurred at noon or in the afternoon after school hours. After school, a large number of students walk or cars cross the road. The traffic order is chaotic and can easily cause accidents. Accidents often occur when students cross the street to take the bus or so.

(3) The type of traffic accidents

The accidents were concentrated in the collision of cars with electric cars, motorcycles, bicycles and pedestrians, and they suffered more injuries when riding or walking. Taking the Shenzhen in 2017 for example, there are 921 traffic accidents concerning the students in middle and primary school under the age of 15, among which 872 simple accidents, 37 injured accidents, 12 death accidents to make 9 children dead and 40 children injured. In accordance with division of traffic mode of children in the accidents, there are 13 people of taking the bus, 74 people walking, 39 people taking the motor and electric vehicles, 11 people driving the motors and electric vehicles and 21 people who take the bicycles.

3.2 *The Analysis of Caused Accidents*

3.2.1 **The Factors of Participants in Transportation**

- (1) Herd mentality. This kind of psychology is irrational. Most of the pupils do not have a mature concept of traffic safety. They will only follow suit. When they see other people crossing the non-motorized lane without causing accidents or punishments, blindly following them across the road, there will be a psychological blind sense of security;
- (2) Psychology is immature. Children are willing to take risks and think that they can rely on their own ability to avoid risks and get on with motor vehicles;
- (3) Weak awareness of road safety. Pedestrian especially primary school students, because of their lack of knowledge of traffic safety, do not recognize the danger of crossing the motor vehicle lanes subjective.

3.2.2 **Facility Factors in Transportation Management**

- (1) Lack of recognizing road traffic signs and markings

There are generally lack of necessary traffic sign signs around the campus. For example, the speed limit signs are not displayed repeatedly, the warning signs, prohibition signs are missing or the number of settings is insufficient. In terms of traffic marking settings, the marking lines are blurred and difficult to identify. Crosswalk lines, lane lines, center lines, stop lines, lane edge lines and traffic-induced marking lines are lacking.

(2) Non-standardized the traffic facility

The traffic signs and markings are not set according to the national standard. They are arbitrariness, lack of systematicness, continuity and standardization.

3.2.3 The Factor of Illegal Transportation

(1) Over-speed motor vehicles

Speeding is the main reason for the frequent traffic accidents in front of the school. Because the primary and middle school students are physically smaller, they are less likely to be detected by the rear vehicle when they walk through the parked vehicles, causing accidents.

(2) Motor (non-motor) vehicles parking orderless

There is limited road space at the entrance to the campus and there is a lack of necessary management measures. The non-motor vehicles are parked indiscriminately, not only occupying road space, but also infringing pedestrian rights, causing pedestrians to crowd through the middle of non-motor vehicles.

(3) Not giving-way pedestrians

At the entrance of non-light-controlled schools, vehicles in front of the school meet pedestrians or non-motor vehicles and should meet the parking rules. However, in facts, many drivers don't obey the rules; the pedestrian can only make use of the very tiny space to cross the road, which is very dangerous.

3.2.4 The Factor of Management

The traffic safety around the campus has always been the focus of traffic management work. However, the concept of traffic safety management is still relatively backward, and it is believed that chaos can bring about a lower speed and cause no casualties. During school hours, only a few traffic policemen are usually assigned to evacuate traffic in front of the campus, and there is no corresponding management of the parking of motor vehicles around the schoolyard and the phenomenon of mixed vehicles.

4 The Transportation Safety Guarantee System Construction at the Entrance of School

4.1 The Strategies of Transportation Safety

4.1.1 Optimize Transportation Facilities

- (1) Pedestrian facility at the entrance of school: facilities designated crosswalk, stop line and a crosswalk matching set prompt markings.
- (2) Regional speed limit and attention to children's signs: In the school road sections on both sides of the road between the opening of the 150 m area, the speed limit value should be scientific and reasonable.
- (3) Mesh line: The no parking area at the entrance of the school is subject to a yellow grid marking as required. Parking is prohibited for any reason.
- (4) Parking facilities: Set the parking lot for the shuttle bus, standardize parking lane marking, sign setting and parking guidance.
- (5) Pedestrian overpasses or pedestrian crossings Underpasses: Pedestrian overpasses or pedestrian crossing underground passages can be set up on the road sections with large traffic flow in front of the campus.
- (6) Colored road surface and reflective spikes: Use colored roads and reflective spikes to enhance visibility and induce traffic participants to regulate travel. The use of reflective spikes also improves the safety of pedestrian crossings at night.

4.1.2 Vehicle Speed Control

The use of speed limit signs in conjunction with the use of oscillating markings, visually and perceptibly reminds the driver to reduce the speed of travel and ensure that vehicles travelling on the roads around the school travel at a safe speed.

4.1.3 Traffic Separation

Pedestrians and non-motor vehicles are relatively small in term of size and have a flexible path, and it is difficult to punish illegal acts. Therefore, it is necessary to set pedestrian crossing signals and pedestrian barriers to separate traffic conflicts in the dimension of time and space to regulate the path of pedestrians and cyclists.

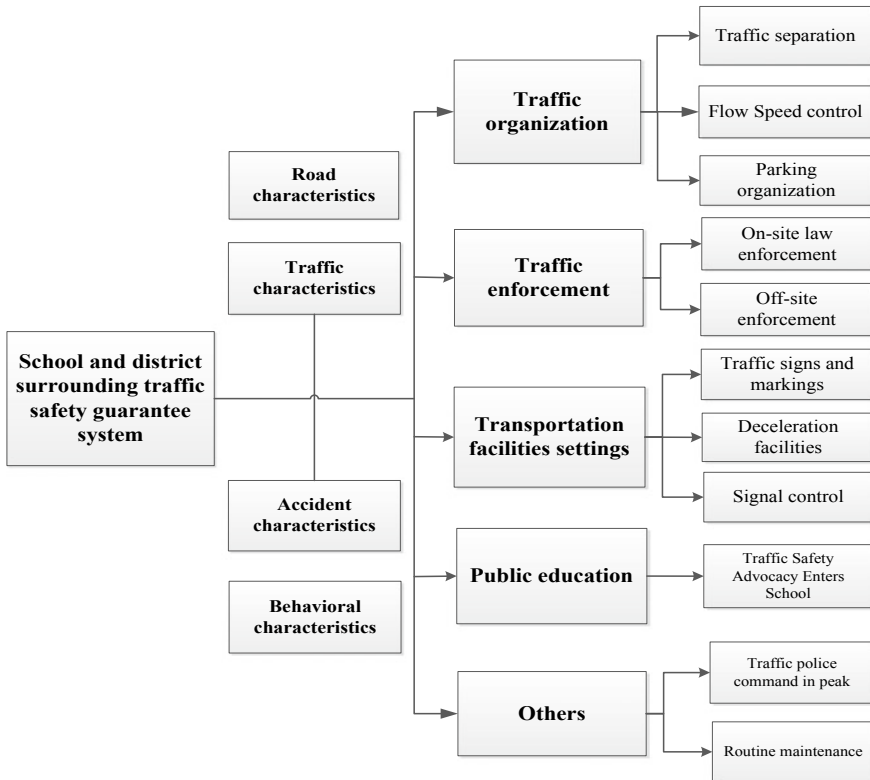


Fig. 1 School and district surrounding traffic safety guarantee system framework

4.2 Transportation Safety Guarantee System

In order to solve the traffic safety problems around the school gate, the paper puts forward the countermeasures of traffic safety management from the four aspects of traffic organization, law enforcement administration, facilities setting and publicity education, and constructs the framework of the traffic safety guarantee system in the campus. As shown in the Fig. 1.

5 Analysis of Transportation Safety Guarantee on the Living Example

Taking Xigong District Experimental Primary School in Luoyang, Henan Province as an example, according to the traffic safety guarantee system, traffic safety management measures for the actual situation of the primary school were formulated.

5.1 Current Investigation of Transportation Safety at School

Luoyang Experimental Elementary School lies in Kaixuan east road, Xigong District, Luoyang city. There is a large number of children who cross the road during the school hours, at the same time there are many vehicles gathering at the entrance of the school to pick up children. According to the traffic characteristics and research needs of the primary school entrance, the study was carried out at the 300 m range of the primary school entrance. As shown in Fig. 2.

- (1) Current situation of the road environment. Kaixuan east road for the urban trunk road, two boards for the form, the four lanes, road central segregation, green belts with green belt width is 30 m, inorganic barrier facility, the pavement is 25 m wide, no pedestrian barriers. Only simple front school, pay attention to the pedestrian sign.
- (2) Traffic amount is investigated. Making statistics for traffic volume with Kaixuan East road which in front of the experimental school. As shown in the figures of Table 1.

The investigation revealed that the road’s vehicle on the two directions is complicated with certain proportions of each type, where the motor vehicle can be reached the largest proportions of 51%, second is bicycle whose share 26%. The smallest

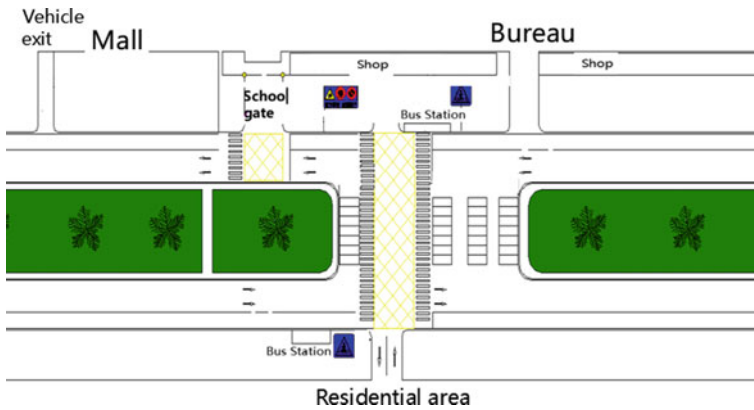


Fig. 2 Current status of the scope of the study

Table 1 Survey of traffic volume

Direction	Number of lanes	Traffic volume (veh/h)		Average speed (km/h)	
		Non-motor vehicle	Motor vehicle	Non-motor vehicle	Motor vehicle
West to east	2	288	696	11.4	14.8
East to west	2	216	516	15.6	30.1

Table 2 Survey of primary school students' cross street behaviors

Type	Counting	Proportion (%)
Compliance with regulations	90	45
Cross the street	76	38
Straight line crossing	34	17

proportion is motorcycle of 6%. Since many parents choose bicycles and mini-cars to pick up children, the proportion of bicycles and mini-cars from east to west is higher than the one from west to east, so total amount is.

- (3) The current conditions at the bus stop. The 60 m of the eastern side in the front gate of school is a bus stop, at which there are 7 buses to stop. At the peak, buses are frequent to make sections to inside non-motor cycles to cause congestions and disorder. The full length of the bus stop is 40 m long and can allow two buses to come into the bus stop at the same time. The investigation for pupils' crossing the street is made.
- (4) By the investigation, for pupils to cross the street after school, we study the choice pathway for pupils to cross the road and explore the rule for pupils to choose the pathway when they cross the road.

The time of investigation is 15:45–16:15 of March 25, 2017. Taking the type of sampling as an example, which shows the pathway of crossing the street with 200 samples. The result of the investigation is shown in Table 2.

Through the investigation, we found that the population in the front gate of primary school who obeys the laws to cross the street is not beyond 50% while the proportion of crossing the street is large to further cause the disorder at the gate of the school and even cause pedestrian accidents.

5.2 *The Analysis of Transportation Safety Problem on Campus*

5.2.1 **The Aspects of the Transportation Facility**

- (1) The sidewalk setting is not reasonable. School of the pavement and road median pedestrian access does not connect, in addition, the pavement occupation by non-motor vehicles, majority of people will not choose a pedestrian crossing, but choose to cross the road directly, or illegally cross the straight way. As shown in Fig. 3.

The sidewalk which the western side of experimental school is extremely lowered to use. The non-consistency of facility in crossing street to vehicle and pedestrian were both made the trouble.

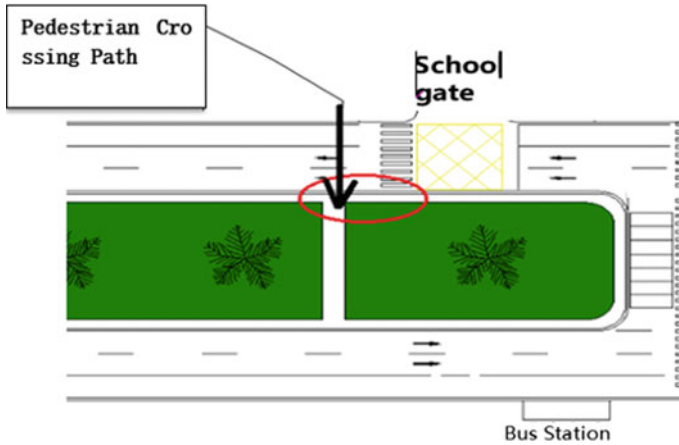


Fig. 3 Crosswalk status

- (2) The facility of transportation management is not completed. Through the investigation of current condition around the school:
- ① The transportation markings are only for pedestrian without non parking markings, limited speed markings or limited speed release markings;
 - ② The facility crossing the street only has sidewalks without preview line sign and pedestrian signals of crossing the street to make pedestrian in a mess when crossing the streets and are difficult to cross the street;
 - ③ No signal and no way to separate conflicted points so that the traffic order at the gate of school cannot get guaranteed. As the key protected area of traffic safety, it is essential to add the signals for guarantee;
 - ④ No fence for pedestrian and no fixed pathway for pedestrian and the phenomena of crossing the street is serious.

5.2.2 The Aspect of Traffic Order

- (1) From the result of investigation of vehicle's proportion, the number of cyclists on the road in the west direction is as high as 25%. There is no non-motor vehicle parking area around the school entrance, and non-motor vehicle parking which cause the pedestrian crossing to become "difficult to walk", thus resulting in security risks.
- (2) Illegally parking at the road occupies the non-motor driveway. Large amounts of non-motor vehicle flow into motor driveway to bring many hidden trouble to non-motor vehicles and pedestrian.

5.2.3 Bus Stop Setting

- (1) Take up non-motorized lanes. The 40 m east of the experimental primary school is a bus station. There are 7 buses in and out of the station. There is no bus shelter, and the traffic flow of the buses is intermixed with the non-motorized traffic flow.
- (2) Occlusion of vehicle visibility, rear vehicle parking space is insufficient. After the bus stops, the body directly blocks a pedestrian crossing, and the front of the car is about 1 m in front of the road.

5.3 Transportation Safety Management Solutions

5.3.1 Transportation Organization Methods

- (1) Speed-flow control

Set up deceleration facilities. Use the speed limit sign and multiple sets of oscillation mark to remind the driver to slow down and control the speed of the motor vehicle.

- (2) Parking organization

For motor vehicles, it is possible to wait in the existing road central green belt parking space, and forbid the roadside parking within 150 m on both sides of the school gate. For non-motorized vehicles, it is necessary to set up the parents' waiting area of 60 m long and 6 m long in front of the mall on the west side of the campus. The parents of non-motor vehicles are waiting in the waiting area.

- (3) Add a pedestrian crossing signal. Break up the flashpoint from time to time. It is possible to design the timing scheme of the signal lamp, and to set the phase of the pedestrian crossing.

5.3.2 Traffic Enforcement Methods

- (1) On-site law enforcement

Clearing up the illegal parking on the side of the road to guarantee the driving space for non-motor vehicle, at the meantime, strengthening enforcement of vehicle without giving away, and the penalty of causally cross the street of non-motor vehicles and behavior of occupying the zebra crossing.

- (2) Off-site law enforcement

The electronic policeman is utilized to monitor the road around the school on the whole day. Avoid parking illegally and running a red light.

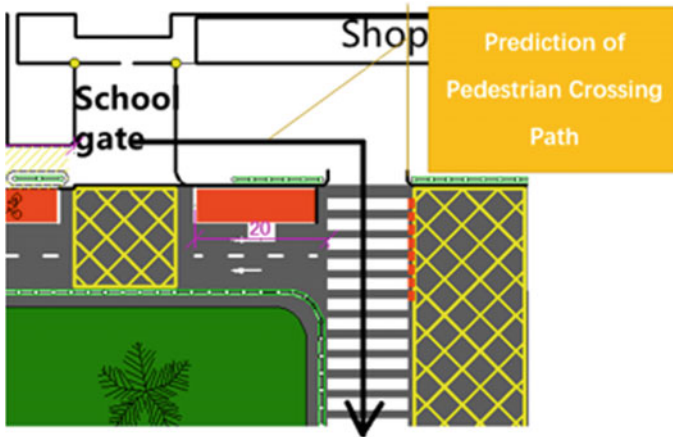


Fig. 4 Schematic of the crosswalk

5.3.3 The Transportation Facility Setting

- (1) Set the stop sign, speed limit sign, decelerate slow sign, school sign ahead, and add non-motor lane color road surface. Reorganize the crosswalk to ensure its continuity. To improve the existing pedestrian crossing and add the necessary pedestrian guardrail, the pedestrian crossing path is mandatory, so that the teachers and students can cross the street along the pedestrian crossing to improve the safety. Schematic of crosswalk is shown in the Fig. 4.
- (2) Set non-motor vehicle color lanes and reflective stitching to enhance visual identity and ensure the safety of pedestrians crossing the street at night.
- (3) The bus station should be designed with the surrounding pedestrian and non-motor vehicle system. The bus station on the north side of the kaide east road should be properly removed from the zebra crossing, and the bus station on the south side of the road should be set to the lower part of the sidewalk to ensure the safety visibility.

5.3.4 Pay Emphasis on Public Education of Transportation Safety

For primary and secondary school students, it is effective and necessary to promote education for traffic safety. Schools can organize various forms of public education, such as invite the police to preach, organize the traffic safety warning film and so on. The traffic safety publicity education was incorporated into the important content of the traffic police department and education department, and effective prevention and control from the source.

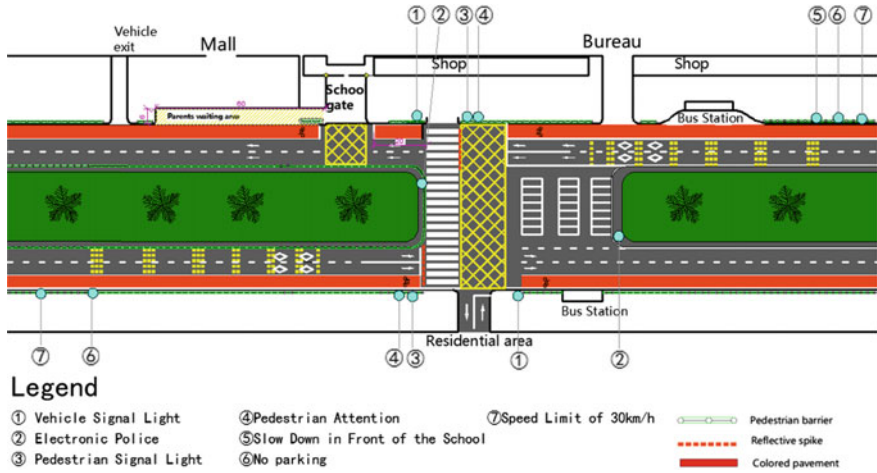


Fig. 5 Implementation of safety and security measures

5.4 Prospect for Implementation of Countermeasures

Facilitating solutions to cross the streets with pedestrian around the experimental primary school are shown in Fig. 5.

Taking the solutions with above safety guarantee:

- (1) Utilize the coordination of pavement marking and limited signs to control the speed of the road to make sure safe speed. At the same time, utilizing the combination of Rhombus line and pedestrian signs to make sure the drivers pay attention to the pedestrian;
- (2) The pedestrian guardrail is set up on the side of the road, only opening at both ends of the pedestrian crossing, and regulating pedestrian crossing paths;
- (3) Adjust the location of the bus station and provide sufficient parking space for rear vehicles;
- (4) Set up pedestrian crossing signals to ensure the right of pedestrians crossing the street;
- (5) The color lane is added, which visually enables the driver to clear the driving path and reduce the non-conflict of the machine;
- (6) Strengthen the law enforcement of education and school gate of primary school students, and reduce the violation of laws and regulations from the subjective and objective aspects. It guarantees the stability of the traffic order around campus and improves the safety of pedestrian crossing.

6 Conclusions

Based on the current situation of Luoyang experimental primary school of the traffic safety field investigation and analysis of traffic data, this paper points out the existing problems of traffic organization, bus stations, traffic order, traffic law enforcement and so forth. In view of the existing traffic safety problems, the security measures of the system are put forward, and the improved traffic environment is evaluated qualitatively. But different schools have their different traffic characteristics, so analysis of specific problems should be taken place case by case instead of being all the same.

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