

A Study on the Disaster Prevention Design- Based Safety Signs in School Zone

Hwang-Woo Noh

Department of Visual Communication Design
Hanbat National University, Daejeon, 34158, Korea

Chi-Gyu Oh

Department of Creative Design
Chungnam National University, Daejeon, 34134, Korea

ABSTRACT

The number of accidents in school zone is decreasing than before with the introduction of strengthening traffic safety policy since January 2011, but the danger still exists. The School zone sign is widely known to have much effect in protecting children from risks of traffic accidents, but design improvement is being demanded to improve a sense of safety and legibility of safety signs in School zone due to the lack of understanding on the safety signs in crosswalk and School zone. This study analyzed differences in shape and color of existing safety signs through a case analysis of traffic developed countries as America, England, Japan, and Germany and suggested improvement plans for drivers to clearly perceive the school zone. For improvement methods, this study suggested the importance of delivering definite and unified warning message for school zone to drivers by using indication sign and caution sign together, and to use yellow, a safety color, and to unify the safety sign into triangle shape that symbolizes warning and caution to conform the international standards. Actual design production and experiment through improvement plans are needed in the future, and it is expected to secure safety of children and to provide international standardization of safety signs in school zone.

Key words: Disaster Prevention Design, Safety Sign, School Zone.

1. INTRODUCTION

1.1 Background and Purpose of Study

The number of accidents in school zone is decreasing than before with the introduction of strengthening traffic safety policy since January 2011, but the danger still exists. The School zone sign is widely known to have much effect in protecting children from risks of traffic accidents, but design improvement is being demanded to improve a sense of safety and legibility of safety signs in School zone due to the lack of understanding on the safety signs in crosswalk and School zone.

The purpose of this study is to suggest effective disaster prevention design based safety signs in School zone that considered characteristics of school zone.

1.2 Methods of Study

The research method proceeded based on literature research, internet material survey, case research regarding the application of safety signs of the school zones (child protection zones) by field visit photo-taking and questionnaire survey. The research range was oriented to safety signs of the school zones

of Korea and four advanced countries of traffic culture (USA, Japan, Germany, UK). The questionnaire was developed by question items regarding safety signs of the school zone from the perspectives of institution (system), design and culture. The questionnaire survey was carried out focused on five key elements of design assessment in terms of the visibility, communicability, clarity, aesthetic factor and identifiability regarding safety signs of school zones of five countries (Korea, USA, Japan, Germany, UK).

2. THEORETICAL CONSIDERATION

2.1 DISASTER PREVENTION DESIGN

2.1.1 Definition of Disaster Prevention Design(DPD)

Design behaviors of human have been started with the history of mankind fabricating instruments or housings for their survival. But nowadays design exerts a great influence even on the essence of human. Design is originally a communication activity that gives shape to the thought and/or image of designer to deliver into the conclusion throughout some real modeling. So design is usually willing to generate aesthetical styles as well as fitting the usage of that objects [1].

Therefore, we can define 'Disaster Prevention Design' as follows; DPD is a kind of design activity that protects life and

* Corresponding author; Email: ohchigyu@hanmail.net
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property of human beings, minimizes damages, and makes the recovering process rapid and easy, against any kind of disasters.

2.1.2 Necessity of DPD

We present necessity of Disaster Prevention Design as in Table 5, which divided into its classification and contents. The increment of uncertainty, interoperability, complexity, and cumulative characteristics in the future society make the necessity of DPD more serious.

Table 1. Necessity of DPD, Division & Contents [1]

Division	Contents
Increment of Weak-Party for Safety	Increasing gap between the rich and the poor Increasing female's social activities Entering an aging or super aging society Increasing disabled persons because of various accidents
Increment of Dangerous Entries	Increasing natural disasters(climate changes) Increasing artificial disasters Increasing accidents in big cities Diametrical separation in fortune
Increment of Consumer's Requirements	Increasing requirements for safety Increasing personal requirements for services Increasing high quality & variety Increasing urban survivalists Expectation of increment in the market of personal disaster prevention
Social Variations	From recovery to precaution orientation From facilities to human orientation From physical to psychological recovery Increasing requirements for convergence of response, prevention, and recovery

2.1.3 Scope of DPD

According to their methods of confrontations, we can extend the scope of DPD like 1)Mitigation or Prevention Design, 2)Preparedness Design, 3)Response Design, and 4)Recovery Design [1].

Table 2. Scope of DPD [1]

Scope	Contents
Mitigation/Prevention Design	City Foundations (signpost, danger mark, and information designs) , Disaster Area Notice, Disaster Map(GIS), Safety Facilities, Investigation Equipment of Safety Degree, Content of Disaster Management, Design for Prevention of Crime, Universal Design, Barrier-Free Design, Echo Design, Durable Design etc.
Preparedness Design	Evacuation Facilities, Refugee Camp, Urgent Rescue Facilities, Equipment for Emergency Escape, Education for Disaster, Enlightening Poster, Safety Campaign, e-Learning Content for Disaster Prevention, Disaster Simulations, Safety Management System, Relief Equipment for Weak Hierarchy, Emergency Alarm System, Damage Investigation System etc.
Response Design	Emergency Guide Facilities, Disaster Relief Equipment, Relief Supplies, Life Relief Supplies, Relief Equipment, Emergency Communication Equipment, Urgent Evacuation Shelter, Emergency Medical Supplies, Clothing for Disaster Prevention,

	Disaster Prevention Supplies, Emergency Electric Equipment, Rescue Robot Design, Rescue Equipment, Weapons etc.
Recovery Design	Refugee Camp, Shelters, Equipment & Supplies for Epidemics Prevention, Life Rescue Supplies, Physical & Psychological Healing Program, Recovery Equipment, Pollution Prevention, Pollution Control, Urgent Recovery Facilities, Emergency Recovery Equipment etc.

As for the design development of safety signs of school zone, it corresponds to mitigation design and prevention design aiming at controlling and preventing the possibility of occurrence of catastrophe itself by removing or reducing in advance the causes of catastrophe based on the analysis of vulnerability of the field of prevention-oriented design.

3. ANALYSIS OF SAFETY SIGNS IN SCHOOL ZONE

3.1 School Zone

For protection of children in kindergarten(over 100 students), elementary school, special-education school, daycare center, and academy from traffic hazard, the driving speed is limited to below 30km/h within a radius of 500m from the front gate as a special protection zone [2].

The installation of regulation and sign posts in the school zone are supposed to be placed to right angle or square to the extension line of the same direction of vehicle headway.

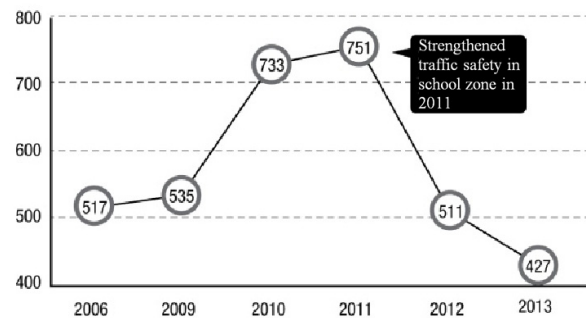


Fig. 1. frequency of traffic accident in school zone

The government established the School zone related law in the Road Traffic Act in 1995, the National Police Agency improved installation instruction for traffic safety facility in School zone in 2003 and strengthened traffic safety in school zone in 2011 that the frequency of traffic accident is decreasing with the increased school zone but safety of children in school zone is still being threatened. Safety signs in school zone is for making in school zone and place in school zone with heavy traffic that installation of signs is required to follow the standard set forth in installation and management manual of traffic safety facilities.

3.2 Analysis of traffic accidents occurred in the school zone

According to the statistics on traffic accidents of 2015 published by Korean National Police Agency, the highest death toll of traffic accidents of children is found in preschoolers

registering up to 39,4% and it is higher than in elementary school students registering 34,8%. Based on the statistics divided by time slot, the accident rate of child pedestrian is higher during the movement on their way to school and on their way home from school. In particular, they were more vulnerable to traffic accidents on their way to school than on their way home. This can be explained from the fact that drivers have weaker safety awareness because of relatively less traffic guidance after school.

Table 3. Traffic accident of children by age

Division	Preschoolers				Elementary school students		Middle School students	
	Non-kindergarteners		Kindergarteners		Death toll	Number of injured	Death toll	Number of injured
	Death toll	Number of injured	Death toll	Number of injured				
Total	18	4,305	8	1,813	23	8,188	17	4,875

*Source: Statistics on Traffic Accidents of Korean National Police Agency (Edition of 2015)

Table 4. Traffic accidents of children by time slot

Division	Number of Accidents	Death toll	Number of injured
Total	12,110	52	14,894
00~02	88	3	124
02~04	34	1	43
04~06	28	1	36
06~08	169	4	219
08~10	1,066	3	1,372
10~12	84	5	1,111
12~14	1,321	3	1,630
14~16	2,187	6	2,604
16~18	2,782	13	3,316
18~20	2,181	11	2,634
20~22	998	2	1,263
22~24	412	0	542

*Source: Statistics on Traffic Accidents of Korean National Police Agency (Edition of 2015)

As for the type of accidents in the school zone, there were more accidents of car vs person than car vs car, and the most accident happened while crossing the crosswalk registering up to 49.9%.

Table 5. Traffic accidents of children in the school zone by the type of accidents

Division	Type of accident	Accident		Deceased		Injured	
		Number of case	Pro portion	Number of person	Pro portion	Number of person	Pro portion
Total		523	100	4	100	553	100
Car vs Person	Subtotal	452	86.4	4	100	459	83.0
	While crossing the crosswalk	261	49.9	3	75	260	47.0
	While crossing the roadway	16	3.1	0	0.0	16	2.9
	While passing the edge of the street	14	2.7	0	0.0	15	2.7
	While passing the	24	4.6	0	0.0	24	4.8

Car vs Car	sidewalk						
	Other	137	26.2	1	25.0	144	26.0
	Subtotal	71	13.6	0	0.0	94	17.0
	Head-on collision	3	0.6	0	0.0	3	0.5
	Side right-angle collision	39	7.5	0	0.0	61	11.0
	Rear-end collision	1	0.2	0	0.0	1	0.2
	While moving						
Other	28	5.4	0	0.0	29	5.2	

*Source: Statistics on Traffic Accidents of Korean National Police Agency (Edition of 2015)

As for the cases of regulation violation of drivers among the traffic accidents occurred in the school zone, the highest case was with duty violation of pedestrian protection registering up to 41,1% followed by non-compliance with safe driving (20,3%) and traffic signal violation (17,6%).

Table 6. Traffic accidents of children in the school zone by regulation violation

Division	Accident		Deceased		Injured	
	Number of case	Pro portion	Number of person	Pro portion	Number of person	Pro portion
Regulation violation of drivers						
Traffic signal violation	92	17.6	1	25.0	116	21.0
Centerline violation	4	0.8	0	0.0	4	0.7
Speeding	4	0.8	0	0.0	4	0.7
Inappropriate turn	2	0.4	0	0.0	2	0.4
Violation of operation in the crossroad	4	0.8	0	0.0	4	0.7
Duty violation of pedestrian protection	215	41.1	2	50.0	215	38.9
Non-compliance with safe driving	106	20.3	0	0.0	108	19.5
Other	96	18.4	1	25.0	100	18.1
Total	523	100.0	4	100.0	553	100.0

*Source: Statistics on Traffic Accidents of Korean National Police Agency (Edition of 2015)

Most of traffic accidents of children happen both in the afternoon when the drivers lack concentration and at night with poor visibility, therefore, in developing design of safety signs of the school zone, the main object of protection should be focused on preschoolers and elementary school students who have difficulty with behavior control. Also, it is required to develop design which can not only emphasize the duty of pedestrian protection and arouse people's attention, but also secure the signal legibility even at night.

3.3 Analysis of safety sign cases in school zone



3.3.1 Current status of safety signs in school zones of Korea

Safety signs in school zone is for making in school zone and place in school zone with heavy traffic that installation of

signs is required to follow the standard set forth in installation and management manual of traffic safety facilities.





Currently, school zones of Korea use two different types of signs composed of indication signs and warning signs as shown in Table 7. However, they are exposed to some disadvantages in the sense that the forms and colors do not comply with ISO7010 and the pictogram is not highlighted because of the combined form of letter with pictogram.


Table 7. Safety sign in school zone

Division	Contents
<p>Indication sign</p> 	<ul style="list-style-type: none"> • Installation on streets or crosswalk that requires special protection of children or infants • Installation within 30m from the school entrance when there is street designated for children in front of school or kindergarten • Installation on both sides of the street in children protection point or zone
<p>Caution sign</p> 	<ul style="list-style-type: none"> • Installation on streets or crosswalk that requires special protection of children or infants • Installation on children protection zone or on the right side of streets within the range of 50~200m of the school zone • Installation on certain section of road within 30m from the school main entrance

There are caution sign and indication sign for safety signs in school zone in Korea, but the use policy of the two is being indicated as a problem because there is no clear use regulations and they are being used together

Table 8. Domestic and foreign cases of safety sign in school zone

Division	Contents
<p>Korea</p> 	<ul style="list-style-type: none"> • There is an image of a little girl walking hand in hand with a little boy on the blue background of a pentagon sign. • One-piece sign with inserted children protection phrase that the indication sign is being used as a caution sign.
<p>USA</p> 	<ul style="list-style-type: none"> • There is an image of a male and female adolescents walking on the sidewalk with a bag on the yellow background of a pentagon sign. • School indication sign is attached on the bottom on yellow background.
<p>UK</p> 	<ul style="list-style-type: none"> • A woman wearing a skirt is walking hand in hand in a rush with a boy on the white background of a triangle sign with a red border. • School indication sign is attached on the bottom of a white background with black border and is being used with caution sign.
<p>Japan</p> 	<ul style="list-style-type: none"> • Diamond shape yellow background with black border • A male adolescent is walking cautiously and slowly behind a little girl. • School walkway indication sign is attached on the bottom of a white background.

<p>Germany</p> 	<ul style="list-style-type: none"> • A woman wearing a skirt with long ponytail is leading a little boy by the hand on white background with red border of a triangle sign. • Used with a caution sign by attaching the school indication sign on the bottom of white background with black border
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According to the analysis of domestic and overseas cases of safety signs in school zone, 2 people are commonly indicated and showed difference in gender, age, clothing, and props, but older person taking care of and walking together with young children was the same. Also, excluding our country, indication sign and caution signs were being used together and the shape, color, and phrase of signs were unified.






3.4 Problems of safety signs in school zone

Effort to set up international standard is needed as it was identified that many cases in various countries including Korea are not following the safety color and outer form regulated in International Standard ISO 7010 of safety sign as in Table 9.

Problems of safety signs in Korea are as follows.

- ① The use policy of caution sign and indication sign is not clear and they are being used interchangeably.
- ② The design does not confirm international standards.
- ③ The pictogram target image is expressed unclearly.

Table 9. ISO 7010 safety sign [3]

Safety sign, reference number and referent	Category				
	E	F	M	P	W
Evacuation route, location of safety equipment or safety facility, safety action (safe condition signs)		Fire equipment signs	Mandatory action signs	Prohibition signs	Warning signs
 Reference number Referent	 F001 Fire extinguisher	 M001 General mandatory action sign	 P001 General prohibition sign	 W001 General warning sign	

4. Analysis method of questionnaire survey and its results

4.1 Analysis of general features of research target

The general features of research target are as follows:
 As for gender, male was 22.5% (9 people) and female was equally 77.5% (31 people). As for age, the majority corresponded to people in their twenties occupying 87.5% (35 people), followed by the forties occupying 10% (4 people) and the thirties registering 2.5% (1 person) in the last place. There were more single people occupying 85% (34 people) than married people. 50% of married people had children (3 people). There were 82.5% of university students/graduate students (33 people), 7.5% of employees (3 people) and 5% of professionals (2 people) and 2.5% of self-employed people (1 person) and 2.5% of housewives (1 person)

4.2 Analysis of general elements

4.2.1 Analysis of institutional perspective

This study inquired into how people value the importance of safety signs of the school zone and the result is as seen in Table 10. 50% of the respondents answered that they were "important" registering the highest score and 45% said they were "very important" in the second place. It was possible to know that most of citizens were aware of the importance of safety signs of the school zone.

Table 10. Importance of design of safety signs of the school zone

Division	Frequency	Proportion (%)
Strongly agree	18	45
Agree	20	50
Neutral	1	2.5
Disagree	1	2.5
Strongly disagree	0	0
Total	40	100

As for the question about the utilization degree of safety signs of the school zone, the highest score was with "neutral" registering 47.5% of totality, followed by 27.5% of "deficient" and 17.5% of "sufficient" in sequence. It turned out that most of respondents thought that the utilization of safety signs in the school zone was low

Table 11. Utilization of safety signs of the school zone

Division	Frequency	Proportion (%)
Strongly agree	1	2.5
Agree	7	17.5
Neutral	19	47.5
Disagree	11	27.5
Strongly disagree	2	5
Total	40	100

4.2.2 Analysis of design perspective

Table 12 shows the result of harmony between safety signs of the school zone and their surrounding public facilities from the design perspective. 57.5% of respondents answered that they were "not harmonious" registering the highest score, followed by 32.5% of "neutral" in the second place. It is estimated that people think that the signs of the school zone are not harmonious with other public designs of the surroundings.

Table 12. Harmony of safety signs of the school zone with the surroundings

Division	Frequency	Proportion (%)
Strongly agree	0	0
Agree	2	5
Neutral	13	32.5
Disagree	23	57.5
Strongly disagree	2	5
Total	40	100

As for the questions about satisfaction with safety signs of the school zone, 47.5% of respondents said that they "neutral" registering the highest score as seen in Table 13 followed by

40% of "were not satisfied" and 40% of "satisfied" in sequence. In sum, most people are not satisfied with them.

Table 13. Satisfaction with safety signs of school zone

Division	Frequency	Proportion (%)
Strongly agree	0	0
Agree	3	7.5
Neutral	19	47.5
Disagree	16	40
Strongly disagree	2	5
Total	40	100

As for the important elements of safety signs design of the school zone, they answered by the order of 47.5% of pictogram, 25% of color and 15% of installation place. The result shows that it is important to Pictogram a good visibility for the drivers so as to prevent accidents.

Table 14. Important elements of safety signs design of the school zone

Division	Frequency	Proportion (%)
Form	4	10
Color	10	25
Pictogram	16	40
Size	2	5
Place of installation	6	15
Other	2	5
Total	40	100

4.2.3 Analysis of cultural perspective

As for the cultural perspective of causes of occurrence of traffic accidents of the school zone, the result is shown in Table 15. As for the causes of occurrence of traffic accidents, 62.5% of respondents answered they happened because of "lack of awareness", 22.5% think they happen because of "lack of legibility" and 7.5%, because of "light penalty" was registered. The awareness of our country's drivers turned out to be weak; therefore, it is estimated that constant follow-up education will be required.

Table 15. Causes of traffic accidents occurred in the school zone

Division	Frequency	Proportion (%)
Awareness lack of drivers	25	62.5
Lack of publicizing	2	5
Lack of signal legibility of directional signs	9	22.5
Light penalty	3	7.5
Other	1	2.5
Total	40	100

Table 16 shows the results of the questions regarding the efforts to reduce traffic accidents in the school zone. In order to diminish traffic accidents in the school zone, they answered as follows by the order of importance: strengthening education (30%), strengthening regulations (20%), strengthening publicity and promotion (20%) and strengthening design (10%).

Table 16. How to reduce traffic accidents in the school zone

Division	Frequency	Proportion (%)
Strengthening publicity (promotion)	4	10
Strengthening design	5	12.5
Strengthening education	10	25
Strengthening regulation	21	52.5
Other	0	0
Total	40	100

4.3 Analysis of design elements

4.3.1 Analysis of design elements of safety signs of the school zone

In this study, as seen in the Table 17, the questions were asked which sign excelled in visibility, communicability, clarity, aesthetic factor and identifiability regarding the safety sign of the school zones of five countries.

Table 17. Analysis of design elements of safety signs of the school zone

Division		Korea	USA	Germany	Japan	UK	Other	Total
Visibility	Frequency	11	8	11	6	3	1	40
	Proportion	27.5	20	27.5	15	7.5	2.5	100
Communicability	Frequency	4	7	9	6	12	2	40
	Proportion	10	17.5	22.5	15	30	5	100
Clarity	Frequency	15	2	2	18	3	-	40
	Proportion	37.5	5	5	45	7.5	-	100
Aesthetic factor	Frequency	2	10	10	6	10	2	40
	Proportion	5	25	25	15	25	5	100
Identifiability	Frequency	5	9	9	3	14	-	40
	Proportion	12.5	22.5	22.5	7.5	35	-	100





The result is as shown in Table 17. A question on legibility that expressed children protection zone clearly, Germany was 27.5%, Korea was 27.5%, and followed by the United States of 20%. For a question on communicability of safety of the children protection zone, it was in the order of England of 30%, Germany of 22.5%, and the United States of 17.5%. For a question on clearly expressing the subject to be protected in children protection zone, Japan was highest with 45% and followed by Korea of 37.5%. It was identified that subjective view of beauty has been reflected as the United States was 25%, Germany was 25%, and England was 25% to a question on aesthetics in safety sign design. To a question on identifiability, England was highest with 35% and followed by the United States of 22.5% and Germany of 22.5%. According to the result, it was identified that safety signs of the United States and Germany evenly earned high scores, and improving clarity of expressing the main subject of protection will be evaluated as an excellent safety sign.

4.3.2 Design development of safety signs for school zones

As shown in Table 18 for newly proposed design of security signs for school zones, a triangle as a warning sign and the yellow color symbolizing “caution” were used, in accordance with ISO7010. Moreover, the new design concerned about an effective way of delivering a strong caution message to drivers, by way of a pictogram appearing a scene of

the main victims of school zones, preschoolers and elementary school students who rush, run and cross the street at the crosswalk only looking ahead. The black line of the back side means the crosswalk, and it was designed showing the scene of children crossing from the right side to the left side, in accordance with the rule of “Keeping to the right”. Furthermore, no letter is included in the indication sign but a text of “Protect children” is included in the warning sign to alert drivers to dangers.

Table 18. Design development of safety signs for school zones

Division	School Zone sign	
	Before	After
Indication sign		
Caution sign		

5. CONCLUSION

This study analyzed differences in shape and color of existing safety signs through a case analysis of traffic developed countries as America, England, Japan, and Germany and suggested improvement plans for drivers to clearly perceive the school zone.

Improvement plan of safety signs in school zone:

- Use with caution sign and indication sign.
- Follow triangle shape to confirm international standards.
- Show the pictogram target image more clearly.
- Use yellow to conform international standards.
- Require to design allowing clear visibility to preschoolers and elementary school students who are the main object of protection.
- It must be designed emphasizing the duty of pedestrian protection and arousing people's attention.
- Children should be warned about the risk of road crossing accidents.
- The design must secure legibility and readability even at night.

Actual design production and experiment through improvement plans are needed in the future, and it is expected to secure safety of children and to provide international standardization of safety signs in school zone.

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Hwang-Woo Noh

He received the B.S. and M.S. degrees from the Department of Industrial Design, Hanbat National University, Daejeon, Korea, in 1996 and 2003 respectively. He also has completed his Ph.D. degree course at the Department of Industrial Design, Chungnam

National University, Daejeon, Korea, in 2013. From 1997 to 2008, he worked as a representative of Design-Comphics Inc. He joined the faculty of the Department of Visual Design, Hanbat National University, Daejeon, Korea, in 2009. During 2008-2009 he served as an executive director of Korea Design Industrial Association where he was nominated Head of the Daejeon-Chungcheong Branch. He is currently a professor of Hanbat National University, a Secretary-General of Daejeon Design Development Forum, and a Vice-president of Korea Contents Association. His main research interests include Visual Communication Design and its Fundamentals, Packaging Design, and Disaster Prevention Design.



Chi-Gyu Oh

Professor of Chungnam National University, Daejeon, Korea