Journal of Innovative Transportation, 5(2), 22-33

Research Article

JOURNAL OF INNOVATIVE TRANSPORTATION

e-ISSN: 2717-8889

Awareness of right-of-way rules at unsignalized intersections: A case study from Isparta, Türkiye

Aydın KICI[a,*], Mesut TIĞDEMİR[b]

[a]Department of Civil Engineering, Faculty of Engineering and Natural Sciences, Suleyman Demirel University, Isparta, Türkiye
[b]Department of Civil Engineering, Faculty of Engineering and Natural Sciences, Suleyman Demirel University, Isparta, Türkiye

Highlights

- The level of awareness of right-of-way rules
- Right-of-way rules are crucial for safety at intersections
- The awareness of traffic rules was determined using a questionnaire method
- Average number of correct answers: 13.89 out of 18

Abstract

This study aims to measure the level of awareness of the participants living in Isparta, Türkiye, regarding the right-of-way rules at intersections. A questionnaire was prepared to determine the level of awareness of the right-of-way rules, and a sample of 302 randomly selected participants were invited to respond to the questionnaire. In evaluating the results, participants were categorized into three groups based on their awareness levels: low, moderate, and high. When all questions were considered, it was observed that 24% of the participants had a low level of awareness, 54% had a medium level of awareness, and 22% had a high level of awareness. We established that the least known rules included traffic signs related to yielding and stopping, and right-of-way rules in terms of road priority. According to this, it has been concluded that drivers do not fully understand some fundamental right-of-way rules, and this situation can be a significant factor leading to driver-related accidents at uncontrolled intersections. In this paper, we propose that responsible agencies take measures to reduce accidents caused by violations of right-of-way rules.

Information

Received:
28.10.2024

Received in revised:
01.12.2024

Accepted:
16.12.2024

Keywords: *Traffic safety, right-of-way rules, unsignalized intersections, questionnaire*

1. Introduction

Intersections are connection points where two or more roads merge or intersect, managed by signalization, traffic signs, or basic right-of-way rules. Intersections are critical points where rules must be followed to ensure the safe and continuous movement of vehicles, pedestrians, and cyclists and to enable balanced interactions. As seen in Figure 1, intersections are road connection points where conflicts, such as vehicle-vehicle and vehicle-pedestrian, occur frequently in the forms of crossing, divergence, and merging. Therefore, the accident risk is significantly higher than other parts of the transportation network. The number of conflict points can be reduced by structures with different geometries, such as grade-separated junctions (interchanges) and roundabouts. Additionally, some geometric designs can be used to reduce accidents [1]. Nevertheless, considering the cost of construction and the challenges associated with expropriation, this may not always be feasible. A wide variety of accidents occur at intersections, including head-on, broadside, rear-end, and sideswipe collisions [2].

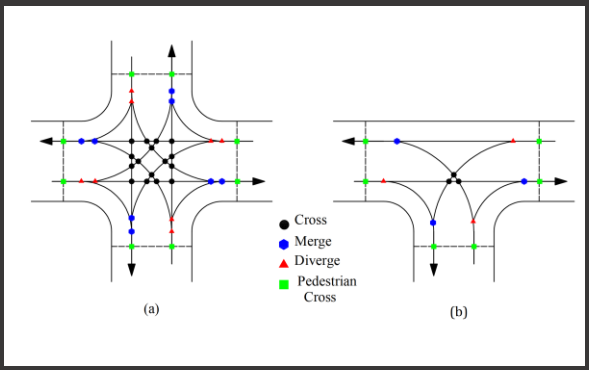

Figure 1. Conflict points at three (a) and four (b) leg intersections [3]

*Corresponding author: aydinkici@sdu.edu.tr (A. Kici), +90 246 211 1222

https://doi.org/10.53635/jit.1575012

The prevailing emphasis in academic research on traffic accidents has been directed towards intersections [4-8]. For this reason, it is crucial to design and manage intersections carefully.

Intersections can be managed using various control methods, which can be evaluated under three main categories [3]: Level 1 involves basic right-of-way rules, Level 2 includes the determination of right-of-way using "Stop" and "Yield" signs, and Level 3 involves the use of signalization.

Choosing the control method for an intersection requires significant engineering knowledge and meticulous evaluation. Traffic control methods for the examined intersection should be determined based on traffic volume, peak-hour factors, and pedestrian and cyclist density. While signalization control is generally considered the most reliable method among traffic control methods, it may not always be the most accurate solution. While signalizations may reduce certain types of accidents and ensure pedestrian safety, they can also lead to increased delays and stop-and-go traffic, potentially causing a higher frequency of specific types of accidents, such as rear-end collisions. The conditions that need to be met to install a signalization system or stop and yield signs for the analysed intersection are specified in the Manual of Uniform Traffic Control Devices (MUTCD) [9]. In cases where these conditions are not met, and the traffic for vehicles and pedestrians is low, the Level 1 traffic control method, based on basic right-of-way rules, is preferred. Uncontrolled intersections include only Level 1 controlled intersections, and in the management of intersections, only basic right-of-way rules are in operation. No traffic signals exist at an uncontrolled intersection, and neither 'Stop' nor 'Yield' signs are present. The presence of location signs and directional arrows does not alter the uncontrolled nature of these intersections.

1.1. Traffic accidents in Türkiye and Isparta

When examining accident statistics, it can be observed that in Türkiye, a total of 281,054 faults were reported in fatal and injury accidents in the year 2023 alone. These faults comprise 249,856 driver-related faults, constituting 86.8% of all faults. As presented in Table 1, the percentages of pedestrian, vehicle, passenger, and road-related faults are 9.02%, 1.12%, 0.62%, and 0.34%, respectively. Approximately 32.5% of driver-related accidents occurred due to non-compliance with right-of-way rules, turning regulations, and traffic sign violations at intersections. In total, 6,548 individuals lost their lives, and 350,855 individuals were injured in accidents, accounting for all fatalities and injuries [10].

When examining the data from the US Department of Transportation, it is observed that during the five years between 2017 and 2021, 192,609 individuals lost their lives due to traffic accidents, with 53,422 of these fatalities occurring at intersections and road connections. 68% of the accidents at intersections and road connections occurred in unsignalized intersections [11].

Table 1. Faults in Fatal and Injurious Accidents Occurred in Türkiye in 2023 [10]

	No. of Faults	Fault Rates
Driver Fault	249 856	88.90%
Pedestrian Faults	25 355	9.02%
Vehicle Faults	3 149	1.12%
Passenger Faults	1 754	0.62%
Roadway Faults	940	0.34%
Total Faults	281 054	100%

A large proportion of accidents at intersections and road connections, as noted by the NHTSA, are caused by human factors. The human factor comprises various characteristics such as age, gender, awareness level, fatigue, stress, socio-cultural background, and many others. Ensuring traffic safety, understanding the human factor, and taking appropriate measures can only be achieved through observations and questionnaires. Using various survey methods, traffic users' awareness of traffic rules and their attitudes toward traffic regulations and safety measures have been examined in many studies [12-21].

To minimize accidents caused by human factors, all road users should learn, know, and understand traffic rules through education, media, or road safety training. In addition, from a holistic perspective, it should be aimed to raise public awareness, internalize the rules by road users, and create a road-safe culture accordingly [12] Especially at un-signalized intersections, drivers are assumed to be aware of traffic signs and right-of-way rules. However, it is not known to what extent this assumption is correct. Therefore, this study aims to determine the awareness of right-of-way rules at uncontrolled intersections using survey method. The study was conducted in the province of Isparta, located in the Mediterranean region of Türkiye as seen in Figure 2. According to the 2023 data, the total population is 449,777, with the city center's population being 271,396 [22]. When considering the number of vehicles per person, the average in Türkiye is approximately 0.31 vehicles per person, whereas in Isparta province, this ratio is approximately 50% higher than the national average, at 0.44 vehicles per person. During the five years between 2018 and 2022, 23,173 traffic accidents occurred in Isparta province. As a result of these traffic accidents, the numbers of fatalities and injuries were determined as 213 and 10,795, respectively [10].

1.2. Right-of-way rules

When considering an at-grade intersection, many factors influence the determination of right-of-way, including the geometry of the intersection, the characteristics of the approach arms, the presence of a police officer or traffic control person at the intersection, and the type of control

at the intersection. In the presence of a police officer or traffic control person at the intersection, other signs and signals at the intersection are disregarded, and the instructions of the relevant individual are followed. If the intersection is a roundabout, the right-of-way always belongs to the vehicle inside the roundabout, and vehicles approaching from the entry arms must yield by slowing down to the circulating traffic. Contrary to common practice, in Türkiye, stop signs or signals within roundabouts often confuse road users. If the intersection control is provided by traffic signals or stop and yield signs, drivers follow these signals and signs to determine the right-of-way rules.

Finally, if the intersection is designed as uncontrolled, basic right-of-way rules are followed. In this case, drivers should approach the intersection cautiously and yield to pedestrians and cyclists. At these intersections, vehicles from the undivided approach road must yield to vehicles from the divided approach road. The 'first in, first out principle always applies in uncontrolled intersections. If two or more vehicles approach the intersection simultaneously, turning vehicles must yield to the vehicles going through and those on their right. These rules are explicitly stated in both the Turkish Road Traffic Law and the Turkish Road Traffic Regulations [23,24]. A flowchart illustrating the right-of-way based on the type and condition of intersections is presented in Figure 3.

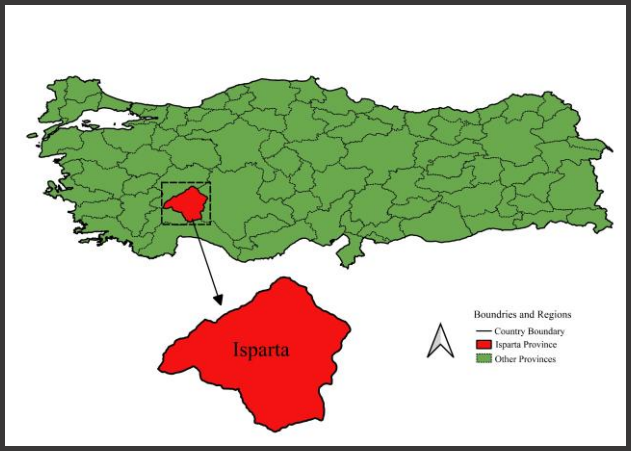

Figure 2. Location of Isparta Province

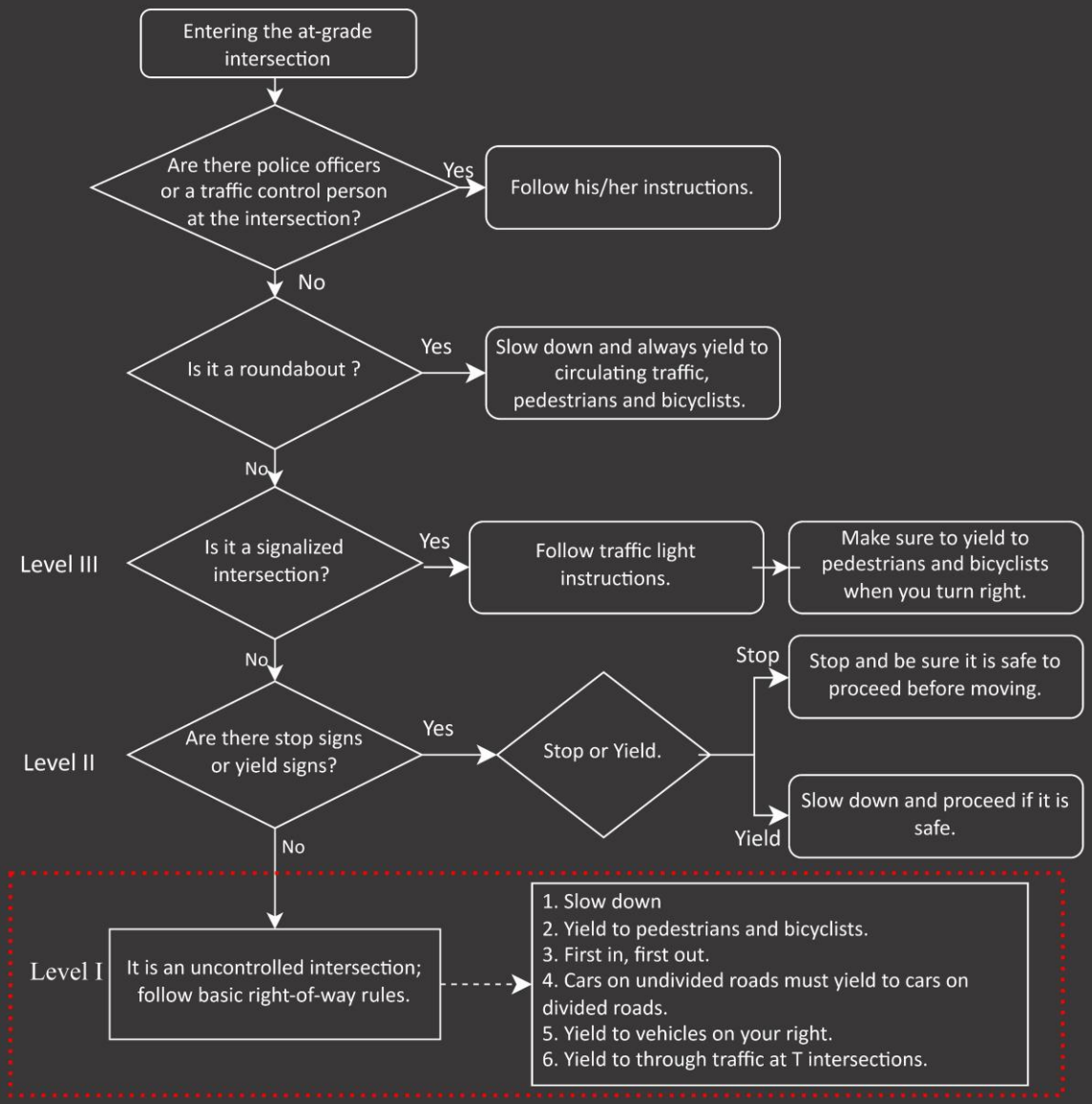

Figure 3. Intersections right-of-way diagram

2. Literature Review

In the study conducted by Bucsuházy et al. [25] the causes of accidents and the effects of human factors on accidents were evaluated concerning experience, attention, mental and physical condition, driving habits, and socio-demographic information. It was emphasized that accidents were more frequent in the young (18-24) and senior (+65) age groups, which was attributed to a lack of experience in young drivers and a decrease in psychomotor functions in senior drivers.

Mutlu and Yakar [26] conducted a study investigating the awareness of traffic signs. According to this study, the recognition rate of the 'yield' sign in multiple-choice questions was found to be 74.6%, while the awareness of the 'main road' sign was determined to be 34.3%. When demographic data was examined, it was observed that driver experience was the most significant factor in correctly answering the questions. Similarly, in their study measuring the recognition of traffic signs, Umar and Bashir [27] found that the average level of recognition was 79% for all participants and that driver experience was the most crucial factor in correctly answering the questions.

Şehribanoğlu [28] conducted a survey to measure the knowledge levels of individuals about traffic signs living in Van province, Türkiye. It was observed that the participants had very low rates of correct answers. The results obtained from the study indicate that young participants are more successful in recognizing traffic signs. Additionally, the study has found that males have a higher level of knowledge compared to females. Çakıcı and Murat [15] conducted a survey in Denizli province, Türkiye, with the aim of measuring the awareness levels of participants regarding traffic signs, using multiple-choice questions, each consisting of four options. According to the study's results, the awareness level of the yield sign was 51%, while the awareness level of the main road end sign was only 41%. It was determined that out of the 27 traffic signs included in the survey, 37% were awareness at a moderate to low level. Out of the 27 traffic signs included in the survey, 37% were found to have a middle and low level of awareness.

Ningal and Oños [29] analyzed where motorcycle drivers acquire their knowledge about traffic. Accordingly, it has been demonstrated that social media, roads and traffic signs, personal observations and experiences, peer and relatives' instructions, and traffic authorities' examinations play a significant role in shaping drivers' knowledge level about traffic. The study also emphasized the crucial role of public institutions in traffic education. Education levels, along with individuals' decisions and preferences, significantly influence traffic patterns, travel mode choices, and consequently, impact overall safety [30].

Using gamified methods can greatly help to improve people's knowledge of different subjects. İçten [31] provided education on traffic signs and rules in virtual 3D rooms. Through the participants' experiences using VR goggles, the study captured their interest, enthusiasm, and attention, leading to a positive change in the participants' cognitive and perceptual abilities. At the end of the application, a significant amount of positive feedback was received from the participants. In another study, Topkaya [32] demonstrated the potential use of comics in teaching traffic rules. According to the results obtained from this study, comics in traffic education have been shown to create an engaging and enjoyable classroom environment, thereby making traffic education more entertaining.

Cheng et al. [33] examined the utilization of artificial intelligence (AI) and virtual reality-supported (VR) driving simulators and reviewed published articles on this subject. According to the results obtained from the study, artificial intelligence and virtual reality are promising methods that can be utilized in driver education. Backlund et al. [34] and Gounaridou et al. [35] have explored the educational effectiveness of a game-based simulation on traffic rules and traffic safety. Based on the results, it can be concluded that a game-based simulation can be employed to enhance learning in driver education.

In addition to advanced technologies like AI and VR, social media, one of today's essential communication tools, can also be utilized to promote traffic safety awareness and inform individuals. In their study, Özel [36] examined the engagement generated by the Turkish Ministry of Interior's social media posts related to traffic safety. According to the study's findings, it has been emphasized that public institutions are successful in generating significant engagement through social media and that it can be a powerful tool for raising awareness among individuals about traffic safety.

Similarly, Gülada et al. [37] noted that in many countries, public service announcements about the importance of traffic safety are implemented using emotional appeals such as fear and sadness, focusing on themes of death, injury, and family. Another result obtained from the study that there are fewer public service announcements in middle-income countries compared to high-income countries, emphasizing the need for more efforts in this regard in Türkiye as well. Kavsıracı et al. [38] examined the impact of social campaigns, enforcement, and administrative penalties on individuals regarding traffic safety. According to the data obtained from the study, it was demonstrated that in the short term, social campaigns and public service announcements are more effective in creating a long-term traffic culture compared to traffic enforcement and penalties.

3. Method

3.1. Data collection tools and participant

In this study, the survey method was employed to determine the awareness of right-of-way rules at uncontrolled intersections. The survey method is a reliable approach commonly used to measure people's knowledge and awareness levels about various subjects in fields such as economics, politics, health, engineering, and more [39-45]. According to the general trend today, mixed-mode survey methods, which allow different data collection methods to be used simultaneously to increase the low response rate, are preferred in collecting data [46,47]. Therefore, in this study, a mixed-mode survey method has been employed, involving face-to-face and online data collection methods.

As the sample size increases, the approach to actual results will become closer, thus enabling more sensitive estimations [48]. However, having a large sample size does not always guarantee the most accurate results. Therefore, considering specific confidence levels and margin error, a sample size is determined within the framework of criteria such as time, cost, and accuracy.

When considering the selected confidence level, margin of error, and population size, Equation 1 can be used to calculate the sample size [49].

$$n = \frac{n_0}{1+\frac{n_0}{N}}, n_0 = [(t.s)/d]^2 \quad (1)$$

Here, t represents the confidence level, N is the population size, s is the standard deviation, and d is the margin error.

A total population of 271,396 people reside in the city center of Isparta province. When considering road users aged 18 and above, it is estimated that individuals in this age group account for approximately 77% [22]. In this case, the total examined population was obtained as 208,975 individuals. Using Equation 1, the minimum sample size for a 90% confidence level and a 5% margin of error has been determined to be at least 271. Therefore, the questionnaire was conducted with N=302 participants, and as presented in Table 2, four main demographic data were requested from the participants, including gender, age, years as a licensed driver, and education level.

3.2. Data collection tools and participants

In this study, as the aim is to test the awareness of right-of-way rules in Isparta province, the sample population consists of traffic users residing in Isparta province. The sample selection followed the principle of randomness and adhered to the specified sample size. The questionnaire was limited to people who had a driver's license. In addition, the gender distribution of participants was determined based on the ownership rates of driver's licenses among male and female drivers. According to 2022 data, the driver's license ownership rates in Türkiye were 70.6% for men and 29.4% for women [22]. This questionnaire comprises four sections: an introductory information section, a demographic information section, a section containing questions related to fundamental right-of-way rules, and a section containing questions about traffic signs. The first section provides information about the questionnaire's objective, voluntary consent, and the structure of the questions. The second section includes questions about the participants' gender, age, driving status, and education levels. In the third section, visual questions were asked to assess the participants' awareness of right-of-way rules. Finally, questions regarding traffic signs, signalization, and priority of emergency vehicles were asked in the fourth section. The contents of the questions are shown in Table 3.

Table 2. Demographic Characteristics of Questionnaire Participants

Gender	**Male (N=205)**				**Female (N=97)**				**Total (N=302)**
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Years as a licensed driver	0-5 47 (23%)	6-20 87 (42%)	+20 71 (35%)	All 205 (100%)	0-5 23 (24%)	6-20 54 (55%)	+20 20 (21%)	All 97 (100%)	**302 (100%)**
Age				-				-	
18-30 (Young)	47 (100%)	27 (31%)	-	74 (36%)	18 (78%)	20 (37%)	-	38 (39%)	**112 (37%)**
31-45 (Middle)	-	56 (64%)	18 (26%)	74 (36%)	5 (22%)	26 (48%)	2 (10%)	33 (34%)	**107 (35%)**
46-65 (Mid-Old)	-	3 (4%)	40 (56%)	43 (21%)	-	6 (11%)	10 (50%)	16 (17%)	**59 (20%)**
+65 (Old)	-	1 (1%)	13 (18%)	14 (7%)	-	2 (4%)	8 (40%)	10 (10%)	**24 (8%)**
Education Level									
Primary Sc.	-	2 (2%)	15 (21%)	17 (8%)	1 (4%)	3 (6%)	5 (25%)	9 (9%)	**26 (9%)**
Middle Sc.	3 (6%)	7 (8%)	7 (10%)	17 (8%)	-	4 (7%)	7 (35%)	11 (11%)	**28 (9%)**
High Sc.	9 (19%)	18 (21%)	17 (24%)	44 (22%)	7 (30%)	15 (28%)	2 (10%)	24 (25%)	**68 (23%)**
University Deg.	31 (66%)	44 (51%)	23 (32%)	98 (48%)	10 (44%)	14 (26%)	3 (15%)	27 (28%)	**125 (41%)**
Graduate Deg.	4 (9%)	16 (18%)	9 (13%)	29 (14%)	5 (22%)	18 (33%)	3 (15%)	26 (27%)	**55 (18%)**

Table 3. Sections and contents of the questionnaire form

Sections of the Questionnaire Form	
Section I - Information About Questionnaire • Information about the goal of the questionnaire • Consent to voluntary participation • Information about the structure of the questions • Other Information	**Section II - Demographic Information** • Gender • Age • Active driving status • Years as a licensed driver • Level of education
Section III - Questions About Basic Right-of-Way Rules • 6 Questions for testing basic right-of-way rules • 2 Questions for testing traffic signals about yield and stop • 2 Questions for testing pedestrian and bicyclist priority • 4 Questions for testing basic right-of-way rules in terms of road priority	**Section IV - Questions About Traffic Signs and Other Questions** • 1 Question for testing traffic lights • 2 Questions for testing traffic signals about yield and stop • 1 Question for testing emergency car priority

Questions were asked visually in the third and fourth sections to assess participants' awareness levels of right-of-way rules. Participants were presented with visually depicted conflict scenarios for various situations and were asked to indicate the right-of-way for vehicles, bicycles, or pedestrians. Pedestrians, cyclists, and vehicles were designated as entities A and B. To avoid influencing participants' responses, vehicle colors were marked as neutral colors, specifically blue and white. Visuals related to some of the questions asked in the study are presented in Figure 4. In each question, "Which vehicle has the right-of-way?" was asked, and participants' responses were collected. To prevent the prolongation of the questionnaire duration, the questions in the third and fourth sections, which were used to assess awareness of right-of-way, were limited to 18 in total. The average response time for the questionnaire was found to be 190 seconds. This duration is considered ideal for participants to answer all questions without getting bored or distracted.

Figure 4. Some of the questionnaire questions

The third and fourth section questions in the questionnaire, which were prepared to assess participants' awareness of right-of-way rules, are generally multiple-choice questions consisting of two options. In two-option questions, since participants have a 50% chance of randomly selecting the correct answer even if they do not know it. The total number of questions participants answered correctly and incorrectly was initially calculated to obtain a meaningful statistical result. Subsequently, based on the number of questions participants answered correctly, they were categorized into three classes of awareness levels: low, moderate, and high. In the questionnaire, a total of 18 questions were asked to measure participants' awareness level regarding right-of-way rules. Similarly, in other studies in the literature, such scaling has been performed to measure the awareness level [15]. Those who answered 12 questions or fewer correctly were categorized as having low awareness, those who answered between 13 and 15 questions correctly were categorized as having medium awareness, and those who answered 16 questions or more correctly were considered to have a good level of awareness about right-of-way rules. Additionally, to determine the questions that participants found easiest and most challenging, the average percentage of correct answers given by all participants to each question was calculated. Questions with a correct answer rate below 70% were classified as low accuracy, those within the range of 71% to 85% were categorized as medium accuracy, and those with a rate exceeding 85% were considered high accuracy.

4. Findings

4.1. Correct answer rates by question

There are 18 questions in this questionnaire to test awareness of the right-of-way rules. 6 of these 18 questions were asked to test basic right-of-way rules, 4 of these asked to test traffic signals about yield and stop, 2 of these asked to test pedestrian and bicyclist priority, 4 of these asked to test basic right-of-way rules in terms of road priority, 1 of these asked to test traffic lights and 1 of these asked to test emergency car priority. The questions have been classified based on the provided correct answer rates. Questions with a correct answer rate below 70% are categorized as Low Accuracy, those falling within the range of 71% to 85% are considered

Table 4. Rate of correct answers to each question

Question Number	Accuracy Rate (%)	The Aim of the Question	Question Number	Accuracy Rate (%)	The Aim of the Question
1	89.7	Basic right-of-way rules	10	58.3	Basic right-of-way rules in terms of road priority
2	71.9	Basic right-of-way rules	11	70.9	Basic right-of-way rules
3	83.8	Basic right-of-way rules	12	87.4	Basic right-of-way rules in terms of road priority
4	88.4	Basic right-of-way rules	13	57.9	Basic right-of-way rules in terms of road priority
5	93	Pedestrian and bicyclist priority	14	73.5	Basic right-of-way rules in terms of road priority
6	96	Pedestrian and bicyclist priority	15	94	Traffic lights
7	86.1	Basic right-of-way rules	16	45.4	Traffic signs about yield and stop
8	56.3	Traffic signals about yield and stop	17	63.2	Traffic signs about yield and stop
9	84.4	Traffic signals about yield and stop	18	88.7	Emergency car priority

Green – High Accuracy Level (16 or more correct), Yellow – Medium Accuracy Level (13-15 correct), Red – Low Accuracy Level (12 or fewer correct)

Medium Accuracy, and questions with a correct answer rate exceeding 85% are classified as High Accuracy questions.

When the results were examined, it was observed that the accuracy rates of questions 1, 2, 3, 4, 7, and 11, which were asked to test the Basic Right-of-Way Rules, were around an average of 80%. Among these questions, questions 2, 3, and 11 were found to be at the medium accuracy rate, while the others were determined to be at the high accuracy rate. The questions numbered 8, 9, 16, and 17, which were asked to assess awareness of traffic signals about yield and stop, had a significantly lower accuracy rate compared to all other test questions. It was determined that the average accuracy rates of these four questions were around 60%. It has been observed that the awareness of question number 9 is at the medium accuracy level, while the others are at the low accuracy level in this field.

Most participants correctly answered the questions about the priorities of pedestrians and cyclists. Accordingly, it was observed that participants answered questions number 5 and 6 with an average 95% accuracy rate. When examining the responses to questions number 10, 12, 13, and 14, which were asked to test basic right-of-way rules in terms of road priority, it was observed that participants struggled with questions number 10 and 13. Their accuracy rates were below 60%, indicating a low accuracy rate. Question number 11, on the other hand, was answered correctly at the medium accuracy rate. Additionally, it was observed that question number 15, asked to assess the awareness about traffic lights, and question number 18, asked to assess the awareness about emergency car priority, were known at very high accuracy rates. The Accuracy rates for each question are presented in Table 4.

The total number of correct answers given by each of the 302 participants in the questionnaire has been calculated. Subsequently, those who answered 12 or fewer questions correctly were considered to have a low level of awareness (LOA), those who answered 13 to 15 questions correctly were considered to have a medium level of awareness, and those who answered 16 or more questions correctly were considered to have a high level of awareness. According to this, it has been determined that 24% of the participants have a low level of awareness, 54% have a medium level of awareness, and 22% have a high level of awareness. The number of correct answers given by participants is presented in Figure 5. When examining this data, it is observed that 23% of the participants, constituting the largest group, answered 14 questions correctly, while only 1% answered all questions correctly.

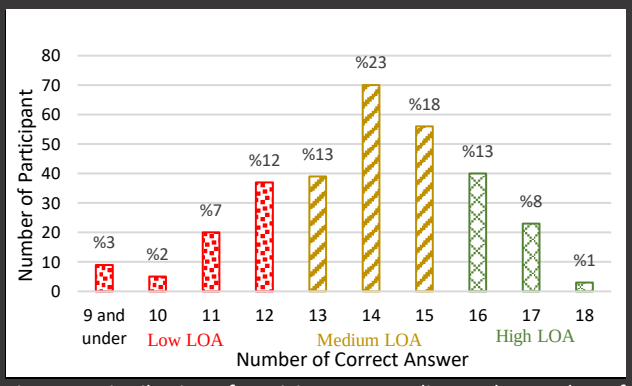

Figure 5. Distribution of participants according to the number of correct answers

4.2. Demographic effect on correct answers

The average number of correct answers for each demographic group has been calculated to examine the relationship between the demographic characteristics of the participants and their correct answers. When considering all 302 participants in the questionnaire, the average number of correct answers is 13.89. Figure 6 provides the average number of correct answers for each demographic group. When considering 18 questions, the overall average correct answer rate was calculated as 77%.

The descriptive statistical data for the participants' scores have been analyzed. According to the analysis results the mean score for correct answers is M=13.89, with a standard deviation of SD=2.09, a variance of var=4.35, and the p-value of the Shapiro-Wilk test is less than p=0.001 were found. As the p-value of Shapiro Wilk Test is below p=0.001 which is less than the %5 level of significance we reject null hypothesis which means that the data is not normally distributed. Non-parametric Kruskal-Wallis and Mann-Whitney U analyses were chosen because the data does not follow a normal

distribution. The chosen tests, Mann-Whitney U test is a non-parametric test used to assess differences between two independent groups, while the Kruskal-Wallis test is a non-parametric test used to compare differences among three or more independent groups.

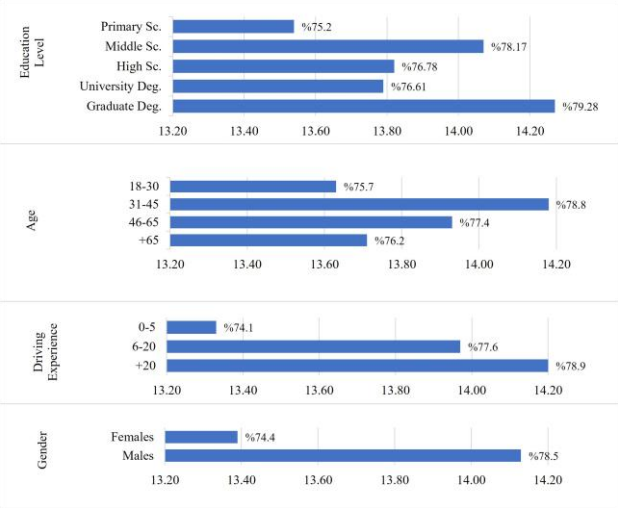

Figure 6. Average number of correct answers and rates by demographic group

Since gender has only two categories (male and female), we used the Mann-Whitney U test. For variables like education level, experience, and age, which have three or more categories, the Kruskal-Wallis test has been preferred. According to the Mann-Whitney U test, a significant difference was observed between female and male groups in terms of scores (p=0.00). The size of the male group is 205, and the size of the female group is 97. The mean and standard deviation values for the male and female groups are found Mmale=14.2, SDmale=1.82 and Mfemale=13.4, SDfemale=2.35, respectively.

When examining the results of the Kruskal-Wallis test, no significant difference was observed among age groups (p=0.20) and education level groups (p=0.54), while a significant difference was found among experience groups in terms of scores (p=0.02) (Table 5).

Table 5. Kruskal-Wallis test parameters

Scores	Kruskal-Wallis		
	χ^2	df	p
$Experience_{score}$	7.55	2	0.02
Age_{score}	4.60	3	0.20
$Education_{score}$	3.09	4	0.54

When examining pairwise comparisons, no significant difference was observed between participants with over 20 years of experience and those with 6-20 years of experience (p=0.89). However, significant differences were found among other groups in terms of scores (p=0.03 and p=0.05) (Table 6).

Examining the participants' education levels it is shown that participants with postgraduate degrees have the highest average with 14.3 correct answers. This group is followed by middle school graduates with an average of 14.07 correct answers. Participants with high school and university degrees were found to have correct answer averages of 13.82 and 13.79, respectively. Thus, participants with middle school education have surpassed those with high school and university degrees in terms of average correct answers. This is mainly because most middle school graduates among the participants fall into the middle-age group of experienced drivers. In Türkiye, in 2012, mandatory education was elevated from middle school to high school level, resulting in a situation where middle school graduates among adults in society are predominantly from middle and older age groups.

Table 6. Pairwise comparisons of experience groups

Experience Group 1	Experience Group 2	W	p
+20 years	6-20 years	-0.66	0.89
+20 years	0-5 years	-3.57	0.03
6-20 years	0-5 years	-3.36	0.05

When examining the number of correct answers by age group, it is observed that the middle-age group (31-45) surpasses other age groups with an average of 14.18 correct answers. The middle age group was followed by the middle-old group, with an average of 13.93. The average number of correct answers for the young and old age groups found 13.63 and 13.71, respectively. Here, it has been demonstrated that experience plays a significant role in answering the questions, but it is also shown that the number of correct answers is inversely proportional to age beyond the middle age group. When these results are examined, it can be said that experience directly influences the awareness of right-of-way rules.

When examining driver experience, those with less than five years of experience scored the lowest at an average of 13.33 correct answers, while the increase in experience corresponded to a higher number of correct answers. It has been observed that drivers with 6-20 years of experience have an average of 13.97 correct answers, while drivers with more than 20 years of experience have an average of 14.20 correct answers. When examining the average number of correct answers for gender groups, it is observed that the average number of correct answers for women is 13.39, whereas for men, it is 14.13.

5. Discussion and recommendations

In this section, the participant awareness levels about right-of-way rules, as measured through conducted survey studies, are discussed. Additionally, recommendations are provided for enhancing individuals' awareness levels.

5.1. Discussion

When considering all participants, the average number of correct answers is 13.89. This result indicates a 77.2%

accuracy rate for all participants. Based on the results the level of awareness level for the right-of-way rules has been found to be insufficient for a safe traffic environment. The analysis of questionnaire responses also revealed patterns in participants' awareness of right-of-way rules. Questions were grouped into three accuracy levels: low, medium, and high. While many questions were answered accurately, some had medium or low accuracy. Participants particularly struggled with recognizing stop and yield traffic signs. These findings emphasize the necessity of taking measures for traffic safety and awareness.

The analysis of participants' responses and demographic data revealed that driver experience was the most significant factor influencing the correct answer scores. As experience increased, scores improved. Those with 6-20 years of experience answered correctly at a slightly higher rate, while drivers with more than 20 years of experience achieved the highest accuracy. These findings emphasize the critical role of experience in driver proficiency and suggest that targeting educational interventions at young and inexperienced drivers could enhance traffic safety by bridging their knowledge gap.

When examining the average correct answers of gender groups, it is observed that women have fewer correct answers compared to me. Regarding age groups, the middle-age group surpasses others with the highest average of correct answers, reflecting the potential impact of experience. Following this group is the middle-old age group, which also performs well. The young and old age groups have similar averages, with both slightly below the middle-old group. This result demonstrates that experience plays a significant role in answering the questions. As a solution, educational and information update programs should be tailored to each age and gender group to help improve level of awareness about right-of-way rules of drivers.

5.2. Recommendations

Bucsuházy et al. [25] link traffic accidents in young individuals to driver experience and associate them with psychomotor functions in elderly drivers. In addition to Bucsuházy et al. [25] findings, when the responses of these young and elderly drivers were examined, it was observed that these age groups had a low level of awareness in our study. Therefore, it is believed that another reason for accidents observed in the young and senior age groups is a low level of awareness.

Studies conducted in the literature to measure people's knowledge levels on traffic safety mostly focus on the awareness of traffic signs [15, 26-28]. In our study, unlike these studies, the awareness of right-of-way rules at intersections has been examined. When examined from the perspective of traffic safety, our results align with the mentioned studies. When examined in conjunction with other studies, drivers have a significantly low awareness of traffic signs and rules. This situation constitutes a threat to traffic safety, increasing the likelihood of accidents. Therefore, it is crucial to educate individuals about traffic safety through various methods, beginning with schools.

The conducted studies demonstrate that drivers can obtain information about traffic from a wide range of sources, such as social media, roads and traffic signs, personal observations and experiences, peer and relatives' instructions, and traffic authorities' examinations [29]. Therefore, all available communication methods should be utilized to raise awareness among individuals regarding traffic safety.

When examined in the literature, it is observed that civil society organizations, public institutions, and schools are making efforts to establish more effective communication with individuals to increase their awareness of traffic safety. This communication can be facilitated through gamified educational methods that emphasize human experience, incorporating technology, virtual 3D rooms [31], and simulations [33-35]. We also believe and recommend that the implementation of virtual rooms and simulations, which allow participants to experience, especially in schools, will increase awareness of traffic safety and reduce traffic accidents.

The evolving communication methods of today have allowed social media to have a substantial impact on people. It is also possible to utilize the communication power of social media for traffic safety [36]. It is believed that public institutions, civil society organizations, and well-recognized politicians, writers, artists, athletes, and celebrities, by using social media, can play a significant role in raising awareness among individuals about traffic safety, which is thought to be crucial in reducing traffic accidents. Furthermore, public service announcements using emotional appeals such as fear and sadness, with a focus on themes of death, injury, and family, can be utilized in raising awareness among individuals [37]. In this regard, it is believed that well-crafted public service announcements, when presented to the right audience, can raise awareness among individuals about traffic safety.

According to the results obtained from the study, participants with medium and low levels of awareness comprise 76% of all participants. To increase the awareness level of individuals in this group, responsible agencies take measures to reduce accidents caused by violations of right-of-way rules. These measures should include tightening the eligibility criteria for obtaining a driver's license, conducting public service campaigns, public service ads, and disseminating information about traffic right-of-way rules. The primary objective of these measures is to enhance public awareness of right-of-way

rules. All these outlined measures can be implemented in the province of Isparta and nationwide in Türkiye.

6. Limitations and Future Research

The scope of this study has been limited to the province of Isparta in Türkiye. In future research, the awareness of right-of-way rules can be examined with a larger number of participants from different provinces and regions. This way, the level of awareness regarding right-of-way rules can be more accurately determined for all of Türkiye, and the results obtained for different regions can be compared with each other to identify regional variations.

Due to the challenges of finding participants in the questionnaire method, the participants of this study may not fully represent the demographic groups within the society in equal proportions. In forthcoming studies, increasing the number of participants can lead to a more accurate representation of the demographic groups within the society by the selected participants.

In traffic, driver, pedestrian, and cyclist behaviors can also be influenced by psychological and sociological reasons. Therefore, knowing a rule in traffic does not guarantee compliance with that rule. Knowing them alone does not give them meaning when rules or norms are not followed. In this regard, the behaviors of traffic participants may need to be approached from a more comprehensive perspective. Societies may know or not know the laws, accept or reject them, agree or disagree with the rules, and comply or not comply with them. Therefore, in future studies, participants' levels of awareness about right-of-way rules, their real-life adherence to these rules, and their behaviors can be observed together to determine how well awareness translates into practice.

Declaration of Interest Statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author Contribution Statement

A. Kıcı: Formal analysis, Investigation, Resources, Software, Validation, Visualization, Writing – Original draft, Writing – Review & editing; **M. Tığdemir:** Conceptualization, Data curation, Methodology, Project administration, Supervision, Writing – Review & editing.

Acknowledgement

The method and topic of the study were reviewed and approved by the Süleyman Demirel University Ethics Committee, with the approval granted on December 27, 2022 (Decision No: 69/5).

References

[1] Erişkin, E., Karahançer, Ş., Terzi, S., & Saltan, M. (2020). Highway geometric design using Bézier curve approximation. *Journal of Innovative Transportation*, *1*(1), 1104.

[2] Ye, X., Pendyala, R. M., Washington, S. P., Konduri, K., & Oh, J. (2009). A simultaneous equations model of crash frequency by collision type for rural intersections. *Safety Science*, 47(3), 443-452. https://doi.org/10.1016/j.ssci.2008.06.007

[3] Roess, R. P., Prassas, E.S., & McShane, W.R. (2004). Traffic Engineering. Pearson/Prentice Hall.

[4] Baireddy, R., Pour-Rouholamin, M., Zhou, H., & Qi, Y. (2017). Factors contributing to injury severity of pedestrian crashes at uncontrolled locations in Illinois. *In Transportation Research Board 96th Annual Meeting* (No. 17-03502).

[5] Bhatt, K., & Shah, J. (2022). Driver's Risk Compelling Behavior for Crossing Conflict Area at Three-Legged Uncontrolled Intersection. Paper presented at the Intelligent Infrastructure in Transportation and Management: *Proceedings of i-TRAM 2021.* https://doi.org/10.1007/978-981-16-6936-1_4

[6] Lakshmipriya, C. P. (2018). Development of crash prediction models for uncontrolled intersections. *International journal of engineering technology science and research*, *5*(5), 104-110.

[7] Vajari, M. A., Aghabayk, K., Sadeghian, M., & Shiwakoti, N. (2020). A multinomial logit model of motorcycle crash severity at Australian intersections. *Journal of safety research*, *73*, 17-24. https://doi.org/10.1016/j.jsr.2020.02.008.

[8] Zhang, C., Zhou, B., Chen, G., & Chen, F. (2017). Quantitative analysis of pedestrian safety at uncontrolled multi-lane mid-block crosswalks in China. *Accident Analysis & Prevention,* 108, 19-26. https://doi.org/10.1016/j.aap.2017.08.018.

[9] Federal Highway Administration (FHA). (2009). Manual on uniform traffic control devices for street and highways (MUTCD). Washington, DC: Federal Highway Administrator U.S. Department of Transportation.

[10] Turkish Statistical Institute (TÜİK). (2024). Ulaştırma ve Haberleşme İstatistikleri, Ankara, Hazine ve Maliye Bakanlığı (accessed November 28, 2024, public access data sets available at: https://data.tuik.gov.tr/Kategori/GetKategori?p=Ulastirma-veHaberlesme-112).

[11] National Highway Traffic Safety Administration (NHTSA). (2023). Fatality and Injury Reporting System Tool (FIRST), Washington, DC, Department of Transportation (accessed August 10, 2023, public access data sets available at: https://cdan.dot.gov/query).

[12] Alonso, F., Esteban, C., Montoro, L., & Useche, S. A. (2017). Knowledge, perceived effectiveness and qualification of traffic rules, police supervision, sanctions and justice. *Cogent social sciences*, 3(1), 1393855. https://doi.org/10.1080/23311886.2017.1393855

[13] Björklund, G. M., & Åberg, L. (2005). Driver behaviour in intersections: Formal and informal traffic rules. *Transportation research part F: traffic psychology and behaviour*, 8(3), 239-253. https://doi.org/10.1016/j.trf.2005.04.006

[14] Brandt, R. K., Haustein, S., Hagenzieker, M., & Møller, M. (2022). Cyclists' handheld phone use and traffic rule

knowledge. *Transportation research part F: Traffic Psychology and Behaviour*, 86, 121-130. https://10.1016/j.trf.2022.02.004

[15] Çakıcı, Z., & Murat, Y. Ş. (2017). Trafik işaretlerinin bilinirliği üzerine bir araştırma: Denizli örneği. *Bitlis Eren Üniversitesi Fen Bilimleri Dergisi*, 6(1), 21-30. https://doi.org/10.17798/bitlisfen.305485

[16] Hossain, S., Maggi, E., Vezzulli, A., & Mahmud, K. T. (2021). Determinants of awareness about road accidents and knowledge of traffic rules: Empirical evidence from Khulna City in Bangladesh. *Theoretical Economics Letters*, 11(6), 1247-1272. https://doi.org/10.4236/tel.2021.116079

[17] Islam, M. R., Khan, M. M. A., Hossain, M. M., Mani, K. K., & Min, R. M. (2020). Road traffic accidents in Bangladesh: Why people have poor knowledge and awareness about traffic rules? *International journal of critical illness and injury science*, 10(2), 70. https://doi.org/10.4103/IJCIIS.IJCIIS_65_19

[18] Nagar, K. (2022). Safety Education on Knowledge, Attitude and Practice Towards Road Traffic Signs and Regulations Among College Students At Gujarat. *Journal of Pharmaceutical Negative Results*, 948-958. https://doi.org/10.47750/pnr.2022.13.S04.112

[19] Riaz, I., & Shahid, S. (2018). Knowledge, attitudes, and practice of drivers towards traffic rules and regulations in Multan, Pakistan. *In 7th International RAIS Conference on Social Sciences*. https://doi.org/10.2139/ssrn.3152120

[20] Shaaban, K. (2021). Impact of experience and training on traffic knowledge of young drivers. *The Open Transportation Journal*, 15(1): 61-68. http://dx.doi.org/10.2174/1874447802115010061

[21] Yahia, H. A., & Ismail, A. (2014). Research Article Knowledge of Traffic Laws and Drivers Behavior on the Roads of Tripoli City, Libya. *Research Journal of Applied Sciences, Engineering and Technology*, 7(10), 2040-2045. https://doi.org/10.19026/ajfst.7.497

[22] Turkish Statistical Institute (TÜİK). (2024). Nüfus ve Demografi İstatistikleri, Ankara, Hazine ve Maliye Bakanlığı (accessed November 28, 2024, public access data sets available at: https://data.tuik.gov.tr/Kategori/GetKategori?p=Nufus-ve-Demografi-109)

[23] Presidency of Republic of Türkiye Legislation Information System (1983). Highway Traffic Law (Law No. 2918), Ankara, Presidency of Republic of Türkiye (accessed August 17, 2023, public access legislation available at: https://www.mevzuat.gov.tr/mevzuat?MevzuatNo=2918&MevzuatTur=1&MevzuatTertip=5)

[24] Presidency of Republic of Türkiye Legislation Information System. (1997). Highway Traffic Regulation, Ankara, Presidency of Republic of Türkiye (accessed August 17, 2023, public access legislation available at: https://www.mevzuat.gov.tr/File/GeneratePdf?mevzuatNo=8182&mevzuatTur=KurumVeKurulusYonetmeligi&mevzuatTertip=5)

[25] Bucsuházy, K., Matuchová, E., Zůvala, R., Moravcová, P., Kostíková, M., & Mikulec, R. (2020). Human factors contributing to the road traffic accident occurrence. *Transportation research procedia*, 45, 555-561. https://doi.org/10.1016/j.trpro.2020.03.057

[26] Mutlu, M. A., & Yakar, F. (2022). Effects of driver characteristics, questionnaire type, and sign design on drivers' comprehension of traffic signs. *Journal of the Faculty of Engineering and Architecture of Gazi University*, 37(2), 595-608. https://doi.org/10.17341/gazimmfd.894629

[27] Umar, I. K., & Bashir, S. (2019). Comprehension of road traffic signs by various road users in Kano city. *Cumhuriyet Science Journal*, 40(1), 197-203. https://doi.org/10.17776/csj.403516

[28] Şehribanoğlu, S. (2019). Van ilinde yaşayanların trafik işaretleri bilgisi ve trafik kurallarına bakış açıları üzerine bir araştırma. *Trafik ve Ulaşım Araştırmaları Dergisi*, 2(1), 1-15. https://doi.org/10.38002/tuad.479023

[29] Ningal, J., & Oños, C. (2021). Traffic education, publicity and training in road safety: basis for road safety and accident awareness program. *Social and Crimonol*, 9, 212. https://doi.org/10.24941/ijcr.41750.06.2021

[30] Guzel, D., & Altıntaşı, O. (2023). Exploring the traveler group-based ridership fluctuations before, during and after the COVID-19 pandemic: A case study of rail transit system in Izmir, Türkiye. *Journal of Innovative Transportation*, 4(1), 1-8. https://doi.org/10.53635/jit.1262737

[31] İçten, T. (2021). Trafik güvenliği kurallarının ve işaretlerinin eğitimi için etkileşimli 3B sanal ortam. *Bilişim Teknolojileri Dergisi*, 14(2), 191-206. https://doi.org/10.17671/gazibtd.791458

[32] Topkaya, Y. (2019). Trafik kurallarının öğretilmesine yönelik kullanılan eğitici çizgi romanlara yönelik öğrenci görüşleri (Hatay Mustafa Kemal Üniversitesi örneği). *In International Educational Sciences Congress*.

[33] Cheng, Y.-Q., Mansor, S., Chin, J.-J., & Karim, H. A. (2022). Driving simulator for drivers education with artificial intelligence traffic and virtual reality: a review. *In Proceedings of the 8th International Conference on Computational Science and Technology: ICCST 2021*, Labuan, Malaysia, 28–29 August. https://doi.org/10.1007/978-981-16-8515-6_38

[34] Backlund, P., Engström, H., Johannesson, M., & Lebram, M. (2010). Games for traffic education: An experimental study of a game-based driving simulator. *Simulation & gaming*, 41(2), 145-169. https://doi.org/10.1177/10468781073114

[35] Gounaridou, A., Siamtanidou, E., & Dimoulas, C. (2021). A serious game for mediated education on traffic behavior and safety awareness. *Education Sciences*, 11(3), 127. https://doi.org/10.3390/educsci11030127

[36] Özel, M. (2022). Türkiye'de yürütülen karayolu trafik güvenliği farkındalık kampanyalarının sosyal medya paylaşımları üzerinden incelenmesi. *Türk İdare Dergisi*, 494: 229-266.

[37] Gülada, M. O., Avcı, Ö., & Çakı, C. (2023). Emniyet kemerinin trafik güvenliğindeki rolü: kamu spotlarının nitel analizi. *Trafik ve Ulaşım Araştırmaları Dergisi*, 6(1), 59-79. https://doi.org/10.38002/tuad.1179833

[38] Kavsıracı, O., Demirbaş, M., & Sena, T. (2021). Karayolu trafik güvenliği'ne yönelik gerçekleştirilen sosyal kampanya, denetim, idari cezalar ve bireyler üzerindeki etkileri. *İdeakent*, 12(34), 1285-1309. https://doi.org/10.31198/idealkent.1013602

[39] Esfandiari, Z., Marasi, M. R., Estaki, F., Sanati, V., Panahi, E., Akbari, N., Madani, R. A., & Tanha, J. M. (2019). Influence of education on knowledge, attitude and practices of students of Isfahan University of Medical Sciences to traffic light inserted on food labeling. *Tehran University medical journal*, *77*(1), 54-62.

[40] Mirzaei, R., Hafezi-Nejad, N., Sabagh, M. S., Moghaddam, A. A., Eslami, V., Rakhshani, F., & Rahimi-Movaghar, V. (2014). Dominant role of drivers' attitude in prevention of road traffic crashes: A study on knowledge, attitude, and practice of drivers in Iran. *Accident Analysis & Prevention*, 66, 36-42. https://doi.org/10.1016/j.aap.2014.01.013

[41] Parmenter, K., & Wardle, J. (1999). Development of a general nutrition knowledge questionnaire for adults. *European journal of clinical nutrition*, 53(4), 298-308. https://10.1038/sj.ejcn.1600726

[42] Sun, J., Ren, X., & Anumba, C. J. (2019). Analysis of knowledge-transfer mechanisms in construction project cooperation networks. *Journal of Management in Engineering*, 35(2), 04018061. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000663

[43] Tripathi, S. R., & Tiwari, R. R. (2006). Self-reported hearing quality of traffic policemen: A questionnaire-based study. *Indian Journal of Occupational and Environmental Medicine*, 10(2), 82. https://doi.org/10.4103/0019-5278.27306

[44] Tseng, J.-J., Chai, C. S., Tan, L., & Park, M. (2022). A critical review of research on technological pedagogical and content knowledge (TPACK) in language teaching. *Computer Assisted Language Learning*, 35(4), 948-971. https://doi.org/10.1080/09588221.2020.1868531

[45] Useche, S. A., Alonso, F., Montoro, L., & Tomas, J. M. (2019). When age means safety: Data to assess trends and differences on rule knowledge, risk perception, aberrant and positive road behaviors, and traffic crashes of cyclists. *Data in brief*, 22, 627-634. https://doi.org/10.1016/j.dib.2018.12.066

[46] Baş, T. (2001*). Anket: Anket nasıl hazırlanır? Anket nasıl uygulanır? Anket nasıl değerlendirilir?.* Seçkin Yayıncılık.

[47] Saris, W. E., & Gallhofer, I. N. (2014). *Design, evaluation, and analysis of questionnaires for survey research*. John Wiley & Sons.

[48] Büyüköztürk, Ş. (2005). Anket geliştirme. *Türk Eğitim Bilimleri Dergisi*, 3(2), 133-151.

[49] Cochran, W.G. (1977). *Sampling techniques*. Johan Wiley & Sons Inc.