

Road Safety Game for Children: A Thematic Review

Siti Salwa Salleh^{1,2}, Siti Ayu Jalil²

¹College of Computing, Informatics and Mathematics, Kampus Seremban, UiTM Negeri Sembilan, Malaysia, ²Malaysia Institute of Transport (MITRANS), Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

Corresponding Author Email: ssalwa@uitm.edu.my

Ismassabah Ismail

Centre of Foundation Study, Kampus Dengkil, Universiti Teknologi MARA, Selangor, Malaysia

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Abstract

The application of road safety games has progressed as an interactive approach for disseminating information to children in reducing the probability of accidents. To investigate progress achieved in this domain, a comprehensive thematic evaluation has been undertaken with the objective of discerning recurring patterns and emerging trends in the extant body of literature. The review's implementation has been structured according to a sequential process consisting of four primary stages: identification, screening, eligibility evaluation, and analysis. A thorough investigation of electronic databases was conducted, followed by a meticulous review, resulting in the inclusion of 21 relevant papers. The results indicate that a wide variety of gaming genres and platforms were utilized, including driving simulations, mobile applications, and web-based games. The examination of the efficacy of road safety games includes various indications of outcomes, including upgrades in knowledge, adjustments in behavior, and levels of involvement. The concept of road safety encompasses a wide range of topics and issues, such as hazard perception, pedestrian safety, bicycle and motorcycle safety, knowledge of speed limits, understanding of traffic signs and signals, avoidance of distracted driving, application of defensive driving techniques, and compliance with seat belt usage. This implies that it is advisable to use caution when choosing road safety themes, considering their pertinence, influence, and ability to successfully tackle specific challenges and improve road safety outcomes.

Keywords: Education, Game, Game-Based Learning, Road Safety, Serious Game, Thematic Review

Introduction

Road traffic crashes and incidents remain the primary concern in the world. According to the World Health Organisation (WHO), road traffic impacts resulted in the deaths of approximately 1.35 million people worldwide in 2016, and between 20 and 50 million people received non-fatal injuries each year. It is also the eighth leading cause of death for all age

groups, especially for children and young adults aged 5–29 years (World Health Organization, 2023). These fatalities include pedestrians, cyclists, motorcyclists, drivers, and passengers. Southeast Asia shows a significant increase in the death toll due to road accidents, from 250 thousand in 2000 to 400 thousand in 2016. In this context, a lack of police enforcement of road violations and an increasing number of car users are the main factors in road accidents (Hutt, 2022).

In answering Sustainable Development Goal (SDG) number three, to ensure healthy lives and promote well-being for all ages, the WHO targets halving global deaths and injuries from road traffic accidents. One of the ways to realise this goal is by raising public awareness about road safety. According to Law Insider (2023), road safety awareness programs can help reduce the likelihood or risk of persons using the road network getting involved in a collision or an incident that may cause property damage, serious injuries, or death. Apart from the awareness program, there are many conventional ways for the community to learn about road safety, such as public service announcements in the media, campaigns, and rallies. However, instead of a traditional approach, adopting a new concept, such as game-based learning, will be more effective in improving awareness (Dassanayake et al., 2020). Gamebased learning is defined as an assistive tool that has been designed to be more attractive, fun, meaningful, and effective for learning than non-game tasks. Through games, the target users, specifically children, can learn the rules and stimulate their mind and body. Despite the popularity of game-based learning for road safety, more systematic review papers need to discuss the types of games implemented for road safety. Therefore, the motivation behind this review paper is the conviction that games will aid in conducting real-world traffic scenarios to examine and broaden community understanding of road safety. The motivation of past researchers has continued to be the same, which is to provide a safe environment for the community to train in a real-world scenario through games (Johnson et al., 2022; Mostafavi et al., 2019).

Hence, the objective of this thematic study is to do the following: (a) conduct a systematic review of literature spanning from 2018 to 2023, focusing on road safety games; (b) analyse the features and attributes of road safety games featured in contemporary publications, with a central question: "What characteristics define the road safety games discussed in publications from 2018 to 2023?"; and (c) examine the global landscape of road safety games, aiming to provide insights into the current state of these games worldwide. The remaining article is organized as follows: Section two describes adapting the PRISMA-P execution process to conduct the systematic review. Section three introduces the result and discussion, and Section four concludes the article.

Methods And Materials

This study employed the PRISMA-P (Preferred Reporting Item for Systematic Reviews and Meta-Analyses) methodology to examine the publication trends in the field of road safety games. The execution of a theme review has four distinct processes, namely identification, screening, eligibility, and analysis. Figure 1 illustrates the execution process and flow. The research question (RQ) proposed in this study is "What are the present characteristics of road safety games discussed in publications from 2018–2023?". This RQ serves as the guiding principle for the investigation.

The five databases that have been explored are IEEE Xplore, ScienceDirect, ACM Digital Library, Scopus, and Web of Science. The databases encompass a vast collection of more than seven million scholarly publications in the fields of technology, computing, and social science. Following this, the advanced search of each database utilized four primary search strategies, namely boolean operators, phrases, truncation, and wildcards, to locate the term inside the title, abstract, or content. The keywords are derived from the research inquiries pertaining to "road safety" and "game". Table 1 presents the respective quantities of articles contained in each database. It shows the search results identifying IEEE Xplore, Scopus, Science Direct, ACM Digital Library, and Web of Science with 10,552, 2569, 1119, 198, and 106 records, respectively. Hence, the combination of all documents from databases is 14,544 records. All records are then exported into Mendeley to remove duplicate records and then moved to the next stage, the screening phase.

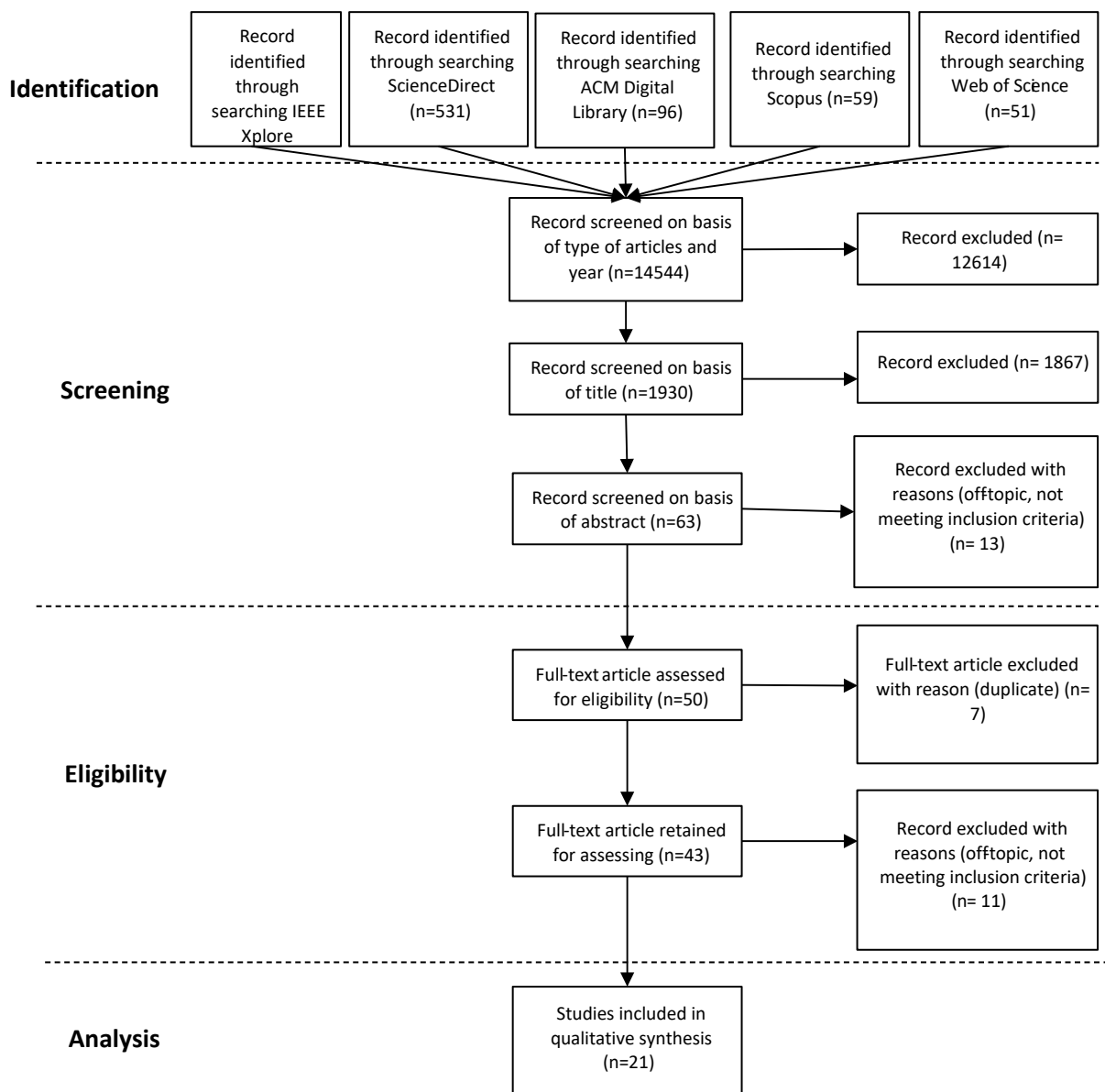


Figure 1. Thematic review execution process.

Table 1

Number of articles for each database.

Database	Number of Articles
IEEE Xplore	10552
Scopus	2569
ScienceDirect	1119
ACM Digital Library	198
Web of Science	106
Total	14,544

Screening Phase

The remaining 14,544 articles were screened based on inclusion and exclusion criteria such as type of document, year of publication, or language. Further measures can be reviewed in Table 2. The researchers first include any journal and conference proceedings. Meanwhile, book chapters, prefaces, opinions, and master dissertations will only be added after a thorough review. Furthermore, only articles from 2019 to 2023 in English are sought after, as this paper needs to find trends within the previous five years.

Table 2

Inclusion and exclusion criteria.

Criteria		
Inclusion	I1	Article related to road safety game.
	I2	Journal or Conference proceeding paper.
	I3	Year of publication; between the years 2018 to 2023
	I4	English language publication.
Exclusion	E1	Article unrelated to road safety game.
	E2	Identical articles across different databases.

Thus, further review of the remaining 63 articles is based on the abstract. The screening phase resulted in 50 full-text articles to be assessed during the eligibility phase. Table 3 shows each database's search string and the number of articles and the entire search string and the number of articles for each database. The remaining 1930 articles were screened based on their title and whether they met the inclusion and exclusion criteria, of which 1867 were excluded due to exclusion criteria.

Result and Findings

The issue of road safety is of utmost importance on a global scale, as it has a profound impact on the lives of millions of individuals who are affected by traffic accidents annually. Road safety-based education has been lacking in the availability of tools such as "serious games" or "game-based learning." The review highlights the existence of a specific group that necessitates a concerted effort to tackle the issue. To effectively handle this matter, researchers and policymakers should consider employing new strategies, such as the utilization of road safety games. This strategy is believed to facilitate the acquisition of knowledge and induce behavioral changes aimed at promoting safer road activities. The review of 21 scholarly works sourced from reputable journals and conference proceedings, including ACM ACM International Conference Proceeding Series, ACM Transactions on Accessible Computing, and IEEE Region Annual International Conference, Proceedings (TENCON), reveals that the observed trend exhibited variations throughout different years. Table 4 presents the scenario. In the year 2018, a singular article was published. Nevertheless, there was a sudden surge in the quantity of articles in the year 2019. This phenomenon may be attributed to the fact that most papers published in 2019 are still in the process of being developed. After the year 2019, there was a marginal decline observed in the quantity of articles. Most of the journals mentioned do not primarily focus on educational technology. For instance, Transportation Research, Traffic Psychology and Behavior, and the 7th SouthEast Europe Design Automation, Computer Engineering, Computer Networks, and Social Media Conference (SEEDA-CECNSM) are more aligned with transportation-related topics.

Table 4

Article reviewed based on journal and year.

JOURNAL	2018	2019	2020	2021	2022	2023
ACM International Conference Proceeding Series	2					
ACM Transactions on Accessible Computing			1			
Applied Sciences						1
Conference on Human Factors in Computing Systems					1	
Education Sciences				1		
IEEE Region Annual International Conference, Proceedings (TENCON)			1			
IEEE International Colloquium on Signal Processing and Applications (CSPA)					1	
International Conference on High Performance Big Data and Intelligent Systems (HPBD & IS)		1				
Proceedings - IEEE International Conference on Artificial Intelligence and Virtual Reality, AIVR		1				
Proceedings - IEEE/ACM 23rd International Symposium on Distributed Simulation and Real Time Applications, DS-RT		1				
Proceedings - International Symposium on Educational Technology, ISET			1			
Proceedings - 3rd International Conference on Next Generation Computing Applications, NextComp					1	

Proceedings - IEEE 10th International Conference on Technology for Education, T4E	1					
Proceedings - International Conference on Applied Artificial Intelligence and Computing, ICAAIC					1	
Proceedings - SAP: ACM Conference on Applied Perception	1					
Proceedings of MobileHCI - ACM International Conference on Mobile Human-Computer Interaction: Mobile Apart, MobileTogether				1		
Proceedings of the International Serious Games Symposium, ISGS	1					
Sensor					1	
7th South-East Europe Design Automation, Computer Engineering,						1
Computer Networks and Social Media Conference, SEEDA-CECNSM						
Transportation Research Part F: Traffic Psychology and Behaviour	1					
Total [21 article]	1	8	3	3	5	1

In the preceding six-year period, IEEE has made a total of 11 contributions in the form of articles. Following IEEE, ACM has contributed six articles, MDPI has contributed three articles, and Elsevier has contributed one item, as depicted in Figure 3. Due to the substantial volume of IEEE publications compared to other publishers, it is believed that IEEE publishers are the main source of information for researchers on road safety games. According to the data shown in Table 5, Germany emerges as the foremost research nation, having contributed a total of five articles. In the present context, it is noteworthy that China, India, Greece, Malaysia, and Sri Lanka each contribute two pieces, respectively. The countries that have not yet been mentioned, namely Ecuador, Iran, Mauritius, Norway, Switzerland, and the United States of America, collectively generate a single article per six-year period.

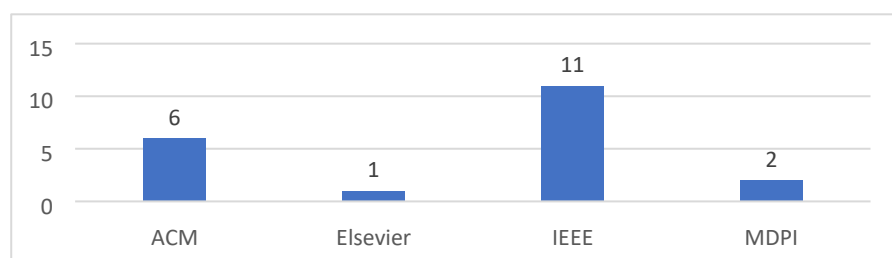


Figure 3. Number of articles published based on the publisher.

A total of 21 articles have undergone a comprehensive review process, wherein thorough comparisons were conducted to identify commonalities and disparities, with the aim of ensuring coherence in the outcome. As a result, road safety topics were identified among the publications, as indicated in Table 5. Table 6 illustrates that traffic signs and signals, with a total of 13 instances, exhibit the highest frequency of articles examined in the research.

Table 5

Number of articles published based on country.

Country	2018	2019	2020	2021	2022	2023	Total
China		1	1				2
Ecuador		1					1
Germany		2	1	1	1		5
Greece				1	1		2
India		1			1		2
Iran		1					1
Malaysia		1			1		2
Mauritius					1		1
Norway				1			1
Sri Lanka		1	1				2
Switzerland						1	1
USA	1						1
Total	1	8	3	3	5	1	21

Pedestrian safety was the most often mentioned topic, with a total of 11 occurrences, followed by hazard perception, which had 6 occurrences. This notable finding is supported by Hutt (2022), that stated that an estimated 20-50 million individuals have injuries because of traffic incidents or crashes. The primary focus lies in highlighting the predominant cause of road traffic events, which is attributed to drivers' inadequate attention towards traffic signs and signals, their limited ability to perceive hazards, and pedestrians' insufficient understanding of their own safety. The following sections discuss these attributes in detail.

Hazard Perception

Hazard perception pertains to the cognitive capacity to recognize and discern probable perils or risks on the roadway, subsequently using suitable measures to avert collisions or mishaps. The subject matter of this discourse centers on the enhancement of individuals' abilities to identify perilous circumstances, including instances of abrupt braking, pedestrian traversal, and unanticipated obstructions. The scholarly articles put center their attention on the development of hazard awareness skills using game-based learning methodologies (Dassanayake et al., 2020; Arslanyilmaz and Sullins, 2019; Gounaridou et al., 2020; Khan et al., 2021; and Proaño et al., 2019). The objective of these studies is to enhance an individual's capacity to recognize potential hazards while driving and thereafter employ suitable measures to prevent accidents. On the other hand, the study conducted by Dassanayake et al. (2020) introduces "AwareME," a system that utilizes game-based techniques to improve individuals' hazard awareness abilities. The research centers on enhancing participants' capacity to discern possible traffic dangers and make informed decisions to prevent accidents. The game integrates authentic driving scenarios and evaluates participants' ability to perceive hazards through a range of game-based challenges. In the interim, Arslanyilmaz and Sullins

(2019) delves into an examination of a multiplayer online simulated driving game that has been specifically developed with the aim of enhancing danger awareness skills.

Table 6

Road safety topic based on articles.

No	Articles	Hazard Perception	Pedestrian Safety	Bicycle And Motorcycle Safety	Speed Limit Awareness	Traffic Signs / Signal	Distracted Driving	Defensive Driving	Seat Belt Usage
1	(Alyamani et al., 2019)					/	/		
2	(Arslanyilmaz and Sullins, 2019)	/							
3	(Bozkir et al., 2019)		/		/	/			
4	(Colley et al., 2021)		/						
5	(Dassanayake et al., 2020)	/	/			/		/	
6	(Dimitriadis et al., 2022)				/	/		/	
7	(Feng et al., 2020)		/			/			
8	(Gerber et al., 2020)	/							
9	(Gounaridou et al., 2020)	/	/			/	/	/	/
10	(Herold et al., 2019)						/		/
11	(Hsu et al., 2019)			/		/			
12	(Jaunoo et al., 2022)		/			/			
13	(Khan et al., 2021)	/	/			/			
14	(Matviienko et al., 2022)			/					
15	(Mostafavi et al., 2019)		/				/		

16	(Abdullah et al., 2022)					/			
17	(Proaño et al., 2019)	/			/	/			
18	(Sangeetha et al., 2019)		/	/		/			/
19	(Thevin et al., 2020)		/						
20	(Wimaladharmasiri et al., 2019)					/			
21	(Xuan et al., 2019)		/						
	TOTAL	6	11	3	3	13	4	3	3

The game offers a simulated setting in which individuals may engage in exercises that enhance their ability to see and respond to potential dangers, as well as improve their decision-making capabilities, inside authentic driving situations. A few studies assess the efficacy of the game in improving the hazard perception skills of the participants. The serious game discussed by Gounaridou et al. (2020) and Proaño et al. (2019) is centered around the topics of traffic behavior, safety awareness, and hazard perception skills. The primary objective of the competition is to enhance participants' hazard awareness abilities and encourage the adoption of safe road practices. The game encompasses a range of traffic scenarios that require players to recognize and react to potential dangers. With regards to the study mentioned by Proaño et al. (2019), participants are involved in simulated driving scenarios where they are tasked with identifying potential hazards within the virtual traffic environment. In the present context, the source examines a dynamic approach to educational intervention in the realm of children's road safety education, employing game-based learning as a central tactic (Khan et al., 2021). The research places significant emphasis on the cultivation of hazard awareness abilities in a virtual environment. The game is designed to adjust according to the child's proficiency and offers authentic road scenarios in which they are required to recognize and react to potential dangers. Various implementations of the game exhibit distinct methods of evaluation. In the "AwareME" game-based system, the evaluation of participants' hazard perceptions via a range of game-based tasks has been assessed (Dassanayake et al., 2020). The assessment encompasses the quantification of participants' reaction speed, precision in hazard identification, or proficiency in making suitable judgments within simulated driving contexts. The evaluation metrics used by Arslanyilmaz and Sullins (2019) assess the hazard perception skills of multiplayer games that look at users' capacity to identify and react to hazards. The assessment covers several measures, such as the quantification of accurately detected hazards or the assessment of participants' responses to dangerous circumstances. Gounaridou et al. (2020) also evaluated hazard perception skills, where the assessment criteria focused on participants' proficiency in recognizing potential risks and exercising prudent judgment when confronted with diverse traffic scenarios.

Pedestrian safety

Pedestrian safety pertains to the measures and protocols that pedestrians ought to adhere to to guarantee their safety when traversing roadways or engaging in walking activities. The knowledge encompasses comprehension of pedestrian crossings, traffic lights, and the utilization of designated paths. The promotion of pedestrian safety has a crucial role in mitigating pedestrian-related accidents and injuries. The problem of pedestrian safety is examined by Mostafavi et al. (2019), Colley et al. (2021), and Gounaridou et al. (2020). These studies employ the use of games and simulations as educational tools to impart knowledge and understanding to pedestrians on safe behaviors, enhance their awareness of potential risks, and encourage compliance with traffic rules and signals. The game-based method by Mostafavi et al. (2019) serves as a tool for investigating the potential hazards associated with advertising displays for pedestrians. This study investigates the perceptual capabilities of pedestrians in relation to the identification of hazards linked to advertising displays, with the aim of enhancing understanding and recognition of the threats that these displays may present. The utilization of external communication by autonomous vehicles for the purpose of improving pedestrian safety is examined in the survey by Colley et al. (2021). This study investigates the utilization of augmented reality as a means of facilitating communication between pedestrians and autonomous cars, with the aim of enhancing safety during their interactions and alerting pedestrians to potential hazards. In addition to this, Gounaridou et al. (2020) have also incorporated the issue of pedestrian safety into their serious game. The primary objective of this inclusion is to enhance players' understanding of safe pedestrian behaviors and encourage compliance with traffic regulations. One approach utilized in assessing user behaviors is by analyzing gaze data, fixation points, and fixation time in relation to the advertisement (Mostafavi et al., 2019). Additionally, both Mostafavi et al. (2019) and Colley et al. (2021) employ participant questionnaires to gauge immersion and involvement levels within the game. The game's content and graphical user interface (GUI) were modified based on the input received from specialists (Gounaridou et al., 2020). Additionally, according to the findings, the pilot validation of RoboRoad demonstrated its ability to boost users' digital skills through the provision of an engaging and immersive experience within a 3D virtual reality environment (Gounaridou et al., 2020). This, in turn, resulted in a significant increase of over 80% in the effectiveness of the intuitive learning process.

Ensuring Safety in Bicycle and Motorcycle Usage

The primary objective of bicycle and motorcycle safety initiatives is to provide riders with comprehensive education regarding the adoption of safe behaviors while utilizing these forms of transportation. The subject matter encompasses various facets, including the utilization of protective equipment, adherence to traffic regulations that pertain specifically to bicycles and motorcyclists, and the practice of coexisting with other vehicles on the road. The safety of bicycles and motorcyclists is discussed in a few studies (Hsu et al., 2019; Matvienko et al., 2022; Sangeetha et al., 2019). The studies employ features to instruct individuals on safe riding practices, enhance their understanding of potential road dangers, and foster a sense of accountability while operating bicycles or motorcycles. Hsu et al. (2019) conducted virtual reality (VR) training that replicates different riding circumstances to improve riders' skills and awareness. The training program seeks to enhance users' capacity to anticipate and address potential road hazards by immersing them in a virtual world, hence fostering the adoption of safer behaviors in motorcycle riding. Sangeetha et al. (2019) examine novel strategies for increasing awareness among the younger demographic about traffic regulations. This study

employs a fusion of VR technology and quizzes to emphasize the significance of safety measures for pedestrians, motorists, and drivers. This research highlights the significance of helmets and traffic signals. The use of virtual reality gear, Oculus SDK, Arduino, Bluetooth, and motorcycles in simulation exercises has been found to effectively enhance participants' safety experience when riding motorcycles in controlled conditions (Hsu et al., 2019). Another study by Sangeetha et al. (2019) allows participants to engage in self-assessment of road safety to identify and acquire a comprehensive understanding of the relevant regulations. The findings mentioned that games facilitate the acquisition of practical knowledge pertaining to road safety for a significant majority of participants, surpassing 84% in total. Matviienko et al. (2022) present an investigation of cyclists' crossing decision-making at uncontrolled intersections using augmented reality (AR). This approach facilitates rapid decision-making for cyclists by providing them with enhanced visual information. It also considers their respective distances traversed by bicycle and automobile, as well as their incidence of accidents.

Enhancing Awareness of Speed Limits

The significance of speed limit awareness lies in the adherence to prescribed speed limits on various types of roads. It is vital to comprehend the correlation between velocity and road safety, encompassing its effects on response time, braking distances, and the gravity of collisions, to foster the adoption of safe driving practices. Bozkir et al. (2019) and Dimitriadis et al. (2022) center their attention on the promotion of speed limit awareness as a means of fostering compliance with speed limit regulations. The objective of the study is to examine potential collision risks between drivers and pedestrians by utilizing VR technology and warning cues (Bozkir et al., 2019). They emphasize the need to maintain a vigilant awareness of traffic signs indicating speed restrictions throughout the entirety of the driving experience in the game. The measurement of the input from the accelerator and brake pedal serves as an indicator of the driver's perception and smoothness in relation to the driving experience. Dimitriadis et al. (2022) examined the impact of speed limits on pedestrian safety, particularly in relation to crosswalks and other routine interactions between pedestrians and vehicles. By implementing a system of rewards and scoring, the player can utilize their acquired knowledge to successfully navigate the challenges presented in the game. This approach serves to incentivize positive behavior and simultaneously facilitate the player's educational development.

Traffic signs and signals

Traffic signs and signals play a crucial role in the regulation and guidance of traffic movement. The subject matter at hand pertains to comprehending the significances and elucidations of diverse traffic signs, signals, and road markings. Furthermore, the significance of adhering to these signs and signals to guarantee a secure and effective flow of traffic on the roadway. Several studies have investigated the educational potential of games and simulations in teaching people about traffic signs and signals (Dassanayake, 2020; Feng et al., 2020; Khan et al., 2021; Abdullah et al., 2022; Sangeetha et al., 2022). The primary objective of these studies is to enhance comprehension, identification, and suitable reactions to various traffic signs and signals. The study conducted by Dassanayake et al. (2020) investigates the use of game-based learning to augment public consciousness regarding road safety, specifically focusing on the acquisition of knowledge pertaining to traffic signs and signals. The study findings show that game-based learning has the potential to enhance the ability of users to recognize,

comprehend, and appropriately react to traffic signs and signals through the utilization of interactive gameplay. Feng et al. (2020) developed a mobile application for safe driving that incorporates elements of gamification. The mobile application incorporates quizzes, challenges, and simulations that require users to identify and comprehend traffic signs and signals, thereby fostering awareness and expertise in this domain. A study by Khan et al. (2021) tailored the game design to the specific needs of children. Although the study does not specifically address the specific content about traffic signs and signals, it is possible to employ game-based learning as an effective method for educating youngsters about these important road safety elements in an engaging and participatory manner. The utilization of virtual worlds, simulations, and quizzes within the game-based learning approach can effectively enhance the acquisition and understanding of traffic signs and signals. Abdullah et al. (2022) concentrate their efforts on the creation and advancement of a learning system centered around a driving simulator game within the realm of VR. The simulator facilitates user engagement in a virtual reality setting, enabling repeated exposure to and familiarization with road safety regulations and protocols, hence promoting skill acquisition and proficiency in driving. Participants engage in a process of error analysis and reflection, utilizing various tools such as scoring systems, virtual support, and coaching, to effectively mitigate and extract valuable lessons from their mistakes or failures. The participant evaluated the game using five important criteria: satisfaction, interaction, motivation, challenges, and efficacy. A study by Sangeetha et al. (2019) increased awareness by implementing VR technology and quizzes to stress the significance of safety measures for pedestrians, motorists, and drivers. It highlights the significance of seat belts, traffic rules, and traffic signals. A self-evaluation process was conducted wherein participants were able to compare their performance in both traditional and VR learning approaches. While Feng et al. (2020) employed many methods, including participant questionnaires, interviews, and observations of pedestrian behaviors before and after debriefing sessions, these methods were utilized to get insights into the limitations of the games, the participants' ability to retain learning experiences and knowledge, and any potential changes in their regular pedestrian behavior. Findings of their study mention that there were notable enhancements observed in the behavior of the participants, as shown by the post-intervention questionnaire administered six months after the intervention. According to Khan et al. (2021), they involved the collection of feedback from children, teachers, and parents to assess their comprehension of road safety knowledge as well as identify the strengths and limitations of the research.

Distracted driving

Distracted driving refers to the act of operating a vehicle while engaging in activities that divert the driver's attention away from driving. It encompasses any action that causes the driver to distract their attention away from the primary responsibility of operating a vehicle. This subject pertains to the potential hazards linked to various distractions such as the utilization of mobile phones, consumption of food, or engagement in other activities while driving. Raising awareness of the perils associated with distracted driving is crucial to mitigating accidents resulting from a lack of attention. The impact of gamification and serious games on driving under unknown traffic restrictions, including features of distracted driving, has been investigated by Alyamani et al. (2019). The motorist may experience distraction when confronted with a shift in the driving environment since they are in the process of adapting to the unfamiliar surroundings. The study's objective is to augment drivers' comprehension and awareness of unfamiliar traffic restrictions through the utilization of

gamification techniques and the integration of serious games. These instructional interventions can cultivate a heightened state of concentration and attentiveness while driving, thereby potentially diminishing the propensity to partake in distracted activities. The game-based method proposed by Mostafavi et al. (2019) investigates the potential hazards associated with advertising displays for pedestrians. This study investigates the perceptual capabilities of pedestrians in relation to the identification of hazards related to advertising displays, with the aim of enhancing awareness of the possible threats that these displays may present. The other research conducted by Alyamani et al. (2019) examines the correlation between the presence of gamification components and the frequency of driving errors. Based on the findings of the study, it was observed that participants preferred visual feedback as a means of rectifying their driving behavior, hence contributing to the enhancement of road safety.

Defensive driving

Defensive driving is a proactive approach to operating a motor vehicle that aims to minimize the risk of accidents and promote road safety. It encompasses a repertoire of techniques and strategies that drivers adopt to proactively anticipate and effectively respond to any hazards encountered while operating a vehicle on the road. The subject matter at hand underscores the need to adopt a proactive and attentive stance during the act of driving, encompassing activities such as thoroughly surveying the road, anticipating the behaviors of fellow drivers, and adjusting one's driving style in response to unfavorable circumstances. Dassanayake et al. (2020) investigate the potential of game-based learning to increase public awareness in this area. Game-based learning can facilitate users' comprehension and application of defensive driving behaviors, including but not limited to maintaining safe distances, predicting, and reacting to potential hazards, and exercising caution in demanding driving scenarios. This is achieved using interactive games and simulations. The study focuses on improving pedestrian safety by examining the exterior communication signals employed by autonomous cars. Although not directly pertaining to the concept of defensive driving, it indirectly highlights the significance of adopting defensive driving behaviors to enhance pedestrian safety. The implementation of defensive driving, which incorporates adherence to speed limits, heightened awareness of pedestrians, and the appropriate yielding of right-of-way, plays a pivotal role in mitigating the potential hazards associated with pedestrian accidents. The primary focus of the discussion by Gounaridou et al. (2020) pertains to the creation of a research-oriented automated driving simulator utilizing video-based technology. According to the findings of the study, the utilization of the simulator demonstrates its potential for prototyping user interfaces, examining user experience, and exploring driving behavior. Adherence to defensive driving principles, which include the maintenance of situational awareness, anticipation of potential risks, and the implementation of proactive decision-making, is crucial for the cultivation of safe driving habits. The simulator has the potential to analyze and improve drivers' defensive driving skills and behaviors.

Safety belts

The utilization of seat belts plays a crucial role in promoting road safety, as it substantially diminishes the likelihood of sustaining injuries or experiencing fatalities in the occurrence of a vehicular collision. Educational initiatives, legislative measures, and enforcement endeavors are implemented with the objective of fostering the adoption of seat belt use among both drivers and passengers. Placing emphasis on the significance of seat belts and highlighting

their potential to save lives contributes to the enhancement of road safety. The study described in Herold et al. (2019) pertains to the creation of a serious game designed for the purpose of facilitating mediated teaching on traffic conduct and promoting safety awareness. Serious games have the potential to serve as practical instruments for the promotion and education of people regarding the significance of seat belt utilization. It enhances knowledge regarding seat belt safety, elucidates the inherent dangers associated with non-compliance, and promotes the adoption of appropriate seat belt usage by involving users in interactive gameplay that incorporates realistic events and challenges. The potential of VR for kid pedestrian safety training is discussed by Proaño et al. (2019). VR platforms have the capability to generate immersive and authentic experiences that replicate the potential outcomes resulting from the failure to utilize seat belts. This immersive experience has the potential to enhance individuals' understanding and recognition of the significance associated with the utilization of seat belts, hence promoting their adoption as a safety measure.

Conclusion

This study presents a structured method of conducting and presenting a theme-based literature review. Throughout the span of the study, it has been recognized that road safety encompasses a multitude of subjects and concerns. These include, but are not limited to, hazard perception, pedestrian safety, bicycle and motorcycle safety, awareness of speed limits, comprehension of traffic signs and signals, avoidance of distracted driving, implementation of defensive driving techniques, and adherence to seat belt usage. Researchers must employ prudence in the selection of road safety themes, taking into consideration their relevance, impact, and capacity to effectively address specific difficulties and enhance road safety results. Through the careful selection of road safety subjects, game creators and researchers could successfully focus on certain areas of concern and encourage desirable modifications in the behavior of road users. Another finding highlights the significance of connecting the content of road safety games with real-world concerns and priorities to optimize the effectiveness of these interventions. The systematic review suggests the need for more investigation into the selected road safety subjects, with a focus on new technologies such as virtual reality, gamification, and AI-driven techniques. These technologies have the potential to improve participation and efficacy in road safety initiatives. Calls for future studies to delve deeper into the chosen road safety topics, exploring emerging technologies such as virtual reality, gamification, and AI-driven approaches to enhance engagement and effectiveness.

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