EXPLORATION OF VIRTUAL REALITY FOR ROAD SAFETY AWARENESS IN MOROCCO

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Exploration of Virtual Reality for Road Safety Awareness in Morocco

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Report Submitted To:

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Abstract

Our project aimed to analyze the distracted driver behavior of young adults in Morocco and discover how interactive models like virtual reality (VR) can impact an individual's control beliefs about texting and driving. We created and conducted a pre-assessment, VR simulation, and summative survey with Ph.D. students at the International University of Rabat (UIR). Following quantitative and qualitative analyses, a series of recommendations was delivered to educational institutions, traffic safety authorities, and technology experts.

Acknowledgments

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Executive Summary

Road safety awareness in Morocco is a prominent issue, as a large number of accidents occur each year. Some of these accidents are due to the lack of awareness around road safety, guiding our team to research and analyze the distracted driver behavior of young adults in Morocco and discover how interactive models like virtual reality (VR) can impact an individual's control beliefs about texting and driving. VR is a technology that has risen in popularity for years, gaining traction in many fields and advancing in its applications. With this research, the team aimed to provide recommendations for using VR to prevent future road accidents and fatalities. The team worked at the International University of Rabat (UIR), in collaboration with Dr. Ouassim Karrakchou and Dr. Mounir Ghogho. The study included 14 Ph.D students from various disciplines and educational backgrounds. We gauged students' interest in increasing driving awareness using an interactive model, specifically VR. We aimed to interpret the effectiveness of VR as a learning tool by addressing various factors such as auditory, visual, and physical cues.

Methods

The VR simulation was made using a game design program called Unity, and the simulation's delivery was done via a Meta Quest 3 VR headset (Figure ES1). The simulation was made by the research team, using existing assets of parts such as roads and buildings while utilizing a realistic car model. The visual representation of the environment consisted of buildings, trees, sidewalks, a main road, and another road running perpendicular to the main road (Figure ES2). Additionally, the study aimed to assess control beliefs, which are perceptions of one's ability to influence driving behavior and outcomes (Ajzen, 1991). Individuals with strong control beliefs are more likely to engage in safe behaviors, reducing the number of road

accidents. To assess control belief, participants were asked several questions about how they viewed themselves as drivers and how they viewed the behavior of other drivers on the road. Participants were asked to complete a pre-assessment (Appendix C) before the simulation to assess their driving habits and how often they engaged in distracting behaviors. Participants who had never driven before or did not have their driver's license did not respond to questions regarding distracted driving behaviors. Participants also completed a summative assessment following the simulation (Appendix D) to understand how the simulation may have impacted future driving behaviors and how effective VR was as a road safety awareness tool.

Figure ES1: Meta Quest 3 VR Headset

Figure ES2: View from Driver's Seat of the VR Simulation

Findings

Based on the survey results, the research team provided road safety recommendations to educational institutions, traffic safety authorities, and technology experts for future implementation regarding VR. Of 11 participants, five said they never looked at their phone while driving, three said they were rarely likely to, and three said they were sometimes likely to (Figure ES3). Nine participants said they never sent a text message while driving, while two said they were sometimes likely to send a text (Figure ES3). Six participants claimed they were either rarely or somewhat likely to look at their phones while driving (Figure ES3). Of the 14 total participants, 13 felt VR could positively alter their perception of road safety, while one did not (Figure ES4). On top of that, nine individuals said they would be less likely to check their phones while driving after using the simulation, while five said they would not be less likely to (Figure ES5).

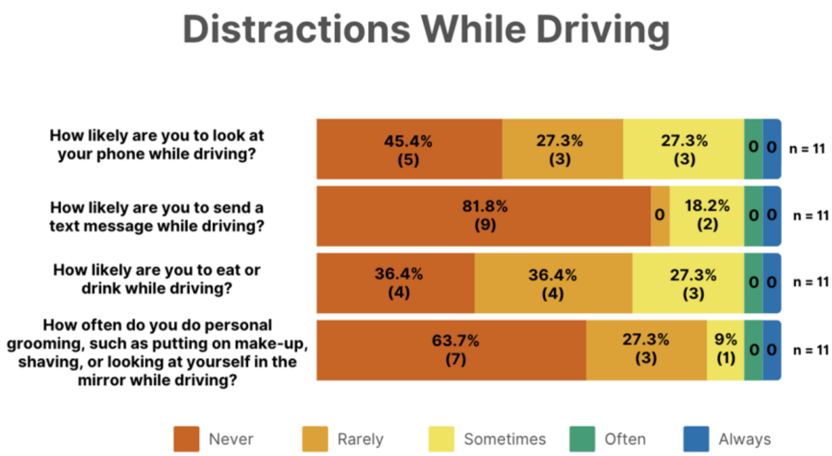

Figure ES3: Participants' Distractions While Driving

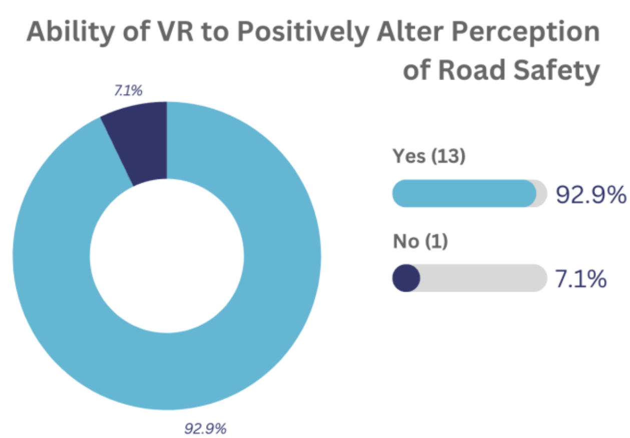

Figure ES4: Participants' Beliefs on VR's Ability to Positively Alter Perception of Road Safety

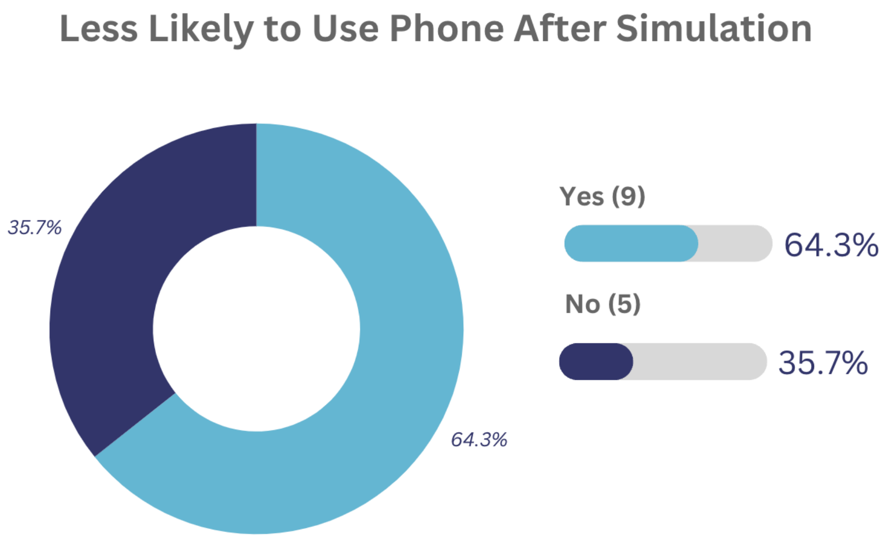

Figure ES5: Participants' Attitudes Towards Using Phone After Simulation

Recommendations

Since the vast majority of students expressed a positive outlook on VR to improve road safety, it suggested a significant potential for VR interventions in the future. However, our team recommends increasing the duration and realism of the simulation, scheduling more time for data collection, enabling access to observe participants' headset view, placing the phone in the drivers' line of vision, and conducting interviews following the VR simulation to increase the value of this study. Building on existing road safety measures, this research project aimed to analyze the distracted driver behavior of young adults in Morocco and discover how interactive models like VR can impact an individual's control beliefs about texting and driving.

Authorship

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1.0 Introduction

Road safety awareness in Morocco is limited, especially in more densely populated areas. Morocco has experienced substantial growth in its number of vehicles, with an estimated increase from 2.7 million in 2015 to 4.3 million in 2022. Concurrently, the traffic volume, measured as vehicle kilometers traveled, has surged by more than 15.7% (International Transport Forum, 2024). This rapid expansion of vehicles has coincided with a concerning trend in road safety. Despite efforts to improve infrastructure and implement safety measures, the number of accidents and fatalities remains high, with over 3,000 road deaths reported annually (International Transport Forum, 2024; Advani, 2020).

In February 2018, the Moroccan government adopted a law to create a National Road Safety Agency (NARSA), which became operational in January 2020 (International Transport Forum, 2024). NARSA coordinates, implements, and manages all road safety actions. This encompasses the implementation of the national road safety strategy, the issuance of registration cards for motorcycles and motor vehicles, driving license examinations, managing the demerit point system, conducting technical inspections of all motor vehicles, executing communication campaigns, and acquiring enforcement equipment (National Road Safety Agency, 2024).

Many European countries have implemented virtual reality (VR) in road safety interventions and awareness campaigns to promote safer driving habits. The United Nations Institute for Training and Research (2021) has created learning modules to address behaviors such as drunk driving, speeding, seatbelt, and phone usage. This innovative approach to fostering safer driving practices could address Morocco's road safety challenges, specifically in urban areas.

Building on existing road safety measures, this research project aimed to analyze the distracted driver behavior of young adults in Morocco and discover how interactive models like VR can impact an individual's control beliefs about texting and driving. With increased road safety knowledge and awareness, the research team aimed to prevent future road accidents and fatalities. Based on student surveys, the researchers provided road safety recommendations to educational institutions, traffic safety authorities, and technology experts for future implementation regarding VR.

2.0 Background

This chapter first examines the threat of road risks on Morocco's population, specifically within densely populated cities. It investigates how accidents are influenced by driver behavior and physical factors, with an emphasis on the impacts of texting and driving. Next, the section highlights current driving laws and regulations, in addition to education about road safety. It also discusses how control beliefs and attitudes shape driver behavior. Finally, the chapter discusses the use of VR as an interactive learning model to increase driver safety and awareness.

2.1 Road Risk Analysis on Urban Cities

Over the last 20 years, Morocco's growing population and socio-economic transformation have led to increased commercial activity and road traffic. To match this ever-expanding growth, Morocco has invested heavily in infrastructure. Between 2001 and 2017, Morocco experienced one of the highest global rates of investment, totaling between 25% and 38% of its gross domestic product (Advani, 2020). However, despite the country's efforts, the development of infrastructure to support this expansion has not kept pace with the rising demand, resulting in heightened road safety risks.

Approximately 80,000 accidents occur annually in Morocco, with projections indicating an increase in the coming decade as the population continues to expand (Youssef & Moujjane, 2023; Ouazzani-Touhami & Souissi, 2021). The lack of infrastructure in urban areas heavily contributes to these road accidents, with over 71% of all accidents occurring in agglomeration between 2011 and 2022 (Youssef & Moujjane, 2023). The most densely populated cities in Morocco have each averaged over 100 fatal road accidents per year including Casablanca, Rabat, Fez, Marrakech, and Tangier (Figure 1). While a majority of road accidents occur in major cities, these urban areas continue to face numerous deficiencies in infrastructure developments, contributing to higher road risks. Among these challenges include poor road conditions, a lack of pedestrian crosswalks, and a shortage of public lighting and road signs (Youssef et al., 2023). These issues are amplified at night, reducing the visibility and alertness of drivers (Ouazzani-Touhami et al., 2019).

Additionally, the diversity of vehicles in Morocco impacts road safety. This includes a mix of traditional and modern vehicles, ranging from bicycles to motorcycles, buses, trucks, and cars. Each vehicle comes with unique risks and challenges such as maneuverability, braking distance, and visibility. However, motorcycles are one of the most dangerous forms of transportation, making up 60% of the total driver fatalities in road accidents and 62.8% of the total drivers seriously injured in Moroccan road accidents (Khyara et al., 2022). Furthermore, outside of vehicles, pedestrians also play a vital role in road safety and can be considered the most vulnerable victims in road accidents. On average, about a quarter of the nearly 4,000 Moroccan citizens who die in road accidents are pedestrians (Youssef & Moujjane, 2023). By understanding road safety challenges in Morocco, with the lack of infrastructural support and a growing population, a comprehensive analysis of driver behavior and physical factors is imperative to interpret urban road risk.

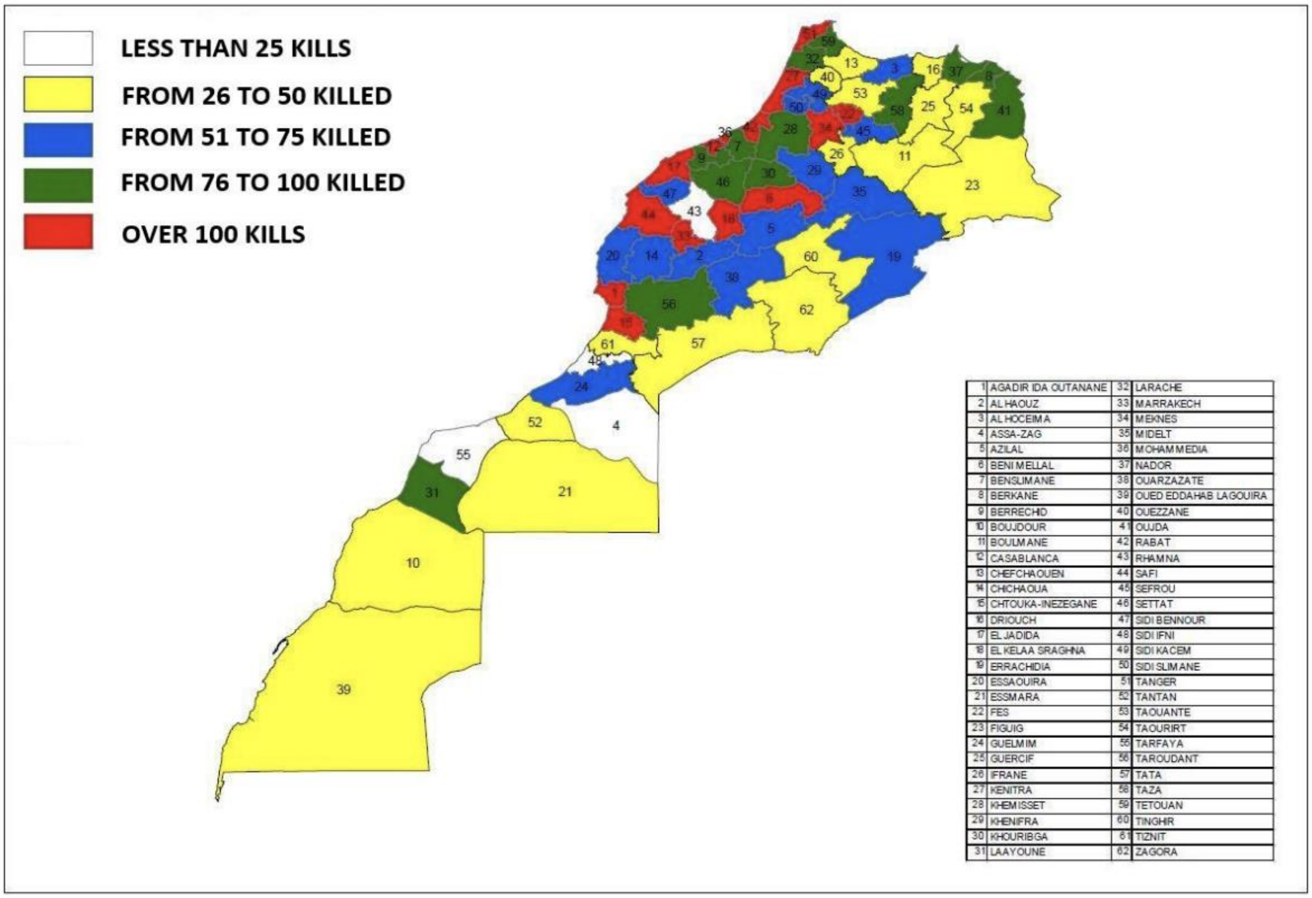

Figure 1: Geographical Distribution of Average Number of Road Accident Fatalities in Morocco (Youssef & Moujjane, 2023).

2.2 Driver Behavior and Physical Factors Impacting Accidents

A combination of driver behavior and physical factors influences road safety. While physical components such as road conditions, weather, and vehicle type play a critical role in accidents, irresponsible driver behavior is the most significant factor in mitigating road safety concerns. These behaviors include speeding, driver negligence, unauthorized or unsignaled lane change, failure to give right-of-way, loss of vehicle control, disregarding stop signs, driving under the influence, and using a mobile phone while driving (Khyara et al., 2022). However, the impact of each of these actions varies, with driving under the influence of alcohol only contributing to 3.7% of accidents (Global Road Safety Facility, 2018). Even so, these behavioral factors stem from a lack of driving experience, failure in evaluating risk management, or ignorance of safety rules and laws regulating driving. One case study found that errors and lapses increase among young Moroccan drivers who have low educational levels, unstable family conditions, minimal driving experience, or mostly drive in urban areas. Additionally, researchers concluded that to reduce the accident rate on Moroccan roads, the country must consider making drivers more responsible, including a continuous assessment of driver behavior and requiring more education on road safety at a younger age (Rachad et al., 2023).

Physical factors contributing to accidents in Morocco can be linked to the circumstances surrounding the accident location. Typically, drivers face an increased risk of accidents in developing countries because of inadequate driving infrastructure. Variables such as density and visibility of a location can lead to accidents being more serious. Furthermore, failure to implement specific safety measures in conditions where they are warranted can lead to adverse consequences. For example, accidents involving cyclists increase in number and severity when bicycle riders fail to equip proper gear such as helmets or reflective vests (Khyara et al., 2022). Another contributing factor is warm temperatures, which have been shown to heighten fatigue, leading to a loss of concentration and stunted reaction time (Zerka & Jawab, 2022). After examining the multifaceted driver behaviors and their influence on road safety, we narrowed the scope of our project to analyze texting while driving.

2.3 Texting & Driving

According to Alotaibi (2019), distracted driving, as defined by the National Highway Traffic Safety Administration, is described as “any activity that diverts attention from driving.” The Center for Disease Control furthers this definition of distractions by placing it into three categories: visual, cognitive, and manual. Visual distractions are when the driver’s eyes are focused on an object in or around the vehicle. Cognitive distractions are when a person is looking at the road but concentrating on something other than driving. Manual distractions are when the driver's hands come off the wheel completely. Texting and driving can be categorized under manual and visual distractions. Sending a text, making a phone call, or answering an email can be considered a manual distraction as it takes the driver’s hands and attention off the wheel and road. Additionally, glancing down at a cupholder when a notification is received, looking at the screen to unlock a phone mounted on the dashboard, and checking a GPS are examples of visual distractions.

From data provided by the International Transport Forum (2024) in Table 1, the largest number of road fatalities in Morocco involve drivers between the ages of 25-64. The second highest age group is individuals between 21-24 years old. In a survey administered by the International University of Rabat (UIR) in 2019, 47% of UIR students admitted to sending a text message while driving. Furthermore, a person is two times more likely to cause an accident when using a device and driving (Ghogho et al., 2022). The increased use of personal devices among young adults has translated into their driving habits, causing increasingly dangerous situations on the road. If a person looks away from the road for three seconds while driving at 120 kilometers per hour, they will travel roughly 100 meters, which is longer than an American football field and slightly shorter than an international football pitch. Whether it is taking their hands completely off the wheel to respond to a message or taking their eyes off the road to glance at a notification, even one second of unfocused driving can cause a road accident. After examining specific factors contributing to accidents on the road, we believe regulatory laws and educational initiatives can be used to improve road safety in Morocco.

Table 1: Road Fatalities by Age Group in Morocco (International Transport Forum, 2024)

	2020	*2021*	*2022*
0-14 years	199	262	281
15-17 years	79	127	105
18-20 years	172	188	177
21-24 years	272	340	326
25-64 years	1,898	2,250	2,118
64-74 years	198	295	287
≥ 75 years	157	144	153

2.4 Laws, Regulations, and Education for Road Safety

Over the years, Morocco has implemented laws, regulations, and educational initiatives to enhance road safety. For example, the minimum driving age in Morocco is 18 years old. The maximum speed limit in urban areas is 60 km/hr and 30 km/hr in residential areas (International Transport Forum, 2024). Moroccan police are strict about following the speed limit. If a driver is slightly above the speed limit, they will likely be issued a fine. Additionally, drivers can be fined for failing to halt at a stop sign. In terms of education, February 18th is National Road Safety Day, where schools offer programs to teach children about driving regulations and laws (Abdellah & Rachid, 2021). While these programs are effective, researchers recommend incorporating other aspects of learning road safety, such as a road safety education club, to help establish a regular educational program.

Failing to adhere to laws and regulations can cause severe injury or even death. According to the International Transport Forum (2024), 18% of all road fatalities in 2022 in

Morocco were due to speeding. Additionally, the use of hand-held devices while driving is prohibited. Lastly, the forum also states that only half of drivers and passengers wear a seatbelt. Even though road regulations and laws are put into place, it does not mean that they will be adhered to, therefore impacting the safety of drivers and pedestrians alike.

Similar to the United States, the process for obtaining a Moroccan driver's license requires the individual to meet physical prerequisites, complete a driver's education course, pass a written test regarding traffic regulations in Morocco, and pass a physical driving exam (Expat Focus, 2023). However, not all drivers in Morocco have a Moroccan license. An International Driving Permit (IDP) is not required in Morocco, although it is highly recommended. Foreign visitors who plan to drive in the country should have an IDP along with their valid home country driving license. Morocco's IDP is recognized in more than 165 countries worldwide and is valid for the duration of the individual's home country license (International Drivers Association, 2023). There are defined steps to ensure that anyone who obtains a driver's license is aware of the rules of the road in Morocco.

In recent years, there has been an increase in awareness around road safety and some of the necessary precautions that should be taken to avoid injury or fatality. For example, in 2022, bicycle and motorcycle helmets were distributed to citizens to help enforce road safety, given that bicycles and motorcycles accounted for 65% of road fatalities. Additionally, to further educate future drivers, a road safety certificate was established in the middle school curriculum (International Transport Forum, 2024). It is also important to note that overall road fatalities have decreased but remain relatively high in Morocco. From the overview of Morocco's legislative and educational efforts for improving road safety, the focus shifts from public beliefs to individual attitudes about road behaviors.

2.5 Control Belief

Safety culture and the beliefs of drivers play critical roles in shaping road safety. The level of compliance is a theory described by the Theory of Planned Behavior (TPB) that highlights three components involved in a person's belief system: behavioral beliefs, normative beliefs, and control beliefs (Ajzen, 1991). A behavioral belief is how an individual perceives the consequences or outcomes of a particular action. A normative belief is how an individual perceives what is socially or culturally acceptable or appropriate. A control belief relates to the perception of factors that may prohibit an individual from acting out. Our project focuses on control beliefs, which are perceptions of one's ability to influence driving behavior and outcomes. Individuals with strong control beliefs are more likely to engage in safe behaviors, reducing the number of road accidents. Control belief is an important aspect for us to investigate because belief interventions were found to be effective for group or public campaigns (Schlembach et al., 2017). Drivers' beliefs can be assessed through the completion of surveys. Understanding these beliefs can provide valuable insights into implementing effective recommendations for interventions, such as awareness or educational campaigns.

Control belief is not only one's ability to drive, but also trusting that other drivers are responsible and competent. If the existence of road awareness measures was more apparent or visible, then it could significantly impact control belief. Providing individualized road safety awareness can enhance driver's confidence in their personal driving skills. However, if the driver knew that these road safety initiatives were being carried out on a larger scale, like through educational campaigns, then the driver could trust that others on the road carry the same knowledge.

Attitudes are another important factor to consider when discussing road safety awareness. They are split into two components, factual and emotional. Factual attitudes are based on the rationale or reasoning behind a person's decisions, and the reasoning is based on previous knowledge and experience. The level of compliance and the TPB describe decision-making as a deliberate and rational process, typically based on education or expert advice. However, situational road safety decisions made by drivers are based on emotional attitudes, intuition, and automatic functioning rather than explicit reasoning. Emotional attitudes are marked by a person's feelings and responses to a certain situation or idea. These attitudes can stem from personal experience and social or cultural norms. Different from factual attitudes, emotional decisions are less dependent on relevant information and more on a person's reactions (Schlembach et al., 2017). An example of an emotional attitude could include a driver's fear of causing harm to themselves or others due to speeding or reckless driving. By working to change the attitudes and perceptions of young drivers, a mature safety culture can be fostered to prevent accidents. Understanding these beliefs highlights areas for safer road practices through initiatives and interventions. Exploring VR as an interactive learning model unveils new possibilities for education. VR offers a unique platform to engage learners beyond traditional educational methods, making it particularly promising for teaching complex subjects such as driver safety.

2.6 Virtual Reality as an Interactive Learning Model

Virtual reality (VR) is a technology that has risen in popularity for years, gaining traction in many fields and advancing its needs and applications. VR is a computer-generated simulation of reality. This alternate world is created in three dimensions, bringing the image to life physically in front of the user's eyes. Brooks (1999) indicates that as early as 1965, Ivan Sutherland stated,

> Don't think of [VR] as a screen, think of it as a window, a window through which one looks into a virtual world. The challenge to computer graphics is to make that virtual world look real, sound real, move and respond to interaction in real-time, and even feel real. (p.1)

The interactive environment generated within VR headsets can be created in a seamless, physical sense. Advanced forms of VR use a helmet with a screen, mittens, and full-body sensors to immerse the person in the alternate universe.

The demand for VR has been rapidly increasing, mirrored by a prompt growth in funding. The fast-paced development has been estimated to grow from $7.3 billion (USD) in 2018 to $120.5 billion in 2026 (Fortune Business Insights, 2023). The versatility of VR extends beyond imagination and is beginning to be used across different fields. Mainly, it has dominated the gaming and entertainment world, making immersive games possible and increasingly accessible. Companies like Meta have created advanced technologies such as the Oculus Quest, which raised over $2.4 million (USD) on Kickstarter in 2012, and HTC's VIVE which are both currently dominating the consumer market (Morgenroth, 2023). VR has been seen in many fields including retail, transportation, energy, consulting, insurance, healthcare, and sports. Although VR is primarily used for corporate training, it is also being used in educational settings such as universities and schools worldwide.

VR is based on three principles: immersion, interaction, and user involvement (Freina & Ott, 2015). These concepts contribute to a better learning environment, making the material more pleasant and engaging for the user. Three challenges have been identified when comparing VR to regular teaching practices: cost, usability, and fear of technology (Bricken, 1991). Upon their initial release, VR headsets were expensive and unrealistic for schools and other educational organizations to implement (Fortune Business Insights, 2023). However, VR has grown immensely in the last decade, changing the market value. Immersive technology is now much easier to obtain, with companies like Google making a cardboard version for mobile devices to introduce VR to the consumer at home for just $15 (USD) (Fortune Business Insights, 2023). Nowadays, prices have dropped significantly for older headset generations, but new consumer models have remained similar in price. More advanced devices have resulted in higher prices from companies like Primax in 2018 and Varjo in 2019, which ranged from $900 to $12,000 (VR Space, 2021). Other models like the HTC Vive Pro could be found for $1,100 upon its release date in 2018. In 2016, when Oculus released the Rift CV1, it initially sold for $600 (VR Space, 2021). Now, in 2024, the Meta Quest 3 (Figure 2), which was used in this project, was obtained for $500.

Figure 2: Meta Quest 3 VR Headset (Ashworth, 2023).

Immersive learning models are designed for those who seek additional assistance in retaining information. Studies conducted at the University of Gothenburg show that VR is most effective when subjects need an interactive learning model (Hussein & Nätterdal, 2015). VR is a learning module that offers a new tool for educators and a way for students to physically grasp the subject they are studying, bringing new life to the term "hands-on learning" (Bell & Fogler, 2004). According to Jack Kaumo (Michel, 2020), director of iWarehouse Technology Solutions for The Raymond Corporation, VR can be more appealing to youth, making it a better option to choose for education;

> For many people entering the workforce who like gaming and virtual reality at home, being able to learn how to do their jobs in that same type of environment is going to appeal to them… It's been a selling point for VR education for some of our customers (p.1).

The exciting innovation of VR allows users to experience the immersive learning model without many risks involved.

Driver safety can also be taught effectively through VR modules (Brooks, 1999). Having a simulated experience can create endless scenarios that may occur on the road, while in a safe environment (Ropelato et al., 2018). Learning how to drive takes hours of time and practice, especially when understanding the vehicle and the roads to ensure safety for everyone including oneself. Operating a motor vehicle requires a driver's full attention, with even the most experienced drivers making mistakes. Therefore, one of the goals of this VR experience is to promote situational awareness to reduce accidents. Placing participants in a motor vehicle and simulating a crash without damages or injuries makes the technology unique. The acceptance of bringing VR into education has been long debated. However, the learner's attitude toward VR is largely positive, with a correlation between incorporating the technology into practice and the individual's retention rate (Bell & Fogler, 2004). The feeling of viewing an alternate reality brings all of the user's focus and attention to the subject in front of their eyes, making the technology widely accepted and persuading students to incorporate it into studying tactics (Huang et al., 2013).

2.7 Summary

Our background research underscored the importance of additional awareness among young Moroccan drivers regarding road rules and regulations to prevent accidents in urban areas. As accident and injury rates remain high in Morocco, our group sought to provide road safety recommendations to be implemented in the future. Since a majority of driving errors and accidents are committed by young people, our objective was to understand current UIR students' driving perspectives and behaviors. Additionally, we wanted to gauge students' interest in increasing driving education and awareness using an interactive model like VR. We aimed to interpret the effectiveness of VR as a learning tool by addressing various factors such as auditory, visual, and physical cues. The goal was to explore how interactive models, such as VR, impact the way individuals learn and retain information about driving regulations to increase road safety in Morocco.

3.0 Methodology

Using both pre-assessment and summative evaluations, our goal was to obtain data on how young students' experiences using interactive learning models, such as VR, can impact an individual's control beliefs about texting and driving. We used qualitative and quantitative surveys that included multiple-choice, open-ended, and Likert scale questions. The Likert scale is a rating metric used to assess attitudes and opinions based on how strongly someone agrees or disagrees with a statement. This variety of questions allowed us to understand and evaluate young driver's control beliefs, attitudes, and road safety habits. Additionally, a VR simulation was designed to establish the current driving behaviors of young adults in the event of an auditory distraction, such as a phone ringing.

3.1 Setting

This research was conducted in collaboration with professors at the International University of Rabat (UIR). The university offers major programs in engineering, medicine, and business. UIR is a smaller private institution, with around 6,000 full-time students (Times Higher Education, 2024). The two individuals at UIR overseeing the project were Dr. Mounir Ghogho and Dr. Ouassim Karrakchou, professors at the School of Computer Science. Dr. Ghogho is the Dean of the College of Doctoral Studies and a fellow of the Institute of Electrical and Electronics Engineering, an esteemed group of qualified individuals in the field of engineering. His expertise includes wireless communication, signal processing, and machine learning. Dr. Karrakchou is a member of the UIR Lab for Technology, Information, and Communication (TICLab) which focuses on topics such as artificial intelligence, machine learning, and cybersecurity.

3.2 Participants

The participants in this project were Ph.D. students enrolled at UIR. The sample included 14 students from various disciplines and educational backgrounds. To obtain quantitative data regarding the interest of young drivers in VR as a potential learning tool for road safety, we distributed a pre-assessment survey to analyze students' driving histories and any prior experiences with VR. The participants then engaged in a VR driving simulation. Following the simulation, a summative assessment was distributed to investigate the effect that VR had on driver safety awareness. All research protocols and modifications were approved by the WPI Institutional Review Board (IRB). Participation was voluntary and anonymous for all study subjects. Individuals who took part in the study were provided with and read a statement of consent before engaging in any research activities (Appendix A). The form marks the purpose of the study and the procedures the individuals followed, allowing them to stop the simulation at any time if needed. The participants were then required to complete a screening process that determined the eligibility of students to engage with the VR technology based on the participant's state of health (Appendix B). Questions in the screening process varied from daily health concerns (e.g. excessive tiredness, migraines, or recent headaches) to more personal health issues that VR may interfere with (e.g. pregnancy, epilepsy, etc.). If there were any health complications with the participants, then they were dismissed from the study. All survey data was deleted following the completion of the study.

3.3 Pre-Assessment

Distributing the pre-assessment gave us perspectives on how experienced the participants were in relevant fields like driving history, control belief, and VR technology (Appendix C). A pre-assessment survey collects participants' demographic information and pre-existing knowledge before an experiment begins. Our pre-assessment and responses were created and securely stored within Qualtrics, a secure data collection and survey distribution website. Our goal was to create direct, quantitative, close-ended questions to reduce ambiguity, specifically for participants with a language barrier. While all the Ph.D. students were multilingual and spoke English, not all participants in the study spoke English as their first language. To prevent confusion, the questions needed to use concise language, allowing the students to give clear but relevant answers.

To assess control belief, participants were asked several questions about how they viewed themselves as drivers and how they viewed the behavior of other drivers on the road. Investigating control beliefs allowed the participants to understand how they can have control over their environment and driving outcomes. Understanding how an outcome can be negatively altered prompted the participants to change their behavior. The simulation could alter one's control beliefs or attitudes by demonstrating how distracted driving can create negative outcomes, such as crashing or swerving to avoid another vehicle. Participants' engagement in various distracted driving behaviors, like looking at a phone in the passenger seat, offered insights into their risk-taking tendencies and susceptibility to distractions while driving.

Participants were also asked about any prior experience using VR on the pre-assessment. These questions aimed to gauge familiarity with VR technology. Having prior experience with VR could help reduce the learning curve and increase the reaction time of participants. Additionally, familiarity with VR could have influenced the participants' comfort levels and confidence while engaging in the virtual environment. Positive attitudes toward VR may indicate a greater receptivity to implementing VR for improving driving skills and behaviors. Analyzing responses to these questions helped identify trends, patterns, and potential areas for intervention in promoting safer driving using VR simulations.

3.4 VR Simulation

To further explore and build upon the ideas discussed in the pre-assessment, participants engaged in a VR simulation designed to recreate real-world driving scenarios. The purpose of this simulation was to represent how brief distractions can result in serious accidents. VR can cater to diverse learning styles due to its interactive and immersive nature. It can provide visual learners with enveloping visual stimuli, auditory learners with audible instructions or appropriate environmental sounds, and hands-on learners with a near-genuine experience. This versatility enables VR to accommodate different learning preferences and improve learning outcomes across varying styles. The VR simulation was made using a game design program called Unity, and the simulation's delivery was done via a Meta Quest 3 VR headset (Figure 2). The simulation was made by the research team, using existing assets of parts such as roads, buildings, trees, sidewalks, and two main roads, while utilizing a realistic car model. Using code, the car in the simulation was able to interact with a Logitech steering wheel and pedal setup. Additionally, the wheel and pedals within the simulation would physically move with the same magnitude as the user's actions.

After the participants were instructed about pedal locations, controls, and how to adjust the head straps, they put the VR headset on. When the simulation began, the participants were immersed inside a realistic car and seated in front of the steering wheel (Figure 3). The VR headset, using tracking software within the cameras, was able to detect the hands of the driver and simulate them within the virtual experience. If the participant was not placed directly in front of the wheel in the simulation, they could use a calibration maneuver to place themselves in front of the steering wheel to preserve realism. To calibrate, a participant held their hand in front of the goggles, palm facing them, and pinched and held their index finger and thumb together in the direction they wanted to move. They were instructed to do this in order to align themselves with the physical steering wheel. Once the participant was satisfied with their position, they were asked to look around at their surroundings. At that point, they were also asked to recognize the phone that was placed in the passenger seat next to them. Once they had acknowledged their environment, they were told to drive straight forward by pressing on the accelerator.

Figure 3: View from Driver's Seat of the VR Simulation

After crossing a certain point in the simulation, a trigger was activated that resulted in the phone ringing. If the participant looked at the phone, they would see a notification stating, "You have 1 new message. From: Work, Subject: Report Due." Shortly after the phone rang, a second car appeared. This car emerged from behind a bus stop and ran perpendicular to the direction the driver was moving, going at a similar speed as the driver. The car was made to be simple to maneuver around if the driver was not distracted. However, it was intentionally designed that if the driver was moving forward at maximum speed, then they would crash into the second car.

When the participants reached the end of the street, they were asked to remove the headset and complete a summative survey, which would collect their feedback on the experience, including opinions on the VR simulation and its use in education.

3.5 Summative Assessment

The summative assessment (Appendix D) was designed to evaluate participants' perceptions of the technology's realism and usability within a distracted driving context. The summative assessment and its responses were created and securely stored within Qualtrics. The survey consisted of quantitative Likert-type questions that evaluated specific components of VR realism and usability. The open-ended, qualitative questions focused on participants' subjective experiences and thoughts regarding the simulation. This experience sought to provide a comprehensive understanding of the feasibility and potential efficacy of VR technology for road safety awareness.

Following the driving experience, additional summative assessment questions were given to assess the participants' experiences and perceptions regarding the learning curve, intuitiveness, pace of understanding, and response time. A learning curve is the progress involved in gaining a new skill. It often follows a pattern where the initial learning growth is slow but increases as the participant becomes more familiar with the subject. The learning curve of our participants depended on whether they had used a similar type of VR before. Similarly, a participant's ability to overcome a learning curve is influenced by the amount of guidance given by the instructor, who is expected to be knowledgeable about the technology.

Additionally, another factor in the summative assessment that impacts a participant's ability to use and understand VR is recognizing the intuitiveness of the equipment. Since our participants were Ph.D. students at UIR, we anticipated they would have proficient technology and computer skills. With this exposure, we wanted to understand how intuitive the user interface was and explore any challenges encountered during the driving experience. We asked the students to assess how well they learned the material when using VR compared to other methods of learning, concerning visual, auditory, and hands-on factors. We also asked them to evaluate how their response time was affected by the technology.

3.6 Limitations

While our project provided valuable insights into the effectiveness of VR as an awareness tool, several limitations should be acknowledged. Fidelity in simulation is the concept where the virtual environment may be compromised by the realism of the technology (Costiuc, 2021). This brought up concerns about using lower-quality VR. Factors such as graphic quality, sensory feedback, and motion tracking accuracy may have impacted perceptions of the immersive world, questioning the validity of participants' responses. A limiting factor in creating the virtual environment was the shareability of the Unity software, which caused difficulties in establishing multi-device collaboration. To overcome this challenge, our team used one computer to design and run the entire simulation.

Another limitation of our research was that we had two days on the project site to work with participants and gather feedback on their experience in the study. This quick turnaround time made it difficult for us to survey a large number of participants, which could have had an impact on our results. Recruiting participants was also difficult for the study team. Our group and sponsors sent an email out to Ph.D. students with a sign-up form for them to complete the study. Due to a quick turnaround time, it was harder for us to find participants for the study. Of those who attended, seven were voided due to existing medical history, which made them unable to complete the simulation.

As researchers, our biases, backgrounds, and perspectives shaped the design of the study, interpretation of the data, and interactions with participants. For example, no members of the research team were international drivers, so we did not have any personal experience driving in Morocco. Similarly, the formulation of questions in our surveys was affected by language barriers. To minimize ambiguity, we provided further clarification of key phrases and terms to communicate the type of information we are researching and evaluating. We checked in with one another and continually worked with Dr. Ghogho and Dr. Karrakchou to ensure that we accurately represented the perspectives of the study participants.

4.0 Findings

After a sign-up sheet was distributed, 21 students agreed to participate in the study. Due to various health concerns and religious obligations regarding fasting during the holy month of Ramadan, a third of the students were dismissed, excluding them from the study. All remaining participants were 23 and older. Eight of the participants identified as female, and six identified as male. Out of the 14 participants, only 11 had driven a car before and had a Moroccan or international driver's license (Figure 4). Due to this, the three participants without driving experience were not required to answer questions 5-12, which related to driver behavior (Appendix C).

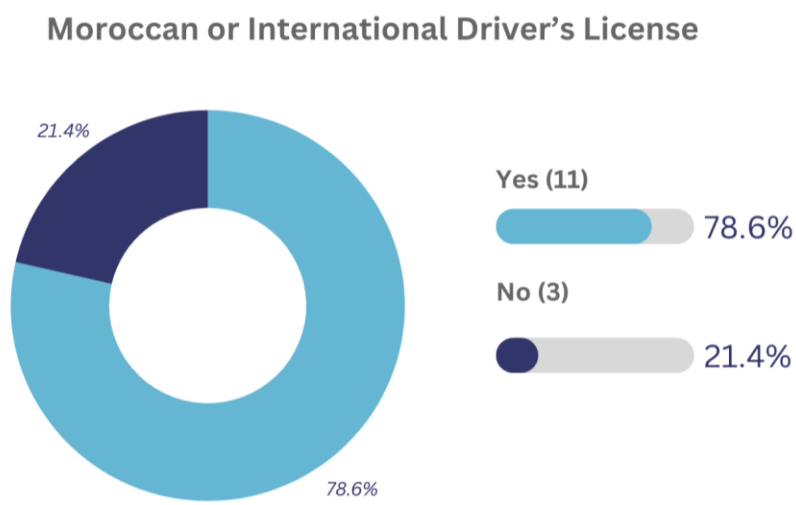

Figure 4: Participants with a Moroccan or International Driver's License

To assess the effectiveness of virtual reality as an educational and awareness tool, we used descriptive statistics to analyze the distribution of responses from Likert scale questions, which provided us with quantitative findings. Thematic analysis was used to uncover frequent patterns in the qualitative data obtained from open-ended responses, providing further insights into the perspectives of the participants. These valuable insights into participants' beliefs and backgrounds helped us analyze trends in the recorded responses. Additionally, all figures were designed to be accessible to individuals with colorblindness (Okabe & Ito, 2008). Following quantitative and qualitative analysis, we found participants viewed themselves as safer drivers than those around them, engaged in distracted driving behaviors, and believed that VR could alter their perception of road safety.

4.1 Finding 1: Individuals Viewed Themselves as Safer Drivers Than Those Around Them

In the first section of the pre-assessment, participants were asked to answer a series of questions that gauged personal beliefs about their driving history. When asked to describe themselves as drivers, five of the participants identified themselves as safe and six as moderately safe (Figure 5). Personal driving safety was a common theme among all participants. Regarding a person's confidence in maintaining control of their vehicle while driving, responses had more variation (Figure 6). A majority of participants were moderately confident while some exhibited a lower level of confidence. Four respondents reported being extremely confident, five reported being moderately confident, and two reported that they were slightly confident. Based on these responses, many participants viewed themselves as safe and confident drivers even in difficult-to-navigate scenarios such as heavy traffic.

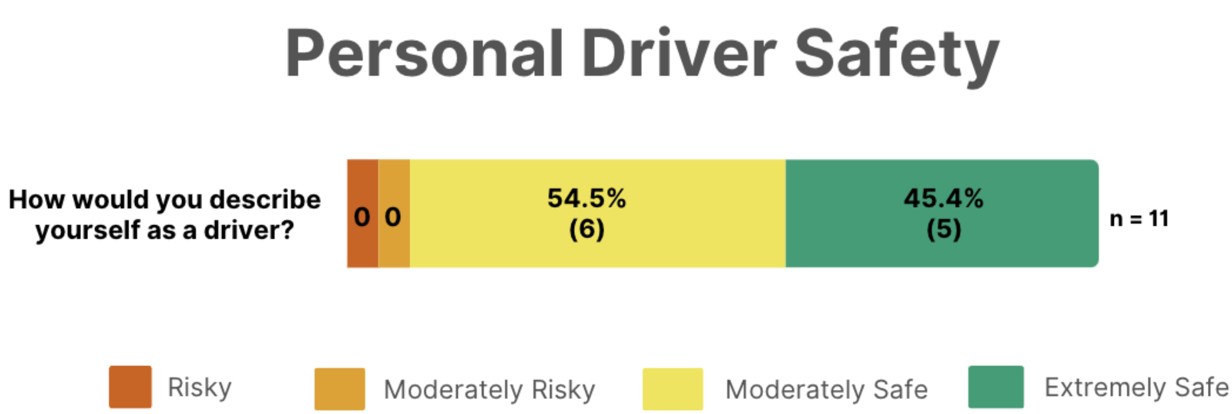

Figure 5: Participants Rating Their Personal Driver Safety

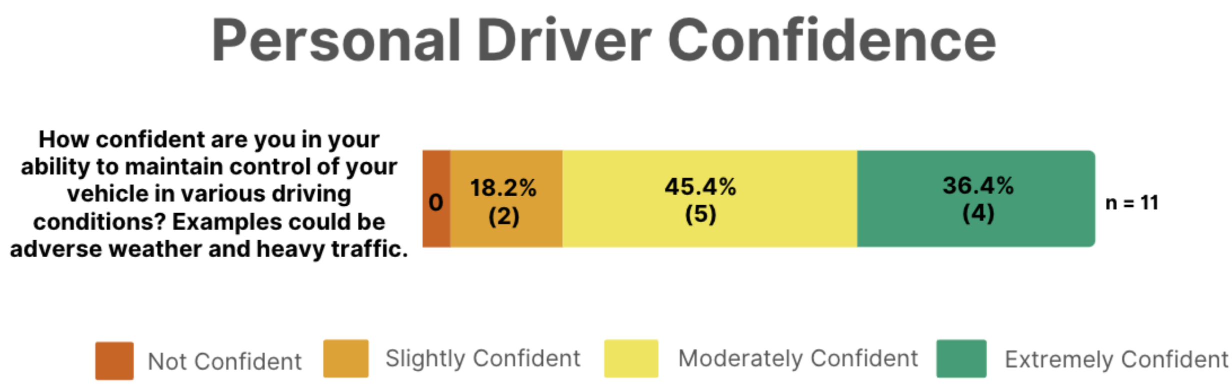

Figure 6: Participants Rating Their Driver Confidence

Drivers' trust in others on the road was also analyzed in the pre-assessment (Figure 7). Two participants said they never trusted other road users, three participants said they rarely trusted others, and six participants said they sometimes trusted others. Despite viewing themselves as safe drivers, many recorded responses expressed skepticism towards other people's driving abilities, while some offered occasional trust. The participants were also asked about how they believed their actions as drivers contributed to a safer road environment (Figure 7). Five participants said they always believed their actions contributed to a safer road environment and four said their actions often contributed, demonstrating that a majority of the participants believe they foster safe driving environments. However, a small portion of the responses did not believe that they greatly contribute to the overall safety of the road, with one participant stating that they sometimes contribute and another one believing that they rarely contribute to the overall safety. Participants generally perceived themselves as moderately safe drivers, however, their confidence levels on the roads decreased when other drivers were considered. With doubt towards other individuals on the road, drivers are more likely to engage in defensive driving, a proactive approach where they take preventative measures to avoid accidents and driving hazards.

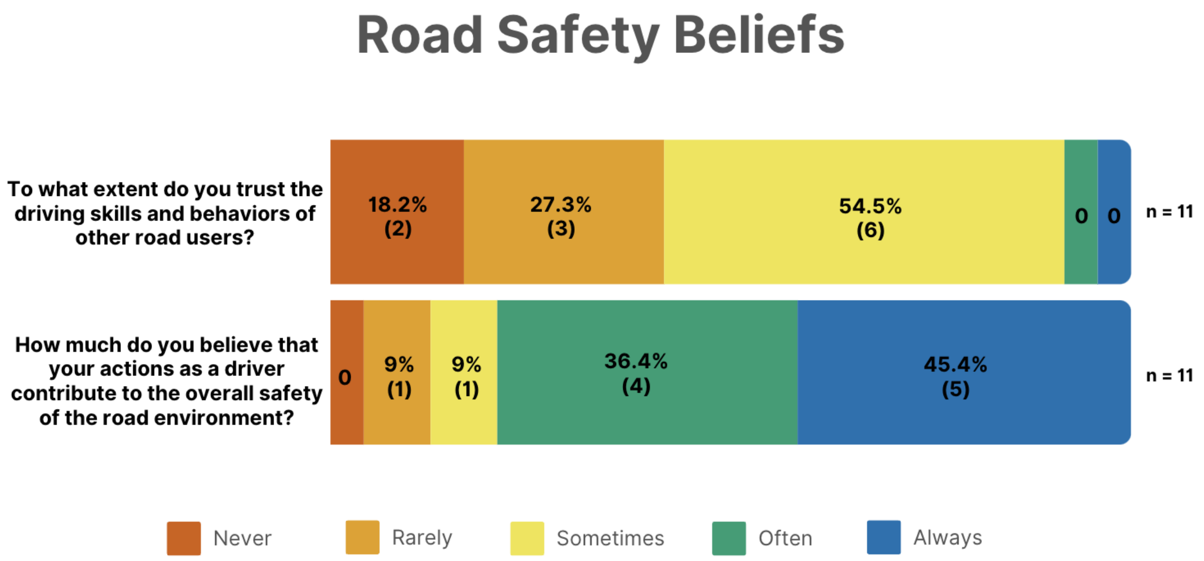

Figure 7: Participants' Road Safety Beliefs

4.2 Finding 2: Participants Engaged in Distracted Driving Behaviors

In this section, participants were asked to answer questions about distracted driving habits (Figure 8). Of the 14 participants, five said they never looked at their phone while driving, three said they were rarely likely to, and three said they were sometimes likely to. Nine participants said they never sent a text message while driving, while two said they were sometimes likely to send a text. Four participants said they never ate or drank while driving, four participants said that they were rarely likely to eat or drink while driving, and three participants said they were sometimes likely to eat or drink. Seven participants said that they never did personal grooming while driving, three participants said they were rarely likely to, and one participant said they were sometimes likely to.

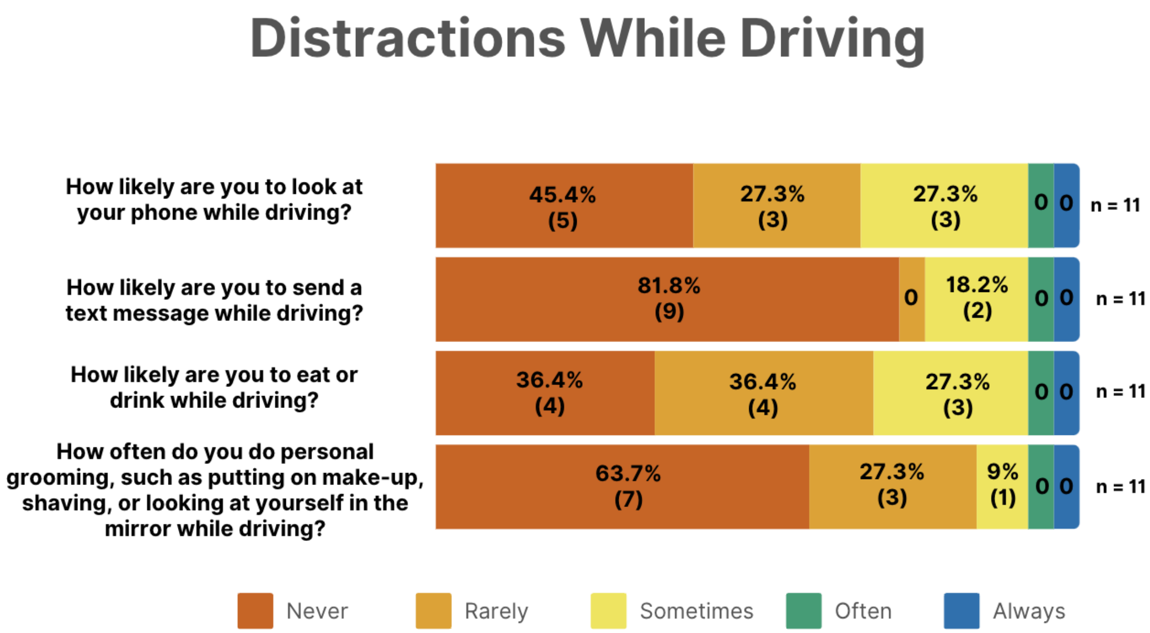

Figure 8: Participants' Distraction Factors While Driving

While six participants claimed they were either rarely or somewhat likely to look at their phone while driving, only two claimed they were likely to text. Despite more than half of the respondents saying they were likely to look at their phone while driving, the most common distraction was eating or drinking. Only four participants claimed they were never likely to eat or drink while driving.

For all questions in this section, most respondents said they had never engaged in distracted driving behaviors. Another important point is that often and always were not chosen as responses for any questions related to distractions. If a small number of people are engaged in distracted driving behaviors, then developments to mitigate accidents caused by distractions could be more achievable because a significant portion of our drivers did not engage in these habits. For more distracted individuals, awareness campaigns could reduce these behaviors. This allowed us to understand that participants do engage in various types of distracted driving, and how those distractions may pose threats on the road.

4.3 Finding 3: Students Believed That VR Could Alter Their Perception of Road Safety

In the last section of the pre-assessment, participants were asked to indicate their previous experience with VR (Figure 9). If applicable, they were also asked to elaborate on their reason for using the technology in the past. Five participants had used VR before, and nine participants had not. Of the five participants who said they had used VR, three used it for entertainment, and two used it for gaming. This allowed us to understand the popularity of VR in Morocco and determine whether it was a tool that individuals could become familiar with in the future for educational and awareness purposes. If someone had prior use of the technology, it was easier for them to use as a learning tool.

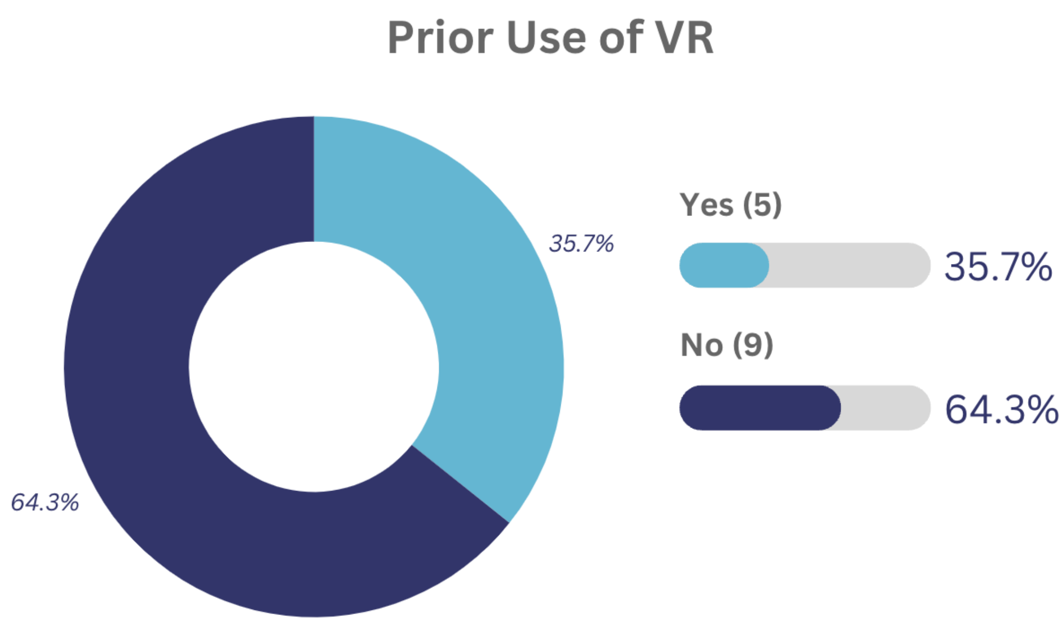

Figure 9: Participants' Prior Use of VR

Of the 14 participants, 13 felt VR could positively alter their perception of road safety, while one did not (Figure 10). Since the vast majority of students expressed a positive outlook, it suggested a significant potential for VR interventions to impact road safety beliefs. However, since a majority of the participants had no prior VR experience, it took time for participants to familiarize themselves with the technology.

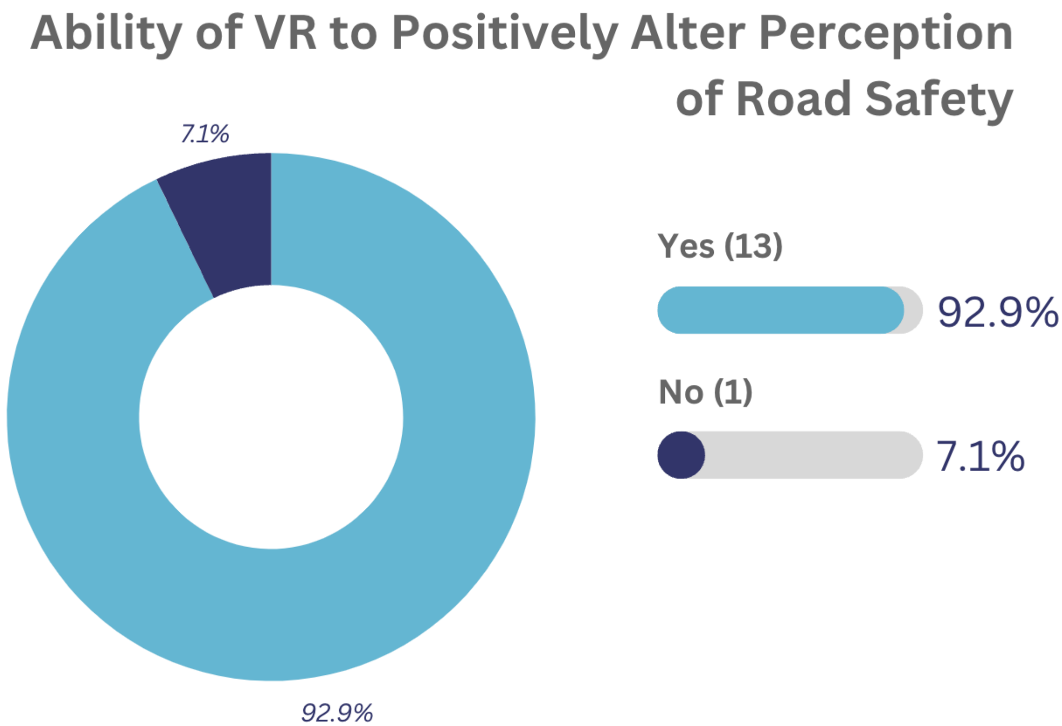

Figure 10: Participants' Beliefs on VR's Ability to Positively Alter Perception of Road Safety

The summative assessment allowed us to understand how the simulation may impact future driving behaviors and how effective VR may be as a road safety awareness tool. Regarding participants' opinions on whether VR simulates the real world effectively and realistically, one strongly disagreed, two somewhat disagreed, two neither agreed nor disagreed, seven somewhat agreed, and two strongly agreed (Figure 11). Of those that disagreed, some referenced poor response time between actions such as using the brake and their translation into the simulation. They also mentioned that the environment was "too perfect to be real." Of those who agreed, they mentioned that the simulation felt immersive. All participants stated that the technology was easy and intuitive to use. They also stated that they were able to learn how to use the technology quickly due to proper instruction given during the simulation. The visual and auditory factors of the VR experience contributed to the participants' feeling that the simulation effectively mimicked reality. However, technological issues between the headset and pedal components negatively impacted the simulation's immersion.

Most participants believed that VR could have a positive effect on learning road safety. Our survey showed that one participant strongly disagreed with this statement, one somewhat disagreed, six somewhat agreed, and six strongly agreed. Additionally, nine individuals said that they would be less likely to check their phone while driving after using the simulation, while five said that they would not be less likely to check their phone while driving (Figure 12).

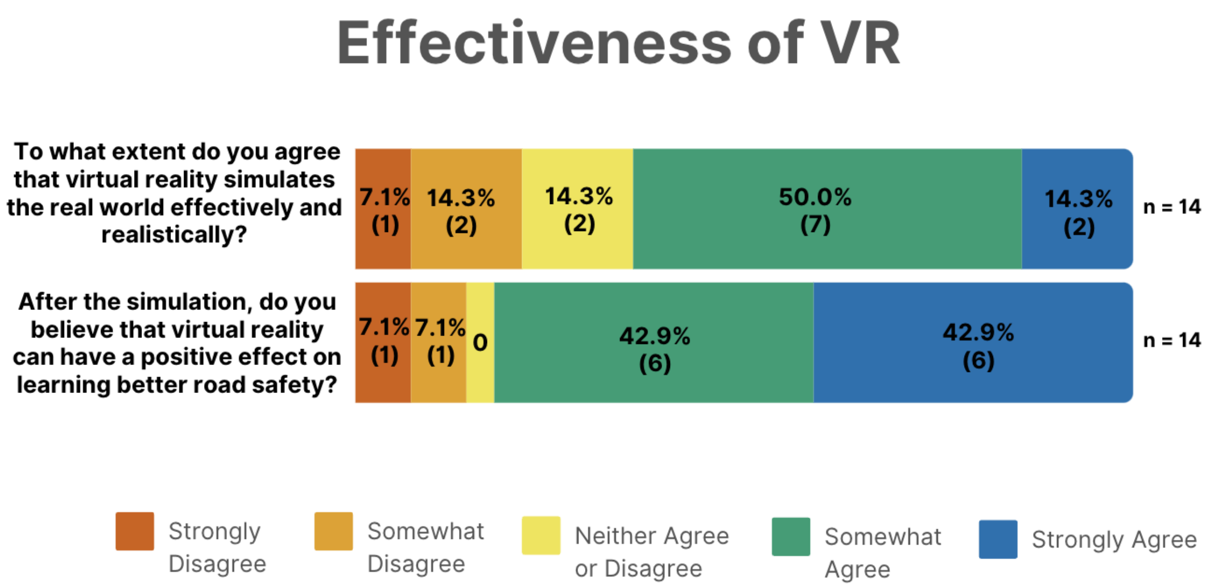

Figure 11: Participants' Opinions on Effectiveness of VR

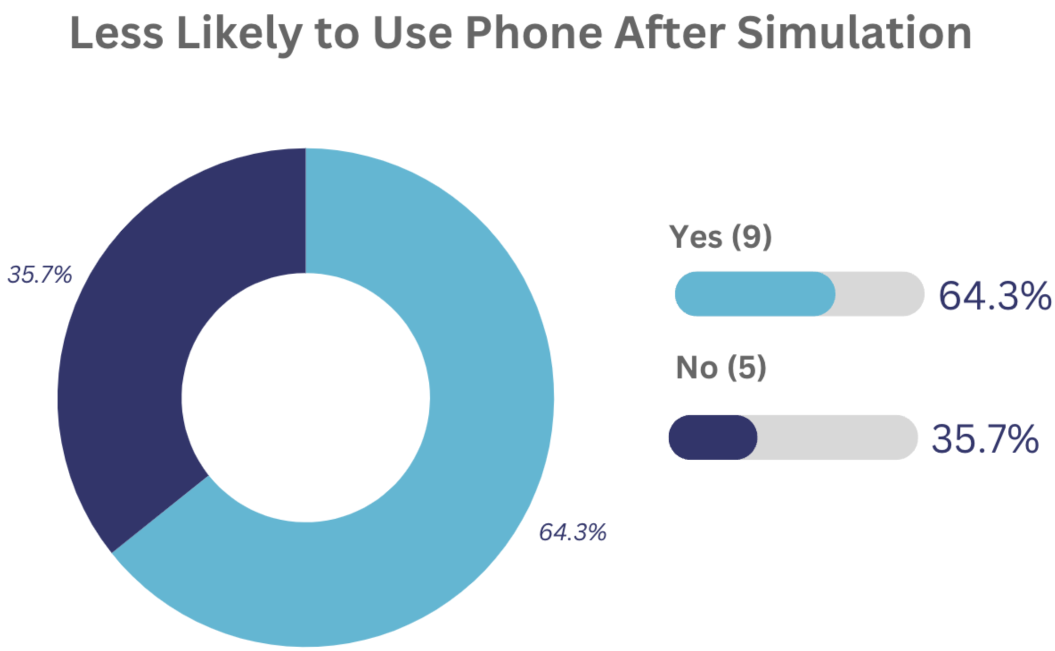

Figure 12: Participants' Attitudes Towards Using Phone After Simulation

Similar to how participants acknowledged that the graphics did not feel like the real world, most participants believed that the technology affected their response time to the distraction. With a delayed response, the simulation became less realistic for the participants. Since car accidents occur unexpectedly and require quick reactions, this delay highlighted an aspect where the simulation diverged from the real world. However, despite not feeling entirely realistic, a majority of participants felt that their phone usage while driving would decrease following the study. This shows that the VR technology did have an effect on phone usage and control beliefs, again suggesting a significant potential for VR interventions to impact other road safety beliefs. With more detail and development, the simulation could have an even greater effect on participants.

Throughout the VR simulation, the research team observed the participants' physical responses and attentional focus. During the driving experience, two subjects looked at the phone in the passenger seat when it rang. Among these individuals, only one attempted to interact with the phone, while the other briefly glanced over. A majority of participants were able to avoid the oncoming car without colliding. After each participant completed the simulation, a member of the team entered the virtual environment to reset the car's position and field of view. During this reset, it was noted that the cars of the two distracted drivers had deviated from the roadway and stopped in the grass near a building, which indicated that they may have crashed. One participant collided with a building; however, this person had minimal prior experience with driving, potentially attributing the accident to a lack of skill rather than distraction. As only two participants turned their heads to look at the phone after it rang, 12 out of 14 participants were not affected by auditory distractions.

Due to the VR headset limiting the user's view of their actual surroundings, participants encountered issues interacting with the physical simulator. Namely, there was trouble distinguishing the accelerator from the brake without guidance from the instructor. Pre-simulation instructions stated that the driving simulator chair was stationary and unable to move forward or backward. It was observed that the seating made it difficult for some individuals to reach the pedals, so they slid forward and sat toward the front of the chair. Certain participants encountered difficulty aligning their position in the car to match the placement of the physical steering wheel in front of them. All users were taught how to complete the calibration and were allowed to adjust the position to their liking. Additionally, most cars in Morocco are operated from a manual transmission, but our simulation used a simplistic automatic transmission, only utilizing the accelerator and brake. Although easier to use in the virtual environment, the change in driving habits was an unfamiliar challenge for participants with prior driving experience. For others, it was their first time driving a car. Despite having no driving experience, these participants were still eager to try the technology and willing to participate in the study. At the end of the study, many participants remarked how the duration of the simulation was shorter than they anticipated after a lengthy pre-experiment process. Participants recommended that the simulation be longer to become more accommodating.

4.4 Limitations Regarding Data Collection

When the data collection was finished, the number of people who filled out a consent form and health evaluation was 21. Of those 21 attendees, only 14 people were able to proceed and engage with the VR simulation due to unsuitable answers on the health screening. While some of the participants were prohibited from continuing because of underlying conditions, some had to be dismissed because of conditional problems such as tiredness and headaches. The nature of these issues led to consideration regarding the time period of this study. Our data collection was completed during the month of Ramadan which constitutes a time of fasting within the Muslim community. Therefore, participants were not able to do things such as drink water or take medications. Regardless, water was provided throughout the experience in case it was needed.

Sampling bias poses a significant concern in survey research. If the sample lacked diversity (e.g. age, gender, VR experience) and was not well distributed, then the findings would have lacked validity and limited the generalizability of the results. Self-report bias is also a concern using qualitative responses. This bias is known as the veracity between self-reported and true values of the same measure. For example, a driver may have had great confidence that their driving abilities affect the overall safety of the road environment positively, but they might not be as safe as they suggested. There was potential for recall bias, where participants may have struggled to accurately recall their driving experience, affecting the reliability of the data

(Rosenman et al., 2011). The Hawthorne Effect (Jones, 1992) suggests that participants' behavior and responses to VR technology could be influenced by the fact that they are being observed for a study. Their answers might exhibit a bias toward a particular direction, overemphasizing the actual effectiveness of VR. Creating a comfortable and consistent research environment helped mitigate this bias.

Additionally, people’s perceptions of VR and how it could change their driving experience could be negatively affected by their confidence. One instance of this is in participants’ opinions on whether they would be less likely to look at their phones after interacting with the VR. If a driver believes that their habits are rare or do not pose a threat to other drivers, then they would not harness the teachings of the simulation. If a participant is not phased enough by the idea of an accident after the experience, whether it be because they avoided the car or because the distraction did not affect them, then they would not believe that the technology could change their perceptions. A burden of this experience is an inability to mitigate this sense of personal bias. As the creators and observers of this experiment, the research team had no way to genuinely gauge whether participants were safe drivers because there was only one factor, a phone, used as a distraction. If a participant looked forward for the duration of the simulation and avoided the car, then we have to assume that their self-reporting is genuine.

The main goal of the simulation was to feel realistic and immersive, such that the user’s experience of VR would not be negatively affected. This issue did not only matter regarding visual effects but also within the simulation’s actual events. Comments related to these issues were found within the responses coming from our summative assessment, which leads to this idea of realism being a liability. Participants cited factors such as “the way the simulator responds to the brakes and accelerator," how "[the environment] moves and shakes around you," and that "the surroundings don't feel real." If the simulation feels like a creation and does not accurately represent the real world, there would be possible difficulty in harnessing the implications presented by the VR scenario. Due to the time allotted for completion of the experience, there was a necessity for a quick delivery in the making of the simulation. This lack of time led to the skipping of some factors that, while not being completely necessary, affected the feeling of our VR representing reality; including but not limited to a longer duration, noises, and more cars on the road. Along with the simulation, not being able to see a live view of the driver's perspective when not wearing the headset led to unknowns regarding how our participants responded to their environment.

5.0 Discussion, Limitations, & Recommendations

In developing the study, the research team recognized points of improvement that should be implemented in future research. The team recommends increasing the duration and realism of the study, allowing more time for data collection, observing the participant's view during the simulation, placing the phone in the driver's line of vision, and conducting interviews following the simulation to better gauge feedback from participants.

5.1 Recommendations for Future Study

The objectives of our project were to create a functional VR environment that simulated driving and a road safety scenario, study participants' reactions to the simulation, and then analyze the statistics associated with their feedback. Within our analysis of the results, we have found that people believed VR can be an effective learning tool capable of making change. The positive feedback that we collected through our surveys leaves optimism when it comes to the future of road safety education and its possible cooperation with VR. However, despite the outlook we left the project with, there were still issues that might have hindered us from getting even better results. When considering the future of this study, several recommendations would increase the productivity and value of the study.

5.1.1 Increase Duration and Realism of the Simulation

In terms of the VR simulation, we believe that making the simulation longer and more realistic would increase the benefit of students using the simulation. To do this, we recommend adding buildings and pedestrians to the environment and working to fix issues such as the lag time between the physical brake and the stopping of the car in the simulation. Beginning the simulation ahead of time as part of the research work before our team came to Rabat could assist with this.

5.1.2 Schedule More Days for Data Collection, Allowing for More Participants

Allotting more days to collect data would help structure the project. Due to the limited time to perform the study, we were only able to spend two days conducting the experiment. However, by creating the simulation ahead of time, the team could provide themselves with more time to conduct the study once in Rabat. Having more time to conduct the study would allow us to recruit more participants and increase our sample size. The study was also conducted during Ramadan, impacting individuals' participation based on the medical screening process (Appendix B). By scheduling more days for data collection, participants will have the flexibility to participate in the study at times that are convenient and beneficial to their health, encouraging more students to participate.

5.1.3 Enable Access to Observe Participants' Headset View

Our team recommends designing the simulation so that the researchers can see what the participants are viewing in the simulation. This would allow the researchers to draw more detailed conclusions from the study by understanding how participants interacted with the simulation and see how collisions occurred.

5.1.4 Place Phone in Driver's Line of Vision

It will be important to place the phone in the driver's line of vision instead of on the passenger seat. Since we found that not many participants were distracted by the phone ringing, placing the phone closer to the steering wheel would help with researching if the driver would be more distracted by having a phone in their line of view, no longer requiring them to turn their head to see the phone.

5.1.5 Conduct Interviews Following the VR Simulation

Expanding the methodology and conducting interviews following the simulation with all study participants will provide more in-depth feedback on the experience. Interviewing participants would give the research team additional qualitative insight into personal driver safety and beliefs. Conducting interviews would also reduce the ambiguity due to the language barrier and allow participants to feel comfortable asking clarifying questions. Similarly, during interviews, researchers can ask follow-up questions and probe for more information based on responses. With this flexibility to adapt and add questions, researchers can identify emerging themes among them and contextualize participants' responses within broader social and cultural contexts. The team recommends adding more questions related to driving behaviors and beliefs including personal accident history and perceptions of what makes a "good" versus "bad" driver.

5.2 Recommendations to NARSA

The deliverable that was used to display our findings was a presentation prepared for NARSA (Appendix E). Our goal with the presentation was to display our findings and show specific figures and feedback from participants to promote future success for VR within road safety awareness. By presenting this information to entities that are responsible for road safety awareness within Morocco, implementations made because of our recommendations will raise more awareness through larger-scale initiatives like NARSA. With these recommendations, we also hoped to include our limitations to promote the expansion of the project and demonstrate the project's value despite some of our obstacles during development.

5.2.1 Use VR as an Effective Interactive Learning Model for Young Adults

Our research team recommends using VR as an interactive learning model for changing the control beliefs of young drivers. 92.9% of our participants believed that VR has the ability to positively alter their perception of road safety, indicating that it can be an effective tool to raise awareness in the future. VR would be best implemented with individuals under the age of 21, or before someone acquires their driver's license. Using VR as part of safety education before someone is granted their license can help foster safe driving habits. Additionally, our team recommends avoiding the use of VR during Ramadan to avoid any potential health complications due to fasting.

6.0 Conclusion

Through the creation of a VR simulation and observation of the user experience, the research team explored the issue of distracted driving and further explored how VR can be used as a tool in education to enhance road safety awareness. The study, composed of Ph.D. students over the age of 23, provided an understanding of participants' self-reported perceptions of driving habits, engagement in distracted driving behaviors, and receptiveness to using VR as a learning tool for road safety.

Significant findings were derived from this study through a comprehensive analysis of driver behavior, control beliefs of drivers on the road, and interactive VR models. Participants generally labeled themselves as safe drivers, although confidence levels varied, particularly in relation to other road users. Phone usage was primarily noted among participants, however, only a minority of participants engaged in distracted driving within the simulation. The participants' attitudes towards VR technology being a potential influence on road safety perceptions was largely positive, despite limited prior experience.

These findings underscored the importance of adapting new forms of learning modules, such as VR, in addressing road safety concerns. Using these insights discovered by the research team, policymakers, such as NARSA, can develop and implement targeted interventions aiming to promote safer driving practices and mitigate the risks of road accidents. Further research and implementation of VR technology hold promise for the future of safe drivers and safeguarding lives on the road.

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Appendices

Appendix A: Informed Consent Agreement

Study Investigator: Michele Femc-Bagwell

Contact Information: mbagwell@wpi.edu

Title of Research Study: Exploration of Virtual Reality for Road Safety Awareness in Morocco

Sponsor: Dr. Ouassim Karrakchou & Dr. Mounir Ghogho, International University of Rabat

Introduction
You are being asked to participate in a research study. Before you agree, however, you must be fully informed about the purpose of the study, the procedures to be followed, and any benefits, risks, or discomfort that you may experience as a result of your participation. This form presents information about the study so that you may make a fully informed decision regarding your participation.

Purpose of the study: Our research aims to analyze the driver behavior of young adults in Morocco and discover how interactive models like virtual reality (VR) impact how they retain information about road regulations. With increased road safety knowledge and awareness for student drivers, we hope to prevent future road accidents and fatalities. Based on student surveys, our group will provide road safety recommendations to educational institutions, traffic safety authorities, and technology experts for future implementation regarding virtual reality.

Procedures to be followed: You are being asked to complete a pre-assessment survey related to road safety which should take approximately 10 minutes. Then, you will engage in a VR simulation that should last approximately 5 minutes. Following the simulation, you will complete a summative assessment that should take approximately 15 minutes. In total, the whole procedure will last about 30 minutes.

Risks to study participants: The risk changes because VR technology can interact with existing medical conditions. The participants will complete a pre-screening (attached below) to determine their eligibility for the study.

Benefits to research participants and others: The benefit of the study increases participant's understanding of VR and road safety.

Record keeping and confidentiality: Records of your participation in this study will be held confidential so far as permitted by law. All screening and survey data will be uploaded into a secure folder that only the research team has access to. However, the study investigators, the sponsor, or its designee, and, under certain circumstances, the Worcester Polytechnic Institute Institutional Review Board (WPI IRB) will be able to inspect and have access to confidential data. All survey data will be deleted following the completion of the study on May 2, 2024. Any publication or presentation of the data will not identify you. All data will be stored in Qualtrics.

Compensation or treatment in the event of injury: Water will be available to participants. You do not give up any of your legal rights by signing this statement.

For more information about this research or the rights of research participants, or in case of research-related injury, contact:

Student Investigators:

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Gabriel Johnson, Tel. 508-831-4989, Email: gjohnson@wpi.edu

Your participation in this research is voluntary. Your refusal to participate will not result in any penalty to you or any loss of benefits to which you may otherwise be entitled. You may decide to stop participating in the research at any time without penalty or loss of other benefits. The project investigators retain the right to cancel or postpone the experimental procedures at any time they see fit.

By signing below, you acknowledge that you have been informed about and consent to be a participant in the study described above. Make sure that your questions are answered to your satisfaction before signing. You are entitled to retain a copy of this consent agreement.

_____________________________ Date: ____________________

Study Participant Signature

____

Study Participant Name (Please print)

_____________________________________ Date: ____________________

Signature of the Person Who Explained This Study

Appendix B: Screening Process

Are you comfortable with testing V.R. Equipment?
- ☐ Yes
- ☐ No

Do you feel dizzy right now?
- ☐ Yes
- ☐ No

Do you feel lightheaded right now?
- ☐ Yes
- ☐ No

Do you feel nauseous right now?
- ☐ Yes
- ☐ No

Do you feel excessively tired right now?
- ☐ Yes
- ☐ No

Do you feel sick right now?
- ☐ Yes
- ☐ No

Have you had more than what is usual for you, of caffeine or energy drinks today?
- ☐ Yes
- ☐ No

Have you had migraines, headaches, or earaches recently?
- ☐ Yes
- ☐ No

Do you have a history of low blood pressure or fainting?
- ☐ Yes
- ☐ No

Do you have a history of vertigo?
- ☐ Yes
- ☐ No

Are you currently pregnant?

- ☐ Yes
- ☐ No

Please select the option that best corresponds to your current state of vision.

- ☐ I have normal vision and do not require the assistance of glasses or contact lenses.
- ☐ I have normal-to-corrected vision for both eyes and require the assistance of glasses or contact lenses which I own.
- ☐ I have normal-to-corrected vision for one eye and require the assistance of glasses or contact lenses which I own.
- ☐ I am blind in one or both eyes.

Are you colorblind?

- ☐ Yes
- ☐ No

Hearing - Please select the option that best corresponds to your current state of hearing.

- ☐ I have normal hearing and do not require the assistance of hearing aids or other hearing devices.
- ☐ I have normal-to-corrected hearing for both ears and require the assistance of hearing aids or other hearing devices that I own.
- ☐ I have normal-to-corrected hearing for one ear and require the assistance of hearing aids or other hearing devices that I own.
- ☐ I am hard of hearing.

Are you highly prone to motion sickness? (From travel, roller coasters, etc.)

- ☐ Yes
- ☐ No
- ☐ Not sure

* Disclaimer: Participants will be using the VR technology for approximately 5 minutes. It is the participant's discretion whether they are comfortable participating.

Have you ever had a brain injury that resulted in memory loss or unconsciousness?

- ☐ Yes
- ☐ No

Are you currently diagnosed with any of the following? Please select all that apply.

- ☐ Autism
- ☐ Cerebral Palsy
- ☐ Encephalitis (inflammation of the brain)
- ☐ Epilepsy
- ☐ Intellectual disability
- ☐ Muscular dystrophy
- ☐ Post-traumatic stress disorder (PTSD)
- ☐ I would prefer not to answer
- ☐ Other (Please describe and consult with research personnel)
- ☐ I am not diagnosed with any of the following.

Appendix C: Pre-Assessment Questions

We are a group of students from Worcester Polytechnic Institute in Worcester, Massachusetts in the United States of America, and we are working with Dr. Mounir Ghogho and Dr. Ouassim Karrakchou at the International University of Rabat (UIR) to understand current UIR students' driving perspectives and behaviors. Additionally, we aim to gauge students' interest in increasing driving education and awareness using an interactive model like virtual reality. Currently, we are conducting surveys to gain a better understanding of existing road safety programs & driver history. Your participation in this survey is both confidential and voluntary. You may withdraw from the survey at any time. Please remember that your answers will remain anonymous. It is not necessary to answer every question on the survey. No names or other identifying information will appear on the questionnaires or in any of the project reports or publications.

01. How old are you?

    a. Under 18
    b. 19
    c. 20
    d. 21
    e. 22
    f. 23 and older

02. With which gender do you most identify?

    a. Female
    b. Male
    c. Non-binary
    d. Prefer not to say

03. Have you ever driven a car before?

a. Yes
b. No

04. Do you have your (Moroccan or international) driver's license or any other motor vehicle license (e.g. motorcycle)?

a. Yes
b. No

05. How would you describe yourself as a driver?

a. Safe
b. Moderately safe
c. Moderately risky
d. Risky

06. How confident are you in your ability to maintain control of your vehicle in various driving conditions? Examples could be adverse weather and heavy traffic.

a. Not confident
b. Slightly confident
c. Moderately confident
d. Extremely confident

07. To what extent do you trust the driving skills and behaviors of other road users?

a. Never
b. Rarely
c. Sometimes
d. Often

e. Always

08. How much do you believe that your actions as a driver contribute to the overall safety of the road environment?

    a. Never
    b. Rarely
    c. Sometimes
    d. Often
    e. Always

09. How likely are you to look at your phone while driving?

    a. Never
    b. Rarely
    c. Sometimes
    d. Often
    e. Always

10. How likely are you to send a text message while driving?

    a. Never
    b. Rarely
    c. Sometimes
    d. Often
    e. Always

11. How likely are you to eat or drink while driving?

    a. Never
    b. Rarely

c. Sometimes
d. Often
e. Always

12. How often do you do personal grooming, such as putting on make-up, shaving, or looking at yourself in the mirror while driving?
    a. Never
    b. Rarely
    c. Sometimes
    d. Often
    e. Always
13. Have you ever used virtual reality before? Virtual reality is the use of technology to simulate a certain environment.
    a. Yes
    b. No
14. If yes, what was the purpose?
    a. Entertainment
    b. Gaming
    c. Retail
    d. Education
    e. Other: (Explanation)
    f. Not applicable

15. Do you feel that virtual reality could positively alter your perception of road safety?

a. Yes

b. No

Appendix D: Summative Assessment Questions

This survey is intended to follow the pre-assessment and VR road safety simulation.

01. To what extent do you agree that virtual reality simulates the real world effectively and realistically?
    a. Strongly disagree
    b. Somewhat disagree
    c. Neither agree or disagree
    d. Somewhat agree
    e. Strongly agree
02. If not, what features contributed to this? Some factors might include auditory sounds, visuals, steering wheel, etc.
03. If so, what features contributed to this? Some factors might include auditory sounds, visuals, steering wheel, etc.
04. To what extent was there a learning curve involved in using the VR program? A learning curve is defined as the progress in gaining a new skill. How quickly did you understand how to use the technology?
05. After the simulation, do you believe that virtual reality can have a positive effect on learning better road safety?
    a. Extremely negative
    b. Somewhat negative
    c. Neither positive nor negative
    d. Somewhat positive
    e. Extremely positive

06. Are you less likely to check your phone while driving after using the simulation?

a. Yes
b. No

07. Do you feel that proper instruction was given throughout the virtual experience?

a. Yes
b. No

08. Was using virtual reality intuitive? What made virtual reality difficult to use at times, if applicable?

09. Do you feel that your response time to the distraction was affected by the technology?

Appendix E: Sponsor Deliverable

https://docs.google.com/presentation/d/14o_p_V738Ne06uMmV6i-jB-vQC8q798lrsDAK_coV64/edit?usp=sharing