SAFE SHARED MOBILITY VIA BICYCLIST AND MOTORIST EDUCATION

Final Report

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ABSTRACT

In the State of Michigan, bicyclist related traffic crashes are on the rise – the number of bicyclist related crashes in 2015 and 2016 are the highest since 2000. Although one of reasons for this increase may be exposure indicating a higher proportion of population choosing to bicycle in recent years, another major reason is lack of a set of standard rules of interaction between different road users. Bicyclists, unlike vehicle drivers, do not need to take a road test before they are allowed on the road and therefore, it is difficult to measure how well the bicyclists understand the 'safety first' rules of the road and the norms of interaction with other shared users of the roadways. This project aims at developing an engaging learning platform for bicyclists, particularly teen bicyclists, to understand safety critical scenarios when they are in a shared use facility and then teach them the safe maneuver techniques as well as decision making in such scenarios. An online interactive game is developed where the player, as a bicyclist, has to complete a task while navigating through an urban roadway setting, sharing road with vehicles. The game is preceded and succeeded by surveys to measure the learning effectiveness as well as to collect feedback on game design effectiveness. The game is to be deployed in schools in 5 different counties in Michigan next year.

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CHAPTER 1. INTRODUCTION

Bicycle crashes are increasing nationwide – NHTSA estimates a 6% increase in bicyclist fatalities and 2.3% increase in bicyclist injuries between 2006 and 2015 (PBIC 2017, NHTSA 2016). In Michigan there was a 57 percent increase in bicyclist fatalities in 2015 from 2014 and there were more than 1400 bicyclists injured in 2015 in the state (https://www.michigantrafficcrashfacts.org/). While one of the reasons for an increase in bike casualties over the years is an increased number of people choosing alternative modes of transportation, another reason is a lack of understanding of traffic rules and laws as they apply to bicyclists. Interaction between other users of the road and bicyclists happen through a set of mutually recognized signs/gestures that are not well documented and/or standardized as are vehicular traffic laws.

According to 'Summary of comprehensive evaluation of pedestrian and bicycle crashes and causes in Michigan' (http://www.michigan.gov/documents/msp/PEDESTRIAN-BICYCLE_ANALYSIS_-_A_SUMMARY_REPORT_-_FINAL_-_022916_523923_7.pdf), most bicycle crashes are failure to yield type crashes either at intersections or at mid-blocks which implies that either the motorist or the bicyclist misestimated the safe gap/passing distance. Additionally, most failure-to-yield bicycle crashes happen when the bicyclist is riding on sidewalks or travel lanes and has to go onto the roadway when there is a discontinuity in the sidewalks. While having a connected and separated bike-ped facility network is the most effective solution, it is time and investment intensive. Alternative ways to solve the problem may be: (i) posted signage at the points of conflict, (ii) suggesting less conflicted routes to bicyclists, and (iii) awareness and education campaigns for both bicyclists and motorists highlighting particular conflict types and safe maneuvering techniques under such conditions. The project 'Safe Shared Mobility via Bicyclist and Motorist Education' aims to address the problem of bicyclist safety and build a safe shared space for all modes of transportation through creating an engaging public education platform and popularize it through extensive outreach efforts. The particular focus of the project are teen bicyclists or middle school students.

According to the survey in the summary report published by MDOT and prepared by WMU, all involved parties rated education and outreach campaign as the least effective measure in ped-bike crash reduction in spite of research evidence that education improves bicycle and pedestrian crash statistics (Wedell et al. 2012). One reason for the perceived low impact of education and outreach is that very few cyclists are actually motivated to voluntarily undergo training or seek out any standardized education on rules to be followed in a shared use environment, primarily because of the highly theoretical and academic nature of such resources. There is also no mandatory licensing test required before bicyclists are allowed on road, unlike vehicular traffic. On the other hand, the standardized licensing tests for vehicular traffic rarely

test a driver's knowledge on rules of interaction with other modes of transport. It is, therefore, necessary, first, to develop a comprehensive training program for motorists and bicyclists alike and then, for any training material developed for this purpose to be engaging and entertaining enough for the intended audience to get involved voluntarily.

In the world of education research, recent studies had shown that educational games have the potential to engage learners more and with better learning outcomes, particularly for young adults (Meegen & Limpens 2010). Towards that end, we have created a web-based training module for bicyclists as well as motorists that will simulate different conflict situations via animation and present those to participants within a game environment. Thus, an online educational game for bicyclists has been developed last year through this funding opportunity. The game requires the participant, as a bicyclist, to navigate through a city layout through different conflict scenarios along with vehicular traffic. Although the initial plan has been to include all possible conflict scenarios as found in literature, given the project timeline, the conflict scenarios designed in Phase 1 focuses mainly on intersections and turn related conflicts. The game also includes a pre and post game survey to measure learning outcome, game design effectiveness and user experience. The project has already garnered interest in Ann Arbor public schools and the team plans to reach out to other school districts across the state during the second phase of the project and use the survey results to assess the effectiveness and use of the game.

The project begins with literature review to identify best practices in safe bicycling, and then to use Michigan crash reports to identify crash scenarios that illustrate how these best practices might have avoided the crash. This background literature and analysis work provides the content for the web-based game to deliver the education to a broad audience. An online repository of all bicyclist training related materials, organized by target crash/conflict types, most probable location, and recommended best practice is created in this step based on the literature search. The online repository serves two purposes – one, it provides an organized access to bicyclist safety related best practice literature in an open access format and two, the link to the repository is used within the game as reference for participants. When the participants make a wrong choice, they are provided with information on the type of mistake they made (how frequent it is, how fatal etc.) and the best course of action as well as a link to the repository for more detailed reference. At the second level, Michigan crash data are analyzed to obtain more detailed information on crash characteristics and location. The bicyclist related crash analysis shows higher prevalence of intersection related crashes, but rarely provide any other detailed information, because of the crash reporting structure in police reports (UD10). At the third and final stage, a web based game for bicyclists is developed with particular focus on intersection related conflicts. Chapter 2 of this report describes the repository while Chapter 3 describes the game and the surveys. The actual survey instruments and the preliminary results (from survey beta-testers) are provided in Appendix A-C.

CHAPTER 2. SAFE SHARED MOBILITY ONLINE REPOSITORY

[Place for Existing Data and Basic Information to Keep Everyone Safe (PEDBIKES)]

Designing safe shared mobility for bicyclists and motorists starts with identifying conflicts that are avoidable with knowledge of proper communication methods and road sharing rules on the part of bicyclists as well as motorists. In general, for motorists, lack of awareness about presence of bicyclists on road leads to conflicts while for bicyclists, the reasons are often behavioral (ignoring traffic signals, midblock crossing), lack of communication with vehicular traffic (signaling before turning) and lack of or insufficient understanding of safe navigation rules in shared traffic (being on driver's blind spot).

Multiple research have looked into bicyclist related crashes across the nation and have suggested possible causes of conflicts resulting into the crash. The online repository [Place for Existing Data and Basic Information to Keep Everyone Safe (PEDBIKES); www.pedbikes.org] is an attempt to collect such research findings, classify them into appropriate categories and provide the users a curated selection of most relevant and appropriate maneuver techniques for each conflict situation. The purpose of this repository is thus to provide a guideline to cyclists on safe maneuver of conflict scenarios with other road users. The repository is open source, open access and is hosted by University of Michigan as a webpage. The repository is searchable using keywords as well as by specific contents, as detailed in the content segment. Different contents are also linked to the bicycling game described in the later chapter as reference to the best practices that the bicyclist should follow under a particular conflict scenario.

The literature review for the repository started with searches within bicyclist and pedestrian related websites like Pedestrian and Bicyclist Information Center (PBIC), website of League of American Bicyclists, BicycleSafe.com, Bicyclingtips.com etc. At the second step, bicycling safety related research publications were parsed systematically to find relevant information and suggested best practices. The research publications were found via cross references from the websites as well as by web searches using keywords like "bicycling safety laws", "intersection crashes + bicyclists", "bicyclist safety training", etc.

During this extensive literature review, it has been found that crash types and consequently conflicts differ by land use type (urban vs rural), location on the road (intersection vs midblock) and intuitively, by the direction of travel of the bicyclist (along the traffic vs crossing). Accordingly, at the first level, the scenarios are classified into urban and rural as traffic conditions under which conflicts may happen can be very different in rural areas than urban. At the second level, the scenarios are classified based on roadway relations – whether they are at intersections or at other locations (including driveways, midblocks, sidewalks etc.). The final classification is based on direction of travel – whether the bicyclist is traveling along

the travel or attempting to cross the traffic or is turning when they experience the conflict scenarios. For each scenario, a brief description is presented and then a list of relevant references that provide guidance on best practices to avoid and safely maneuver such conflict situations.

It should be noted that crashes that happen due to external environmental conditions like poor weather conditions or run off road type of crashes are not considered for the purpose of this project. For example, while visibility issues related to external light conditions, although important and significant, are not part of this collection, however, crashes resulting from visibility issues caused by cyclists/motorist position and location in traffic are important components of this collection.

The project team also noted in course of the literature search that information on rural bicyclist related crashes are very few and details are rarely found, although generally such crashes are more serious injury related, because of high speed of motor vehicles. In addition, although not in scope of the project, there is also very little data supported literature on sidewalk conflicts between pedestrians and bicyclists as well as on conflicts at the sidewalk egress points where the bicyclist suddenly enters a traffic flow. Since Michigan bicyclists are allowed (and often encouraged) to ride on sidewalks, in spite of lack of sufficient literature, sidewalk egress conflicts has been included in the web game while pedestrian-bicyclist conflicts are suggested as future game improvement elements.

CHAPTER 3. BICYCLEMANIA – THE INTERACTIVE BICYCLING GAME

Introduction

The "hands-on" approach to teaching practical skills is widely practiced in the real world (Squire 2005). But certain skills, such as bicycling and bicyclist safety, can be dangerous to learn entirely through experiential learning. Many important road rules, situations, and safety precautions are not taught to bicyclists, or, if they are, are taught using textual material. However, learning from textual material alone lacks the benefits of learning from an interactive experience: the lack of interactive elements in instruction creates a suboptimal learning effect (Meegen & Limpens 2010). This makes unfamiliar situations particularly dangerous for new bicyclists who haven't fully practiced/processed the rules they've learned.

To address the lack of understanding of bicyclist-related traffic rules and laws, this study examines the effect of learning practical skills through an educational, video game format. Video games act as fun, captivating, interactive simulations of several different types of scenarios and have incredible potential as instructional devices. They help instill a complex understanding of information while also providing a learning environment more motivating than standard, textual methods of learning (Squire 2005). Video games require problem identification, hypothesis testing, interpretative analysis, and strategic thinking skills (Squire 2005), and, by utilizing aspects of fantasy, control, challenge, and curiosity, they act as a form of play that is intrinsically motivating (Rieber 1996) for users of any age (Quandt et al. 2009; Greenberg et al. 2008). Therefore, video games can potentially have more instructional value for learning practical skills than conventional methods of learning. The following section presents a brief review of selected and related literature on video game elements that are known to make the learning environment effective and engaging.

Literature Review

Recreational video games have an extremely high level of interactivity and have developed a reputation for being fun, engaging, and immersive. The high level of interactivity in video games is able to captivate the player while also requiring deep thinking and complex problem solving (Squire 2005). Through their high level of interactivity, video games emulate the trial-and-error style of teaching that occurs with learning practical skills. This provides a rich learning environment for players to practice and process practical safety information without the fear of crashing or injury. In a video game, the player is placed in a learning environment that begins with failure (Squire 2005). Through failing, reflecting, and testing solutions, the player can connect new virtual experiences to their prior real-world experiences (Annetta 2010). New information is then learned by resolving differences between a player's ideas about the real world and their experiences in the virtual world. Once the player stores new experiences and

their accompanying knowledge in memory, they are able to run simulations of the experience in their mind to prepare them for problem solving in new and future situations (Squire 2005). This learning framework encourages active learning of practical concepts, which helps improve memory of material and increases the depth of learning as well (Squire 2005; Malone 1981). When actively engaged and captivated by the learning process, students are more likely to internalize, understand, and remember the content they've learned (Meegen & Limpens 2010).

Intrinsically motivating video games are also dependent on the extent to which the player's curiosity is provoked and satisfied. If the player is not interested in the type of game, dislikes the game's attributes, or the game topic is not appealing to them, then they lose their curiosity to continue playing the game and continue learning. With the virtual format of video games, different techniques can be used to feed into the players' curiosity. For example, if the player is able to play from multiple perspectives in the game or can approach the subject from many different angles, their learning is deeper and more rapid (Malone 1981). Learning autonomy is also important in stimulating player curiosity. When players are allowed to move at their own pace, their learning is protected until they are comfortable to try and test it out in more complex situations. This allows them to control when they receive new, challenging information, which not only increases curiosity but prevents boredom and learned helplessness as well (Squire 2005). A responsive, open environment allows for learning autonomy and increases player curiosity too. Players are able to explore freely and discover different relations between actions and events on their own time, another form of self-paced learning.

Another facet of video games that makes them so appealing is their captivating nature. Strategies employed in video games, such as self-challenge, competition, scoring, audio effects, emotional narratives, realism, and feedback (Korhonen & Koivisto 2006; Greenberg et al. 2008; Malone 1981), encourage the player to continue playing and keep the player invested in the game. Educational games have several motivational characteristics including clear goals, informative feedback, scores that showcase improvement, high response rates, uncertain outcomes, and visual effects (Dempsey et al. 1993). However, the three most important aspects of a motivating instructional environment are a sense of challenge, fantasy, and curiosity (Malone 1981).

A sense of challenge in a video game requires significant thought, time, and effort from the player in order for them to compete and succeed. As a result, a challenging environment is an important motivating factor in video games because of its connection with a player's self-esteem.

When a player succeeds in a game that they have invested time and energy in, they feel better about themselves, have increased self-esteem, and have an increased chance of continuing to play/engage with the instructional material. The feeling of a challenge can also motivate players to stretch their capabilities and perform their best (Meegen & Limpens 2010). However, if a game is too challenging, too easy, or doesn't provide encouraging feedback, players may lose

interest or may quit playing altogether. This decreases the quality of learning, decreases the player's self esteem, and can make the player feel as if their identity as a student or player is compromised (Squire 2005). To prevent this, Gee (2003) suggests that the most effective learning situations occur when players are forced to act on the edge of their ability. This means that the player is able to understand and achieve the game's goals, yet must do so with difficulty (Greenberg et al. 2008). The idea is to create a feeling of flow for the player (Malone 1981)- the relationship between the player and the game that exists when the player's abilities are perfectly matched with the challenges they face (Csikszentmihalyi 1990). Flow experiences cause the player to become deeply engaged and absorbed by the gameplay; they "flow" along with it in a spontaneous and almost automatic way and feel a strong sense of satisfaction as they play (Rieber 1996). Flow experiences are strong intrinsically motivating factors in games and without them, the user would likely experience some level of dissatisfaction with the game (Squire 2013).

For every game, there is some form of an outlined objective. Rather than a loosely established sense of direction, players tend to prefer video games that have clearly defined goals that they can work towards (Malone 1981). People also store their experiences best in terms of goals and how these goals did or didn't work out. By evaluating their experiences, they are able to extract out lessons and work on improving themselves and their knowledge systems (Gee 2008). The game environment is not considered challenging if the player easily reaches the game's goal or finds it too challenging to complete. Because the level of challenge is subjective to the skill set of each person, video games can accommodate for a wide range of people, or the growth of a player by including: hidden information that can be accessed using developed skills, multiple level goals, and variable difficulty levels (Malone 1981). By containing the player in an environment that maximizes "flow" and an optimal level of challenge, educational video games motivate the player to stay invested in trying to reach the game's goals and learn more practical skills in the process.

The project team created the online bicycling game with the aim to incorporate as many of the above principles as practically possible into the game design. The game provides the participant with a predefined task and a goal to accomplish. Challenges and conflicts that imitate real life scenarios are presented to the participant enroute while completing the task. When the participant fails to respond appropriately to a conflict, instantaneous feedback is provided as to why the chosen action is not appropriate and what is the safe/best course of action under the given situation. A link for further references is also provided so that if any participant is interested and curious, they can learn more about that particular conflict. It is anticipated that instantaneous feedback will help the participant to effectively commit to memory the right course of action by providing them a reasoning of why their action was not appropriate.

To measure the effectiveness of the game, a web-based survey is given to the participants before and after they play the video game. Each survey asks participants questions about the

proper way to act in various bicycling scenarios. Both survey scores are then compared with one another to calculate the amount of improvement or knowledge retained from the game. We hope that our video game increases awareness about bicycling safety precautions, facilitates the absorption of bicyclist safety information, and is engaging to play so that the public is eager to play and learn from the video game time and time again. A justification for using this learning format stems from the large amount of video game research that has been conducted promoting the educational capacity of video games. In the following section detailed descriptions of the game and the surveys are presented.

Web based Game for Bicyclist and Motorist Education

Instruments

Two multiple-choice, web-based surveys have been created to assess the participants' knowledge on correct bicycling behavior in given bicycling scenarios. Participants complete the surveys before and after they play the educational video game. The pre-game survey includes questions regarding demographics, biking, and driving information about the participant and the post game survey includes questions regarding game and survey design. The educational video game was created by our research team and was designed to simulate the actions a bicyclist would have to take to navigate out of potential road situations.

Pre-Game & Post-Game Surveys

Each participant is required to complete the pre-game survey before accessing any other part of the study. For part 1 of the pre-game survey, participants are asked to provide demographic information pertaining to age and gender and are asked about the nature and frequency of their biking and driving habits. Many of the questions concerning biking and driving habits are designed on a Likert scale. Part 1 of the post game survey consists of a few questions on the design of the game. These questions consist of multiple choice, open-ended, and Likert scale questions.

Part 2 is the same for both the pre-game survey and the post-game survey. This is done to standardize the questions and prevent any confounding variables due to different survey questions. For part 2 of the survey, participants fill out eleven multiple choice bicycling safety questions, with the answer choices displayed in a randomized order to prevent memorization. Each answer choice to each bicycling safety question details a course of action that could be taken in reaction to the situation outlined in the question. Certain questions (5) include a visual image with graphics similar to the graphics shown in our game in order to help the participant better understand the question. After each page of part 2 in the post-game survey, participants are shown which questions they answered correctly and incorrectly. This was not done on the pre-game survey since immediate feedback as been shown to introduce a surface learning strategy in

trying to memorize the answers to questions (Kassim, Hancock, Hanafi, & Omar 2004). However, immediate feedback is included in the post-game survey because it has been shown to improve learning (Hanna 1976), which is the aim of our study. The feedback also increases motivation and provides a self-challenge for the participant, combatting respondent fatigue and diminishing the perceived burden of the study due to its length and numerous sections (Crawford, Couper, & Lamias 2001).

Part 3 of the pre-game survey displays a score for how many questions the participant answered correctly and the participant is encouraged to improve their score by completing the post-game survey. Part 3 of the post-game survey asks a multiple choice question about whether or not the visuals helped the participant in completing the survey.

Web based Game: Bicyclemania!

Our bicyclist-pedestrian game aims to utilize the high level of interactivity found in the video game format and exploit its learning capabilities to stimulate the learning of practical bicyclist safety. To do this, we designed our game to mimic the situations the player would face as a bicyclist in the real world. Therefore, the player's decision making in the game simulates the decision making they would make as a bicyclist in real life. Participants are tasked with collecting stars around the grid "city" and have to obey traffic laws in order to avoid crashing into cars. If the player crashes into a car, a pop-up fills the game screen displaying an animation of the potential type of crash the bicyclist may have been involved in and providing feedback as to how to avoid crashing in the future. The participants play the game for 10 minutes before being directed to the post-game survey. In order to encourage players to continue learning from our game and increase the depth of the players' understanding of bicyclist safety, our game is designed to include as many gameplay characteristics as possible (Figure 1). In this way, the curriculum concepts are learned through active participation, lead to more complex thinking, and also encourage further exploration of bicyclist safety and a stronger willingness to play/learn (Squire 2005).

1. **Active Learning/High Interactivity**
- Facilitate deep thinking
- Complex problem solving
- Positive perceptions of material
- Motivation to learn
- Greater understanding of material
- Greater depth of learning

2. **Trial & Error Learning**
- Reflective learning
- Active learning
- Improves memory of material
- Increases depth of learning
- Self-paced learning/Autonomy

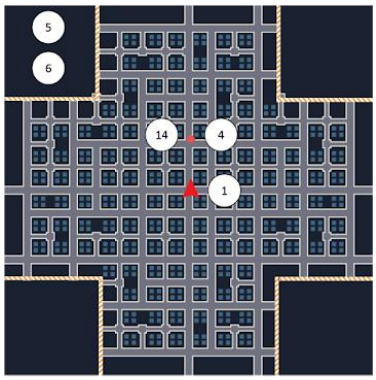
3. **Avatar Identity**
- Encourage curiosity
- More motivational to learn/play
- Encourage trial & error learning

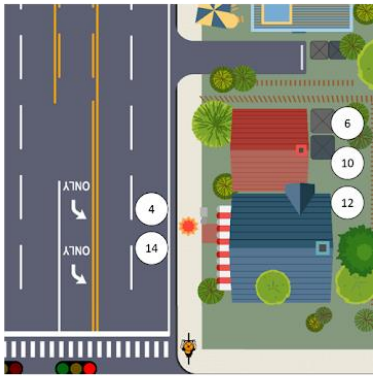
4. **Challenge**
- Increases learner's self esteem
- Encourage more involvement/learning
- Perform your best
- Prevents boredom
- Prevents learned helplessness
- Self-paced learning/Autonomy
- Motivation

5. **Exploration**
- Deep Learn
- Self-paced learning/Autonomy
- Prevents boredom
- Curiosity to learn more material
- Motivation

6. **Fantasy**
- Endogenous
- Increases interest/Prevents boredom
- Motivation

Misc. Motivational Characteristics
- 7. Competition
- 8. Scoring
- 9. Audio effects
- 10. Visual effects
- 11. Emotional narrative
- 12. Realism
- 13. Informative feedback
- 14. Clear goals
- 15. Uncertain outcomes





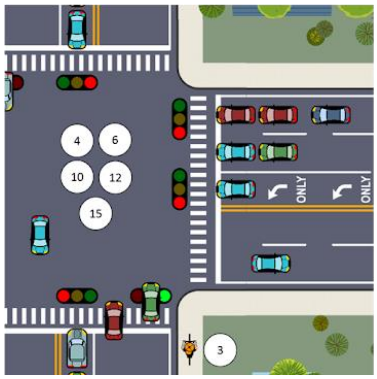


Figure 1. Screenshots of the Bicyclemania! Gameplay

Participants

Since this study is yet to be distributed to participants, no data for the purpose of analysis has been collected so far. However, the survey has been tested by multiple in house volunteers at different stages of the survey design, after the IRB approval. For the pre-game survey, 29 participant responses have been recorded with a maximum of 23 participants answering one individual question. For the post game survey, 21 participant responses have been recorded with a maximum of 15 responses recorded for any individual question. The survey reports are presented in Appendix C while the surveys themselves are presented in Appendix A. Since the responses have been collected through different versions of the survey, they cannot be treated as valid sample responses for any statistical analysis and neither are the respondents our target population. However, the feedback from the volunteers serve as baseline for assessing game design effectiveness and the potential of the game in keeping the target audience engaged. In future, we plan to gather data from participants aged 11+ and are interested to see if certain demographics will perform differently from others. For example, middle schoolers may perform differently than adults due to their greater affinity for web-based games. They may also perform differently because of their naivety to bicycling and road rules. There may also be a difference between those participants who have driving experience compared to those who don't as well.

CHAPTER 4. FUTURE DIRECTION

In this phase of this project the research team developed a game for bicyclists where the conflict scenarios were designed mainly around intersections. However, Michigan crash data indicates a significant number of crashes happening when the bicyclist is riding along the road and is not at an intersection. In future, we intend to extend the developed game by including scenarios like midblock crossing and overtaking, as well as driveway access related conflicts. In addition, some game design elements suggested by beta testers will be addressed too (making it more competitive, effective positive feedback, sound design etc.). In addition, because of the time constraints of the project and the game development activities, the project could only be ready for deployment after the peak cycling season and during school holidays. Therefore, although extensive outreach efforts have been made, game deployment did not happen in this phase. Future plans for the project include targeted outreach to school districts with crash rates as well as hosting training sessions in house. Details are provide in the following sections

Future Game Improvements

Although the current bicyclist-pedestrian safety game incorporates many gameplay characteristics, there are numerous upgrades that can be put into effect to improve the game. In an ideal situation, with more time and resources, these improvements would be implemented into the game to increase the number and quality of gameplay characteristics, thereby increasing the extent of learning and motivation to play.

In order to increase the amount of challenge and competition felt by the player in the game, many competitive elements such as a score, timer, levels, obstacles, and explicit rewards and punishments could be added. These encourage greater competitive play and facilitate the learning of correct behavior. Providing the player with a score or adding a time element encourages self-competition and adding a leaderboard or a multiplayer mode can increase social competition as well. More competition increases the will to perform at the player's best and provides a motivation to continue learning after failure. Adding more suitable challenges such as levels and obstacles increases the player's motivation to play the game and prevents the player from losing interest in the game as well.

Numerous fantasy elements can also be included into the game. A game narrative, more graphical assets, more realism, and the ability to choose different bicyclist avatars would all increase the level of fantasy in the game. A game narrative would increase the curiosity of the player, be able to outline a clear goal for the player to work towards, and provide a fantasy framework that the player would be enveloped in. The increase in the number of realistic assets would increase the interest in the game and spark player curiosity. The realism would convey to the participant the relevancy of the knowledge being learned and would increase the likelihood of them wanting to engage with the game as a result. With the inclusion of a more

realistic/customized bicyclist avatar, the player would feel a heightened sense of presence within the video game and therefore feel more engaged in the content and more intrinsically motivated to succeed in the game (Annetta 2010). If the player is able to choose an avatar that physically resembles themselves, they are more likely to internalize their learning from the video game as well (Hooi & Cho 2013).

There are several more motivational and educational changes that could be introduced to the video game. A counter displaying how many objects were collected and how many still have to be collected outlines a clear goal for the player. Adding more visual effects, such as a crash effect, and dynamic trees, animals, and pedestrians, would increase the realism of the game and make it more engaging. Sound effects for the cars, bicyclist, the vehicles, and the added pedestrians and assets would also have this effect. The ability to exit out of the controls tutorial and adjust the volume of the sound effects and background music would offer a level of autonomy to the player and positively influence the "flow" of the game. If this control was not allowed and both the sound levels were set to a default amount that was unpleasant to the player, this would be influential in deterring them from playing the game.

Future Outreach Efforts

- Reaching out to and collecting game related feedback from League of Michigan Bicyclists (LMB), Safe Routes to School, Washtenaw Walking Biking Coalition and other active lifestyle/bicycling organization
- Based on crash hotspot analysis, establishing collaboration/partnership with middle schools in Washtenaw and Wayne county, specifically focusing on Ann Arbor, Ypsilanti and Detroit; Lansing, Grand Rapids, Kalamazoo, Traverse City, St. Ignace – members of the study team will reach out to and travel, if needed, to schools in these locations to demonstrate the game and to publicize the project.
- Inviting and hosting local students to UMTRI to demonstrate the game and have the participant students play the game
- Coordinating with schools in other above mentioned locations to have students play the game

Conclusion

The amount of bicyclist deaths in the U.S. has risen (Pedestrians and Bicyclists 2017) and one reason for this increase is the lack of understanding of traffic rules and laws that apply to bicyclists. Education of bicyclists and motorists regarding safe bicycle-motorist interactions is an important way to help improve safety in shared facilities. This project focuses on providing an easily-accessible, engaging web-based training game to be deployed in bicycle crash hotspots. If this program is successful in informing participants and changing their self-reported behavior, it

could be expanded to a broader audience at very little cost. Several improvements are intended to be added to the game to increase the amount of information retained by the participants as well. Our goal is to shape this study to best educate the participants and hopefully instill a greater awareness of bicyclist safety and rules.

Our long-term goal for this project is to develop a multimodal game platform where participants will be able to choose their roles and hence will have a better understanding of the views of other users, but the development of the safety training alone will be beneficial in the state's efforts to improve bicyclist safety on the roads.

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APPENDIX A: PRE-GAME SURVEY

Opening

.

BICYCLEMANIA!!

Pre-Game Survey

.

This survey is part of a research project named 'Safe Shared Mobility Via Bicyclist and Motorist Education', conducted by the University of Michigan Transportation Research Institute. This material was developed through a project funded by the Michigan Office of Highway Safety Planning and the U.S. Department of Transportation. Your participation in the survey is voluntary

and anonymous – we will not collect any personal identifiable information or share your information or responses with anyone outside of the research team. The estimated time for completing this survey is approximately 5-7 minutes.

If you have any questions about the survey or your participation, please feel free to reach out to us at aditimis@umich.edu or at (734) 936 - 8333.

Part 1

. Part 1 - Participant Information

i. How old are you?

- ○ Younger than 11 years
- ○ 11 -14 years
- ○ 15-17 years
- ○ 18-20 years
- ○ 21-24 years
- ○ 25 years and older

ii. Do you drive?

- ○ Yes
- ○ No

iii. Do you identify as:

- ○ Female?
- ○ Male?
- ○ Prefer not to say?

iv. Do you bike?

- ○ Yes
- ○ No

Do you drive?

v. While driving, how comfortable do you feel when sharing the road with bicyclists?

	Not Comfortable at All	Very Uncomfortable	Somewhat Comfortable	Very Comfortable	Extremely Comfortable
Select Level of Comfortability	○	○	○	○	○

vi. What is the minimum passing distance drivers must allow for a bicyclist in Michigan?

- ○ 1 ft
- ○ 3 ft
- ○ 5 ft

vii. At an intersection, how often do you look for bicyclists when you turn left or right?

	Not at all	Rarely	Sometimes	Often	All the time
Select How Often	○	○	○	○	○

Do you bike?

***viii*. How often do you bike (during months of good weather)?**

	Less Than Once a Month	Once a Month	Once a Week	More Than Once a Week
Select How Often	○	○	○	○

***ix*. How long have you been biking**

- ○ Less than a year
- ○ More than 1 year, but less than 2 years
- ○ 2-4 years
- ○ 5-9 years
- ○ 10-14 years
- ○ 15 years or more

***x*. How confident do you feel when biking?**

	Not Confident at All	Comfortable, but not Confident	Confident	Very Confident	Extremely Confident

	Not Confident at All	Comfortable, but not Confident	Confident	Very Confident	Extremely Confident
Select Level of Confidence	○	○	○	○	○

Block 3

***xi*. Your home/school Zip Code**

Part 2

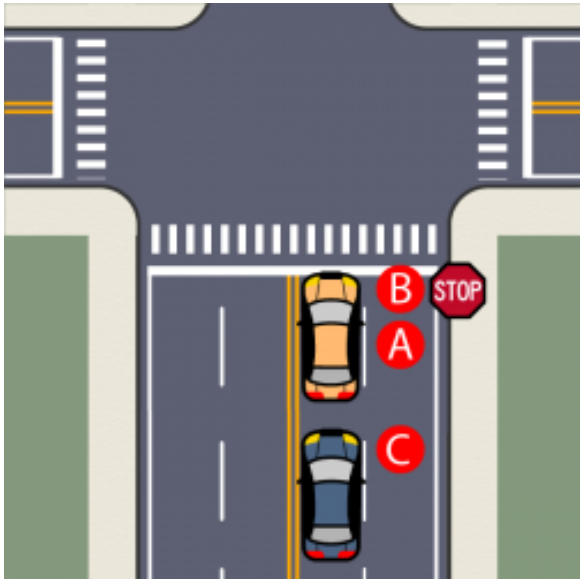
. Part 2 (page 1 of 2) - Road Safety

***Q1*. You are on a bicycle at an intersection with a STOP sign but no vehicles are in the road/lane next to you. You want to go straight and cross the empty one-way street in front of you. You should:**

- ○ Bike through the intersection if it looks safe
- ○ Stop, look for vehicles on the one-way street and cross over when vehicles in all directions seem to be a safe distance away

- ○ Stop, look over your shoulder for on-coming vehicles on your own street, look for vehicles on the one-way street, and cross over when vehicles in all directions seem to be at a safe distance away

***Q2*. You are at the same intersection again, but this time there are a few vehicles in the road/lane next to you. To make sure the drivers can see you, at the intersection you should: (an image is provided to help understand the scenario)**

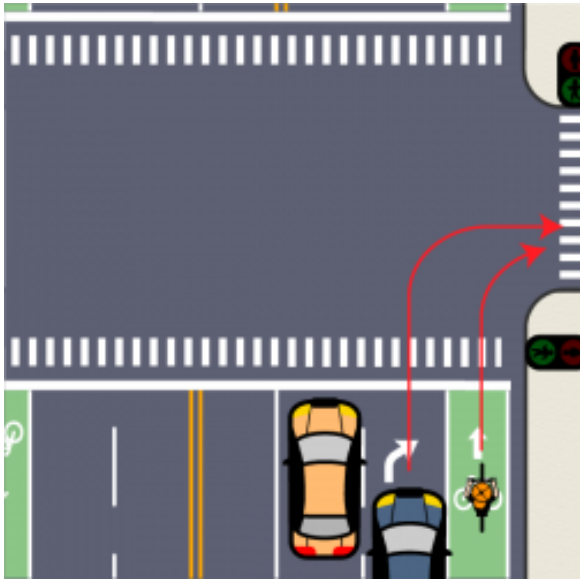


- ○ Stop next to the first car (Stop at A)
- ○ Stop parallel to the first car, slightly in front (Stop at B)
- ○ Stop parallel to the second car, slightly in front, but behind the first car (Stop at C)
- ○ Both B and C

***Q3*. You decide to change your route to school because traffic keeps making you late. Your new route has a 4-way intersection with lights and a walk signal. When you are almost at the intersection, you see the traffic lights for your direction turn red. You should:**

- ○ Bike quickly through the intersection because you saw the lights in the other direction have not turned green yet
- ○ Signal vehicles around you that you are stopping and then stop ahead the first stopped vehicle
- ○ Signal vehicles around you that you are stopping and then stop in front of the crosswalk

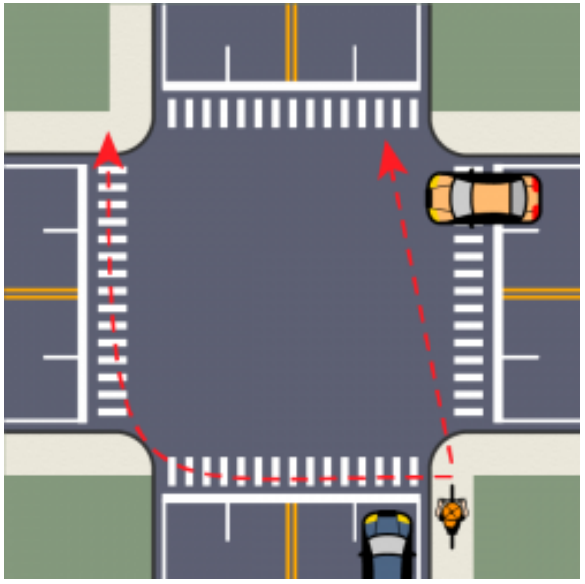
***Q4*. For this new route, you have to turn right at the next intersection to reach your school. There is a right turn lane next to your bike lane (See the picture). You should:**



- ○ Signal that you are stopping. Stop before the crosswalk. Check for pedestrians in the crosswalk and cars coming behind you. Turn right when traffic from the left stops.

- ○ Signal that you are stopping. Stop next to the first vehicle in the right turn lane. If there are no pedestrians in the crosswalks, turn right when traffic from the left stops
- ○ Signal that you are stopping. Stop behind the first vehicle in the right turning lane. If there are no pedestrians in the crosswalks, turn right when traffic from the left stops

_Q5_. At the next 4-way intersection, the sidewalk you are riding on ends. But there's a sidewalk on the other side of the road after the intersection (See the picture). What should you do?



- ○ Stop. When the light for the vehicles next to you turns red, cross the street you are on. Make sure no vehicles are turning left or right into the road you are crossing. When the traffic on the other road has a red light, cross the street in the crosswalk so you can ride on the sidewalk.

- ○ Both answers are correct
- ○ Keep going your way and bike in the road with traffic after the sidewalk ends.

***Q6*. You decide to cross to the other side of the street and continue on the sidewalk. However, this side of the street has shops and businesses. You soon approach a driveway. You should:**

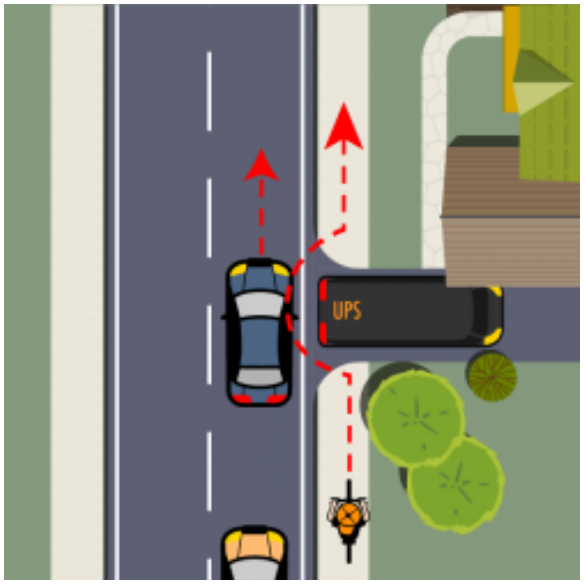
- ○ Slow down before approaching the driveway. Look to your left for vehicles backing out. Look to your right for incoming vehicles. Ride through the driveway when it is safe
- ○ Slow down but bike as usual. You are on the sidewalk and have the right-of-way
- ○ Slow down before approaching the driveway. Look to your left for vehicles backing out. Ride through the driveway when it is safe

Part 2 cont

. Part 2 (page 2 of 2) - Road Safety

***Q7*. On one of the driveways, a UPS van is parked (See the picture). You need to ride behind it because there's no space in front. You will have to go in the**

roadway to go around the van. What should you do?

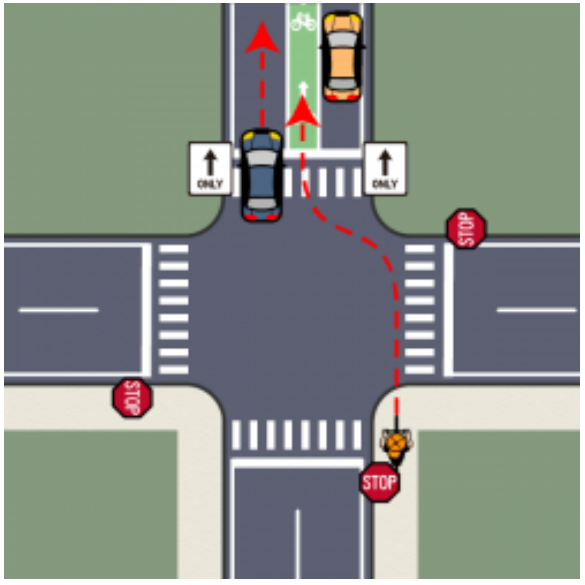


- ○ Wait for the UPS van to leave. It is too risky to get back on the roadway
- ○ See if the van is about to leave. Wait if it is. If the van driver isn't there, check the road for traffic. When no cars are coming, go in the roadway to go around the van and then get back on the sidewalk right away.
- ○ See if the van is about to leave. Wait if it is. If the van driver isn't there, check the road for traffic. When no cars are coming, signal by raising your hand and merge into the road. Get back on the sidewalk when it is easy to do so.

***Q8*. One of your friends is walking right in front of you. She has headphones on. You need to go around her. What should you do?**

- ○ Slow down. Check for pedestrians from the opposite direction. Shout "on your left!"Stretch your left arm out while going around her.
- ○ Shout "on your left!" and go around her
- ○ Slow down. If there's no pedestrians coming from the opposite direction, ride around her

***Q9*. The sidewalk ends at the next cross street (See the picture). The road is a one-way street. There are parked cars, a bike lane, and a lane for traffic. Where should you ride?**



- ○ Close to the parked cars. Be as far away from traffic as possible
- ○ In the middle of the bike lane. Check for people getting in or out of the parked cars and signal your presence if they are.

- ○ In the bike lane close to traffic. You want to avoid getting hit by a parked car door opening

Q10. Your school is on this street but on the other side. You should:

- ○ Cross the street at the intersection before the school. It is dangerous to cross the street in the middle of the block.
- ○ Cross the street when you're directly across from your school. Car drivers watch out for students in school zones.

Block 8

Q30. You Finished the Pre-Game Survey!

Your score is: ${gr://SC_0MzKdWRruk4UuG1/Score}/12

If you think you can improve your score, take the post-game survey!

APPENDIX B: POST-GAME SURVEY

Part 1

BICYCLEMANIA!!

Post-Game Survey

Part 1 - Game Design

Overall, how much did you like the game?

I really don't like it	I dislike it a little	I neither like nor dislike it	I like it a little	I really like it

	I really don't like it	I dislike it a little	I neither like nor dislike it	I like it a little	I really like it
Select:	○	○	○	○	○

What did you like most about the game?

What did you not like about the game?

Overall, how helpful was the game in understanding how to safely share the road with other road users?

	Not helpful	Somewhat Helpful	Very Helpful	Extremely Helpful
Select:	○	○	○	○

What is the most important piece of safety information that you learned from playing the game?

Will you play the game in the future?

- ○ Yes
- ○ No

Part 2

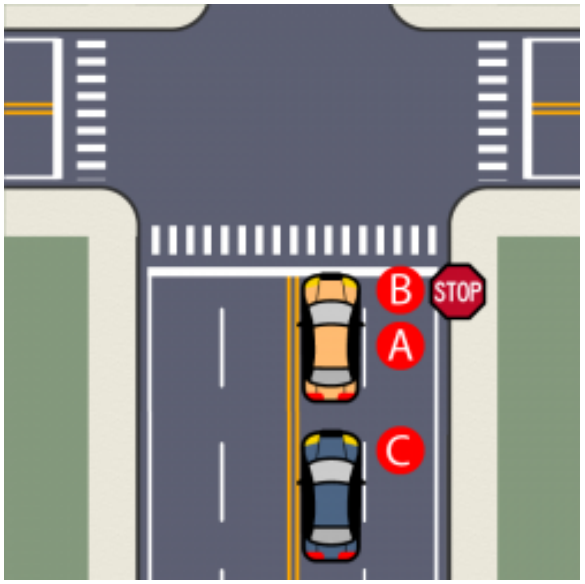
Part 2 (page 1 of 2) - Road Safety

You are at an intersection with a STOP sign but no vehicles are in the road/lane next to you. You want to go straight and cross the empty one-way street in front of you. You should:

- ○ Bike through the intersection if it looks safe
- ○ Stop, look for vehicles on the one-way street and cross over when vehicles in all directions seem to be a safe distance away
- ○ Stop, look over your shoulder for on-coming vehicles on your own street, look for vehicles on the one-way street, and cross over when vehicles in all directions seem to be at a safe distance away

You are at the same intersection again, but this time there are a few vehicles in the road/lane next to you. To make sure the drivers can see you, at the intersection you should: (an image is provided to help understand the scenario)

- ○ Stop next to the first car (Stop at A)
- ○ Stop parallel to the first car, slightly in front (Stop at B)

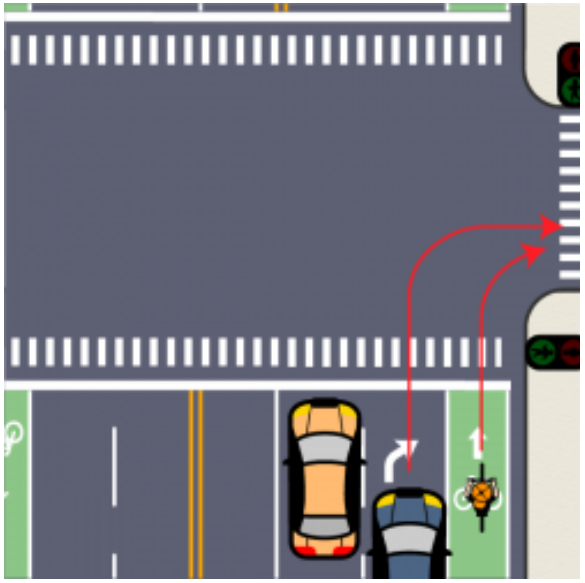


- ○ Stop parallel to the second car, slightly in front, but behind the first car (Stop at C)
- ○ Both B and C

You decide to change your route to school because traffic keeps making you late. Your new route has a 4-way intersection with lights and a walk signal. When you are almost at the intersection, you see the traffic lights for your direction turn red. You should:

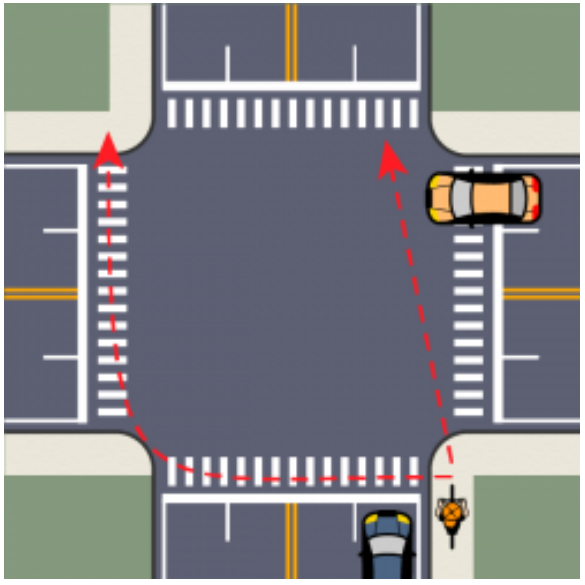
- ○ Bike quickly through the intersection because you saw the lights in the other direction have not turned green yet
- ○ Signal vehicles around you that you are stopping and then stop in front of the crosswalk
- ○ Signal vehicles around you that you are stopping and then stop ahead the first stopped vehicle

For this new route, you have to turn right at the next intersection to reach your school. There is a right turn lane next to your bike lane (See the picture). You should:



- ○ Signal and stop next to the first vehicle in the right turning lane. Turn when traffic from the left is stopped, looking out for pedestrians trying to cross the road
- ○ Signal and stop in front of the crosswalk, then turn right when the traffic from the left is stopped, looking out for pedestrians trying to cross the road and looking over your shoulder for cars coming behind you
- ○ Signal and stop behind the first vehicle in the right turning lane. Turn when traffic from the left is stopped, looking out for pedestrians trying to cross the road

At the next 4-way intersection, the sidewalk you are riding on ends. But there's a sidewalk on the other side of the road after the intersection (See the picture). What should you do?



- ○ Both answers are correct
- ○ Stop, wait for the signal for vehicles on your left to turn red, watch for through and right and left turning traffic, and then cross the street at the intersection and be on the side of the road with the sidewalk
- ○ Keep going your way and bike along with traffic after the sidewalk ends

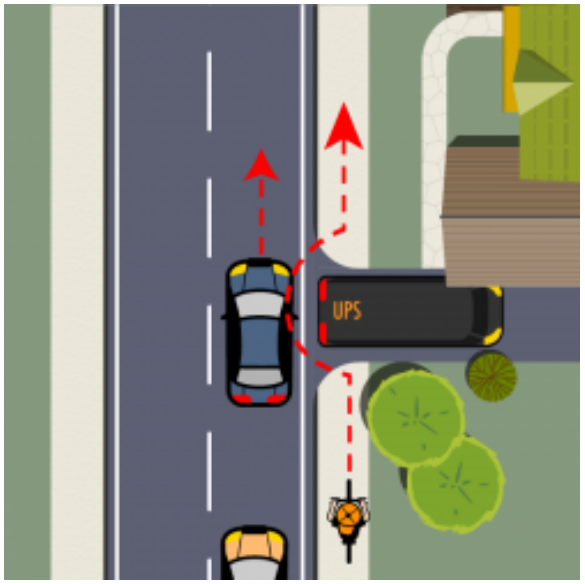
You decide to cross to the other side of the street and continue on the sidewalk. However, this side of the street has shops and businesses. You soon approach a driveway. You should:

- ○ Slow down before approaching the driveway. Look to your left for vehicles backing out. Look to your right for incoming vehicles, and ride through the driveway when it is safe
- ○ Slow down before approaching the driveways. Look to your left for vehicles backing out and ride through the driveway when it is safe
- ○ Slow down but bike as usual – you are on the sidewalk and have the right-of-way

Part 2 cont

Part 2 (page 2 of 2) - Road Safety

On one of the driveways, a UPS van is parked (See the picture). You need to ride behind it because there's no space in front. You will have to go in the roadway to go around the van. What should you do?



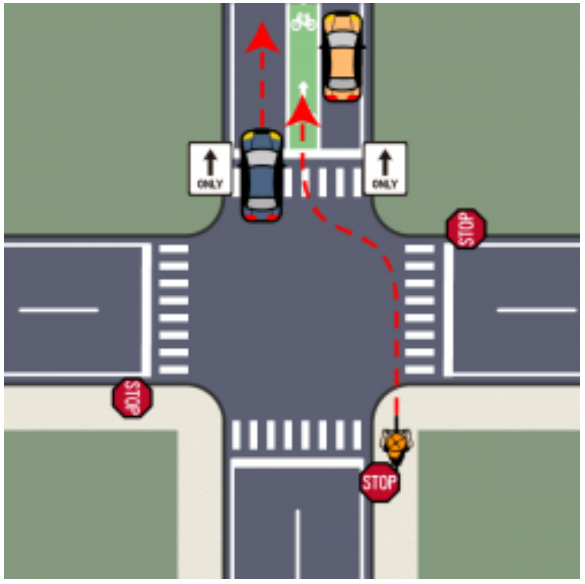
- ○ See if the van is about to leave. Wait if it is. If the van driver isn't there, check the road for traffic. When no cars are coming, signal by raising your hand and merge into the road. Get back on the sidewalk when it is easy to do so.
- ○ See if the van is about to leave. Wait if it is. If the van driver isn't there, check the road for traffic. When no cars are coming, go in the roadway to go around the van and then get back on the sidewalk right away.
- ○ Wait for the UPS van to leave. It is too risky to get back on the roadway

One of your friends is walking right in front of you. She has headphones on. You need to go around her. What should you do?

- ○ Shout "on your left!" and go around her

- ○ Slow down. If there's no pedestrians coming from the opposite direction, ride around her
- ○ Slow down. Check for pedestrians from the opposite direction. Shout "on your left!"Stretch your left arm out while going around her.

The sidewalk ends at the next cross street (See the picture). The road is a one-way street. There are parked cars, a bike lane, and a lane for traffic. Where should you ride?



- ○ Close to the parked cars. Be as far away from traffic as possible
- ○ In the middle of the bike lane. Check for people getting in or out of the parked cars and signal your presence if they are.
- ○ In the bike lane close to traffic. You want to avoid getting hit by a parked car door opening

Your school is on this street but on the other side. You should:

- ○ Cross the street when you're directly across from your school. Car drivers watch out for students in school zones.
- ○ Cross the street at the intersection before the school. It is dangerous to cross the street in the middle of the block.

Part 3

Part 3 - Survey Design

Did having visuals help you complete the survey?

- ○ Yes
- ○ No

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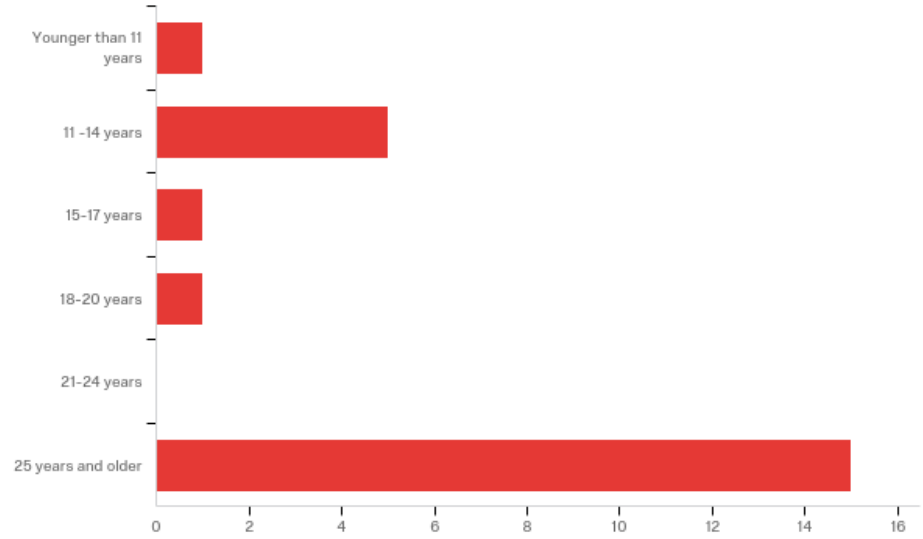
APPENDIX C: SURVEY REPORTS

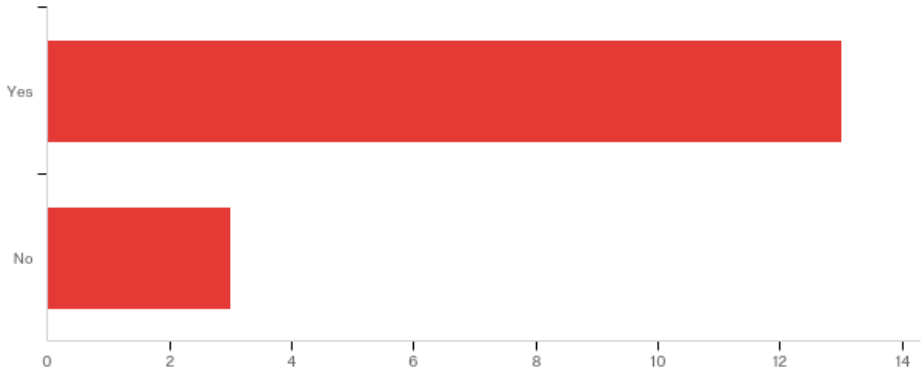
Survey Report 1

Bicyclemania! Pre-Game Survey

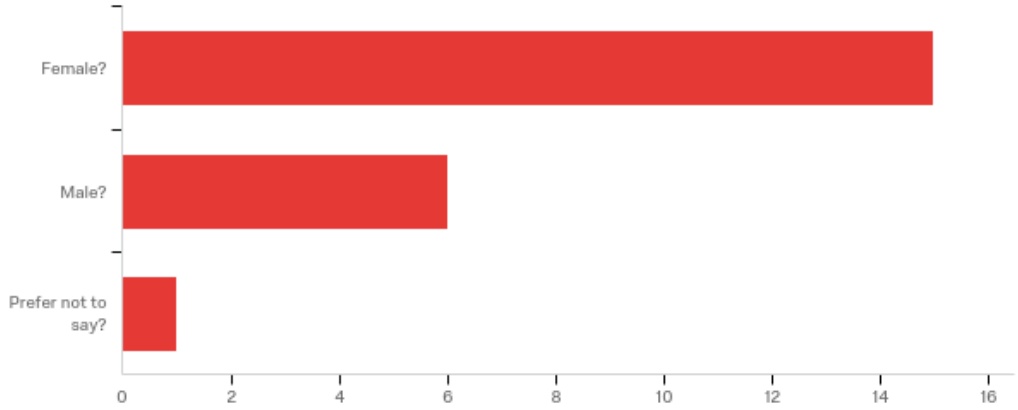
i - How old are you?



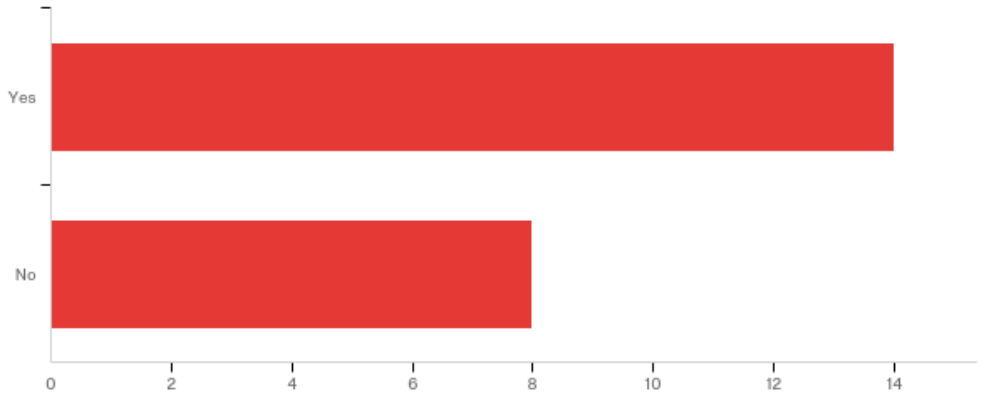
ii - Do you drive?



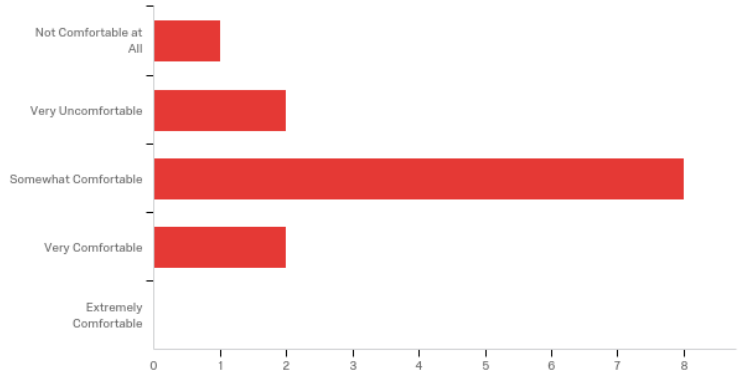
iii - Do you identify as:



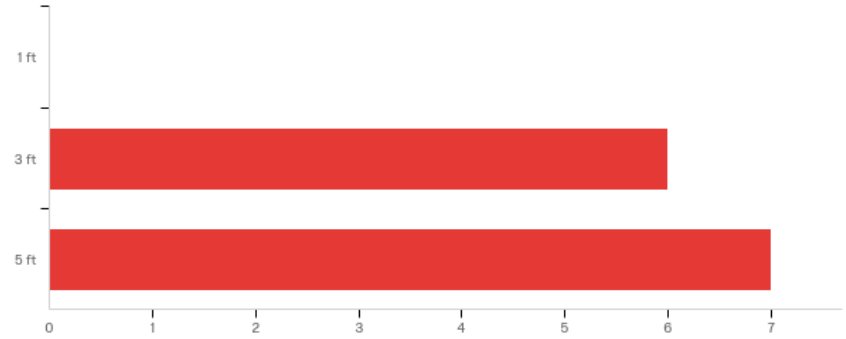
iv - Do you bike?



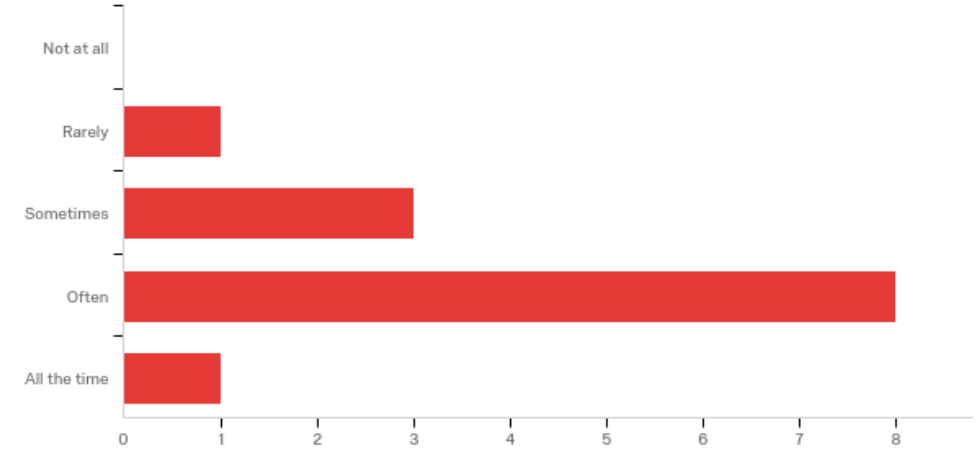
v - While driving, how comfortable do you feel when sharing the road with bicyclists?



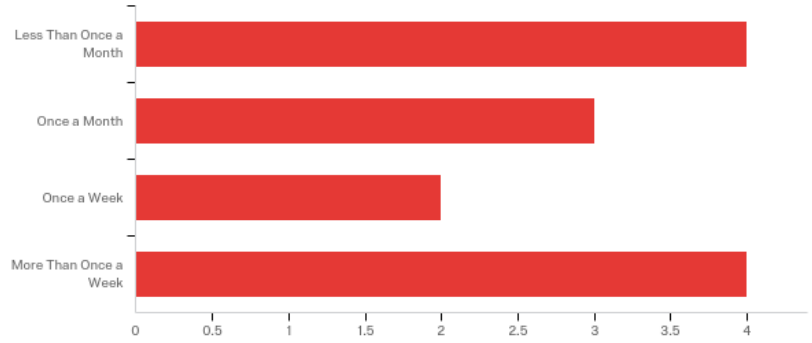
vi - What is the minimum passing distance drivers must allow for a bicyclist in Michigan?



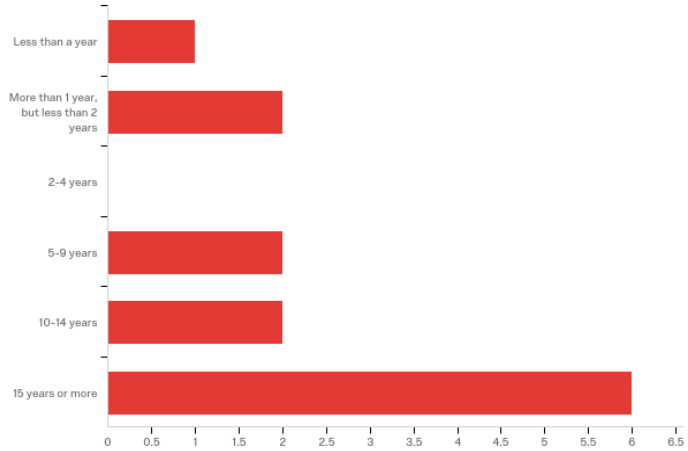
vii - At an intersection, how often do you look for bicyclists when you turn left or right?



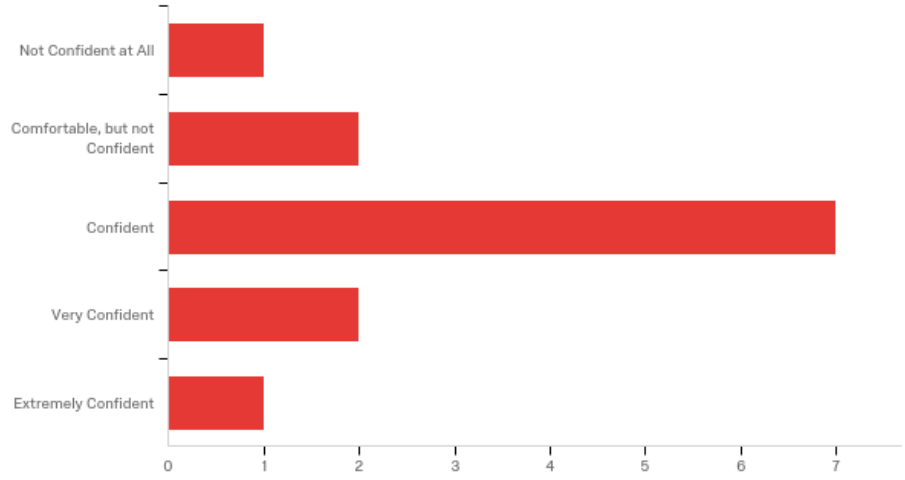
viii - How often do you bike (during months of good weather)?



ix - How long have you been biking



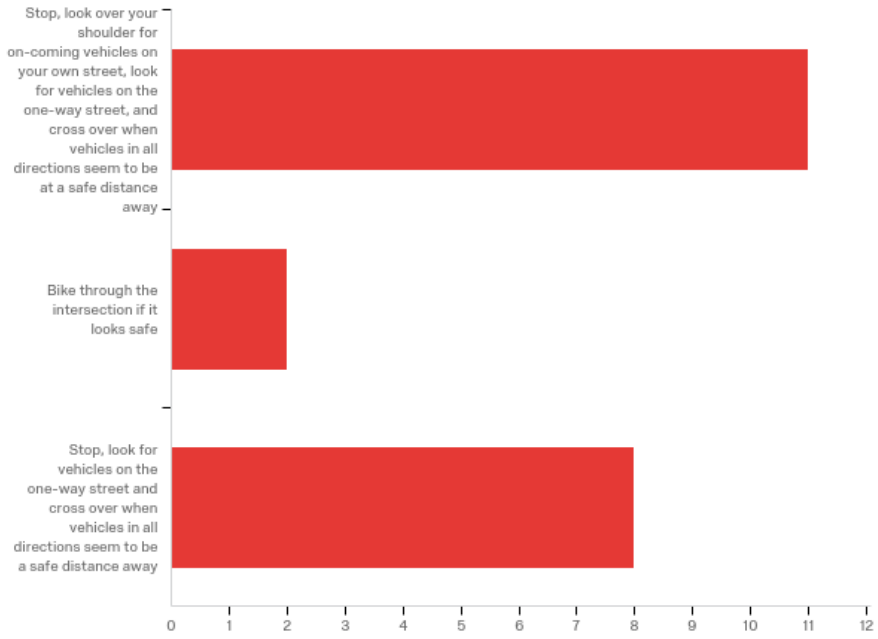
x - How confident do you feel when biking?



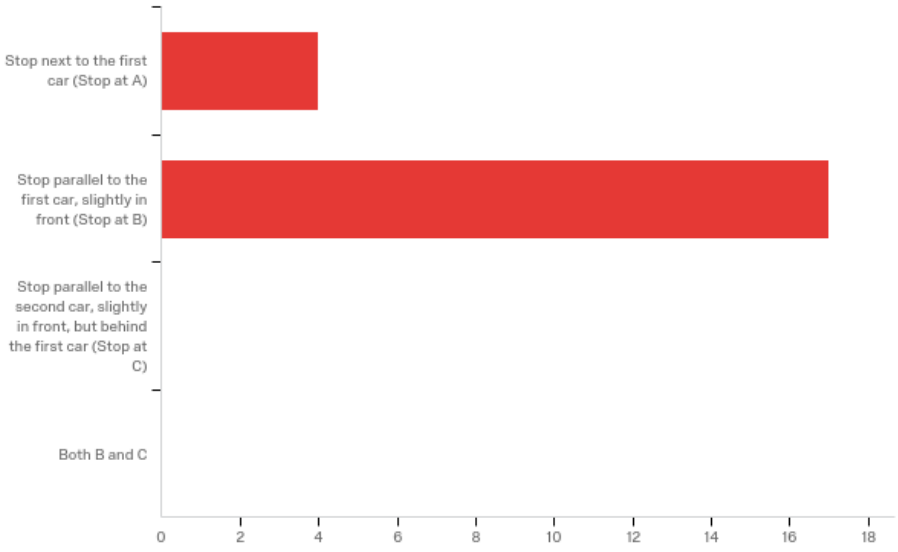
xi - Your home/school Zip Code

Your home/school Zip Code
48105
48235
48105
48109
48176
48197
48103
48103
53713
49503
49333
49503
49333
59503
48386
49503
48197
48130

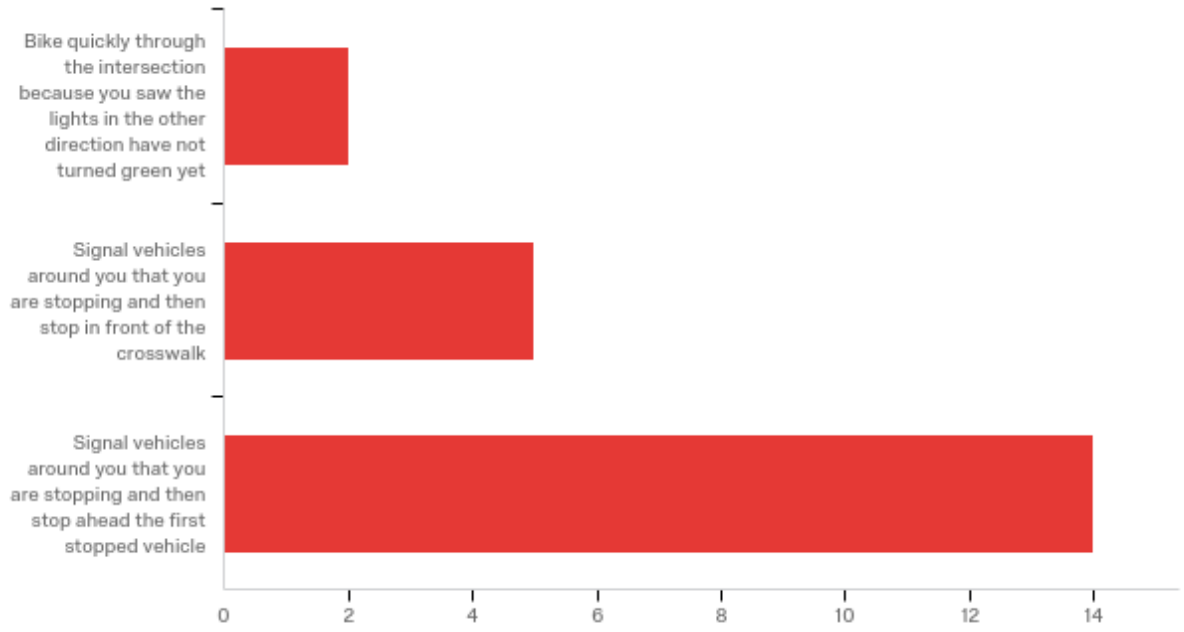
Q1 - You are on a bicycle at an intersection with a STOP sign but no vehicles are in the road/lane next to you. You want to go straight and cross the empty one-way street in front of you. You should:



Q2 - You are at the same intersection again, but this time there are a few vehicles in the road/lane next to you. To make sure the drivers can see you, at the intersection you should: (an image is provided to help understand the scenario)

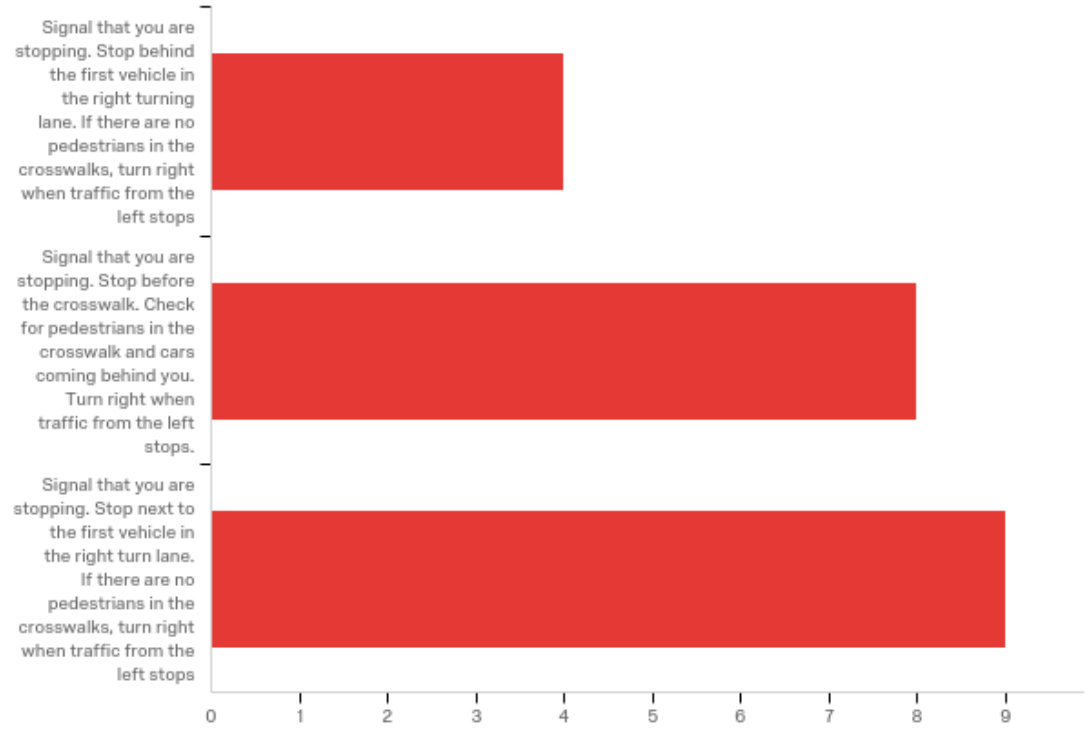


Q3 - You decide to change your route to school because traffic keeps making you late. Your new route has a 4-way intersection with lights and a walk signal. When you are almost at the intersection, you see the traffic lights for your direction turn red. You should:

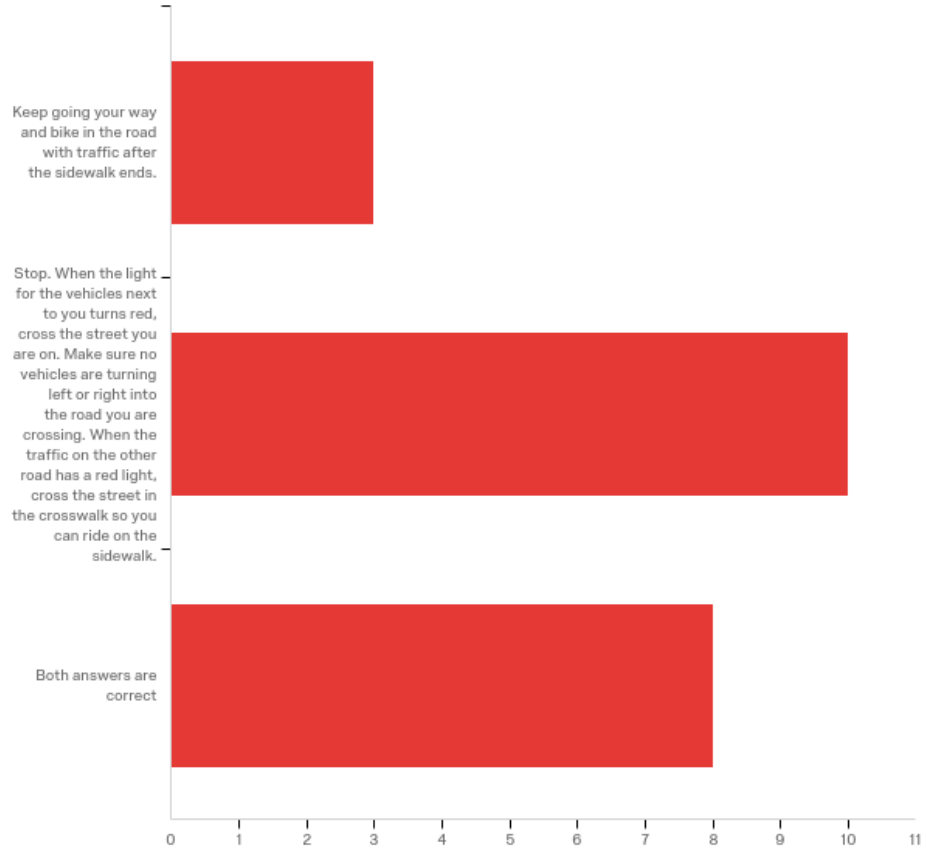


Q4 - For this new route, you have to turn right at the next intersection to reach your school. There is a right turn lane next to your bike lane (See the picture).

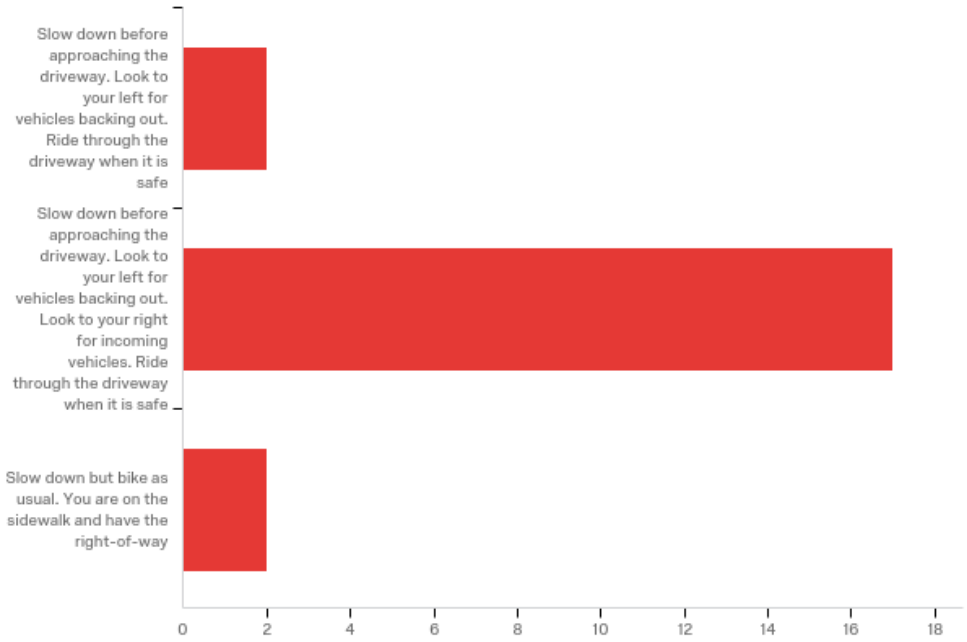
You should:



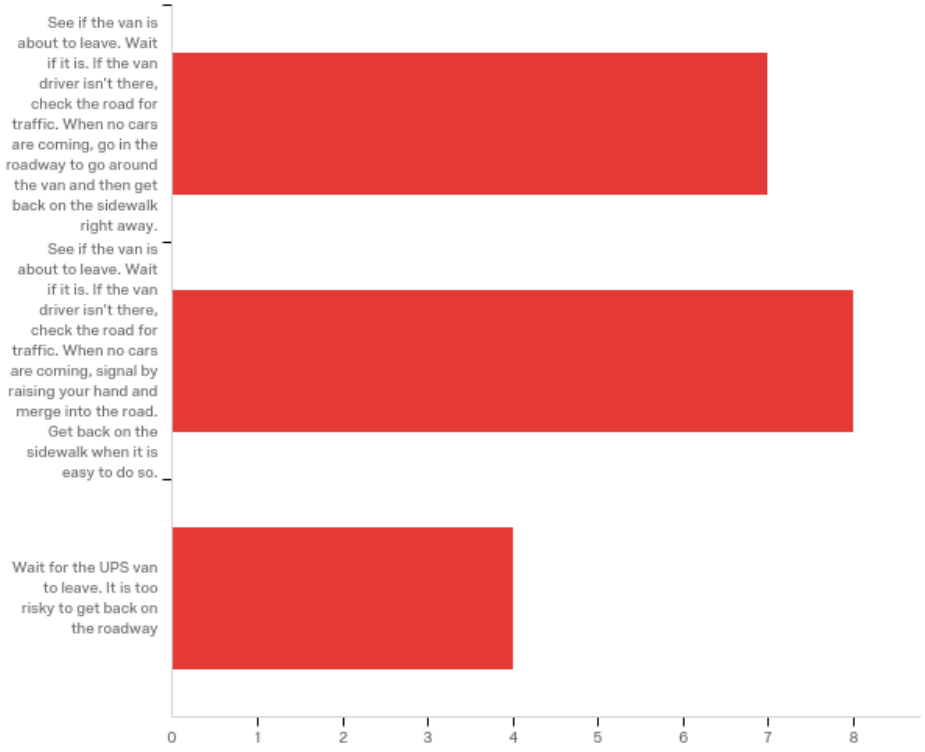
Q5 - At the next 4-way intersection, the sidewalk you are riding on ends. But there's a sidewalk on the other side of the road after the intersection (See the picture). What should you do?



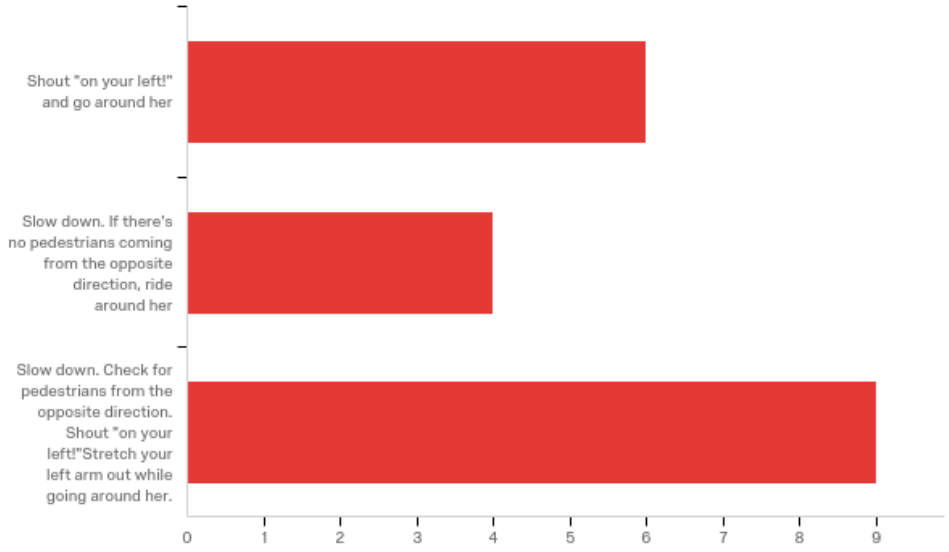
Q6 - You decide to cross to the other side of the street and continue on the sidewalk. However, this side of the street has shops and businesses. You soon approach a driveway. You should:


Slow down before approaching the driveway. Look to your left for vehicles backing out. Ride through the driveway when it is safe
Slow down before approaching the driveway. Look to your left for vehicles backing out. Look to your right for incoming vehicles. Ride through the driveway when it is safe
Slow down but bike as usual. You are on the sidewalk and have the right-of-way
0
2
4
6
8
10
12
14
16
18

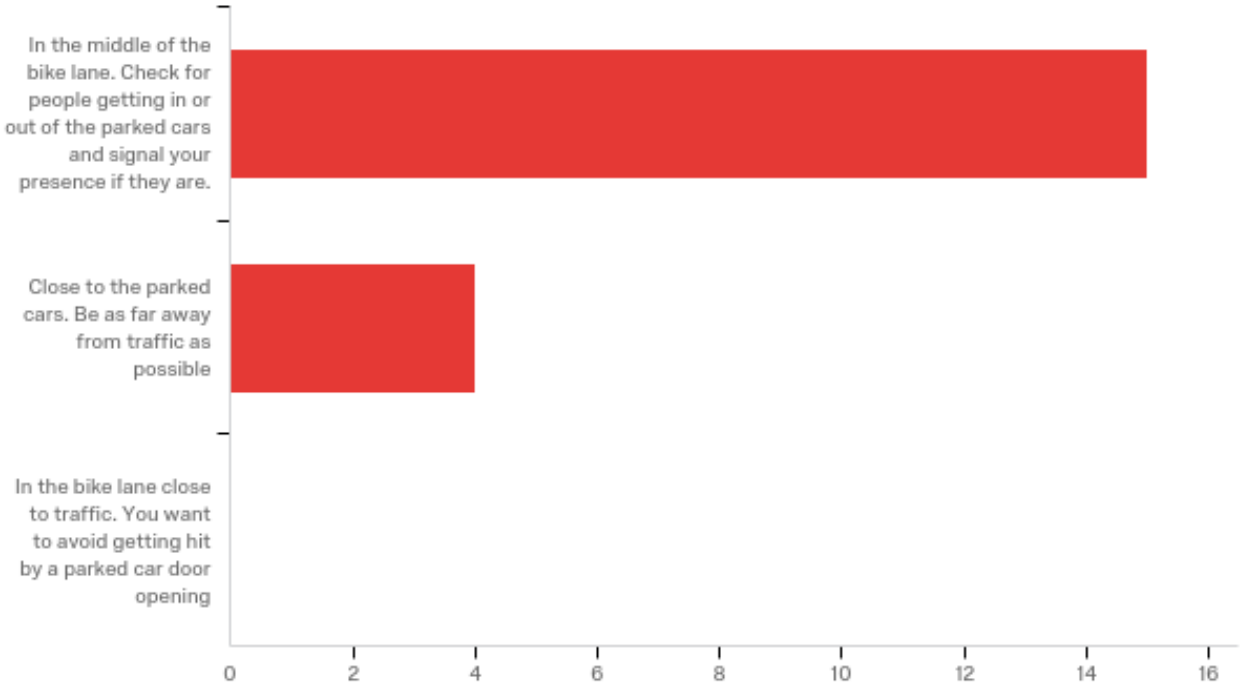
Q7 - On one of the driveways, a UPS van is parked (See the picture). You need to ride behind it because there's no space in front. You will have to go in the roadway to go around the van. What should you do?



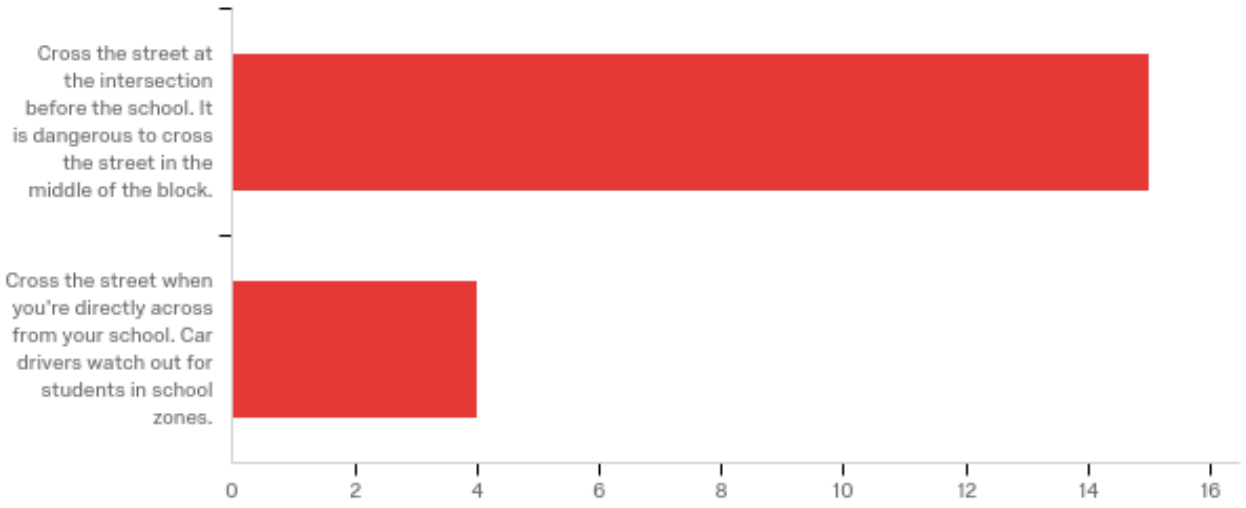
Q8 - One of your friends is walking right in front of you. She has headphones on. You need to go around her. What should you do?



Q9 - The sidewalk ends at the next cross street (See the picture). The road is a one-way street. There are parked cars, a bike lane, and a lane for traffic. Where should you ride?



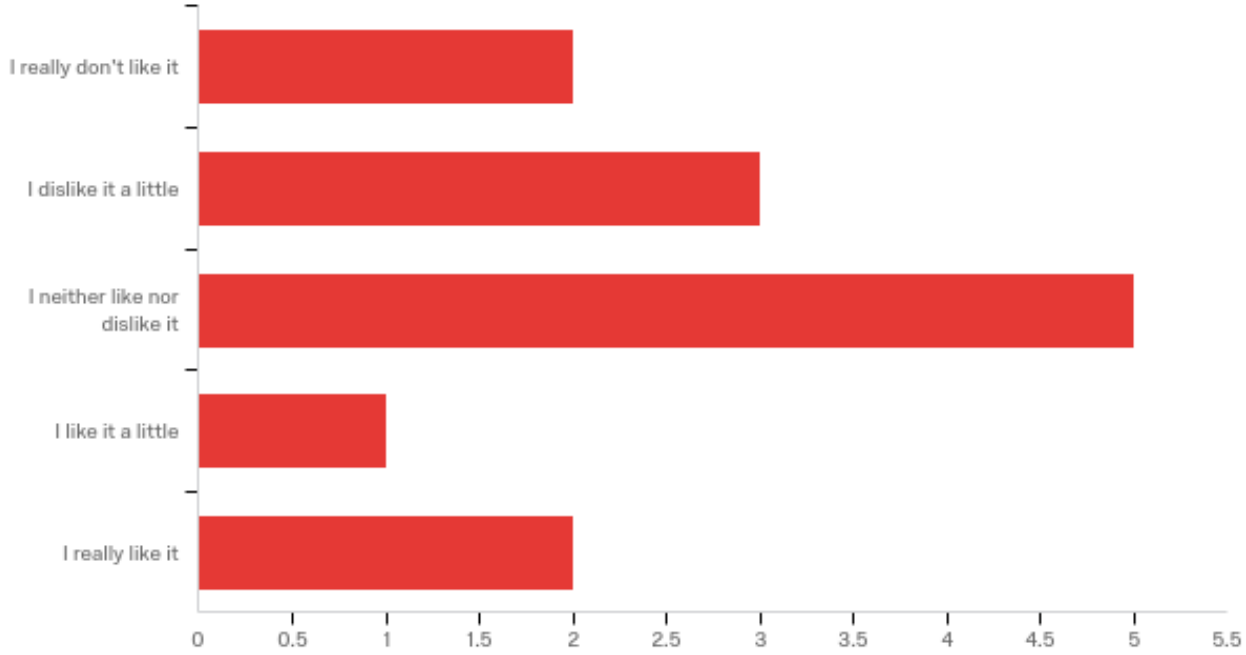
Q10 - Your school is on this street but on the other side. You should:



Survey Report 2

Bicyclemania! Post-Game Survey

Q1 - Overall, how much did you like the game?



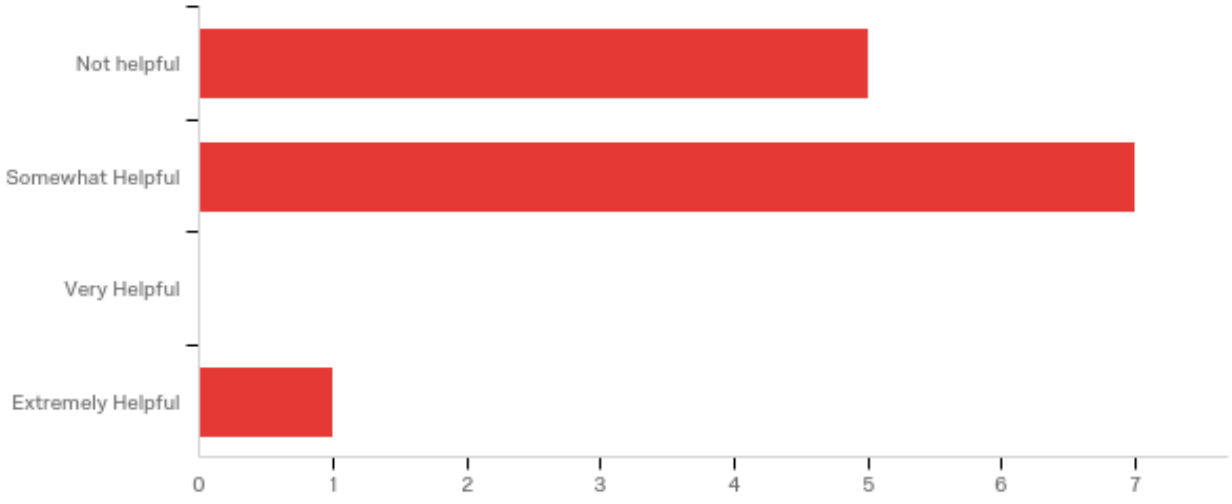
Q2 - What did you like most about the game?

What did you like most about the game?
vehicle simulations
I like the way the game looks.
The intersection traffic signals were obvious.
crazy drivers not obeying stop signs
Beautiful graphics
It was a cute way to simulate biking and had showed a number of the scenarios from the initial survey.
It got me out of my lesson
some
the shape of the stars.
asdf
some
maybe

Q3 - What did you not like about the game?

What did you not like about the game?
Hard for me to steer, I'm not good at video games
I thought I would be able to play and learn more about the concepts from the pre-survey.
Not sure if I remembered how to control the bike.
rear view mode; no bike lanes; speed of cars seem unrealistic
Hard to make turns without running into the street (possibly I didn't figure it out). What should I be doing?
The turning mechanics were unclear and you can get trapped in a sequence of collisions when the game restarts you in the middle of the road. No bike lanes and you cannot ride on the road as you will be rear-ended by the cars. Does not match the survey's focus in this regard.
It was hard to control. It didn't make sense. Not every "oops" was a car turning into me.
some
getting stuck on the grass, having to try to get away from the cars after you die, ans the music was a little boring.
asdf
some
maybe

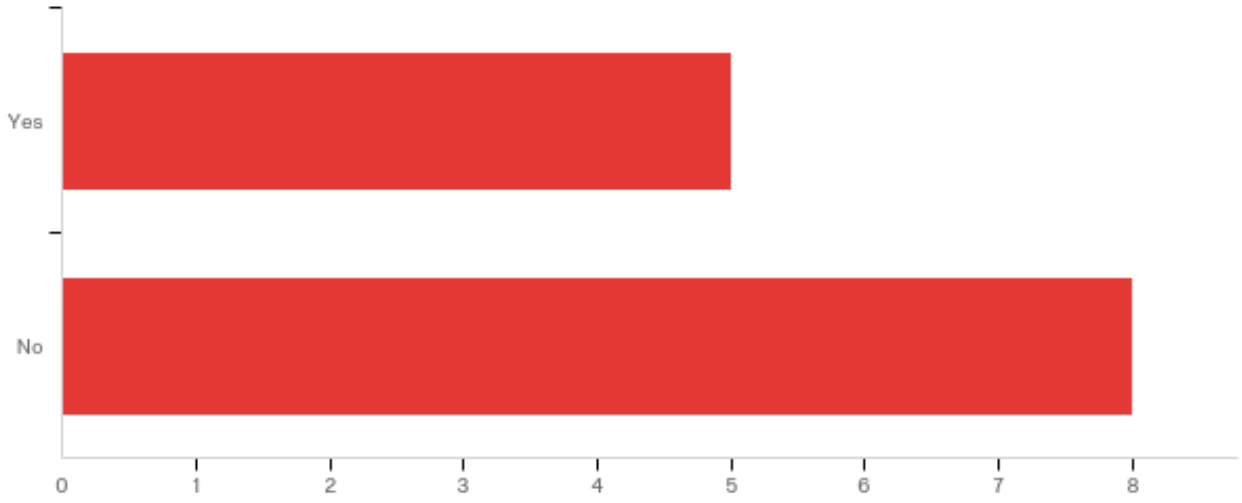
Q4 - Overall, how helpful was the game in understanding how to safely share the road with other road users?



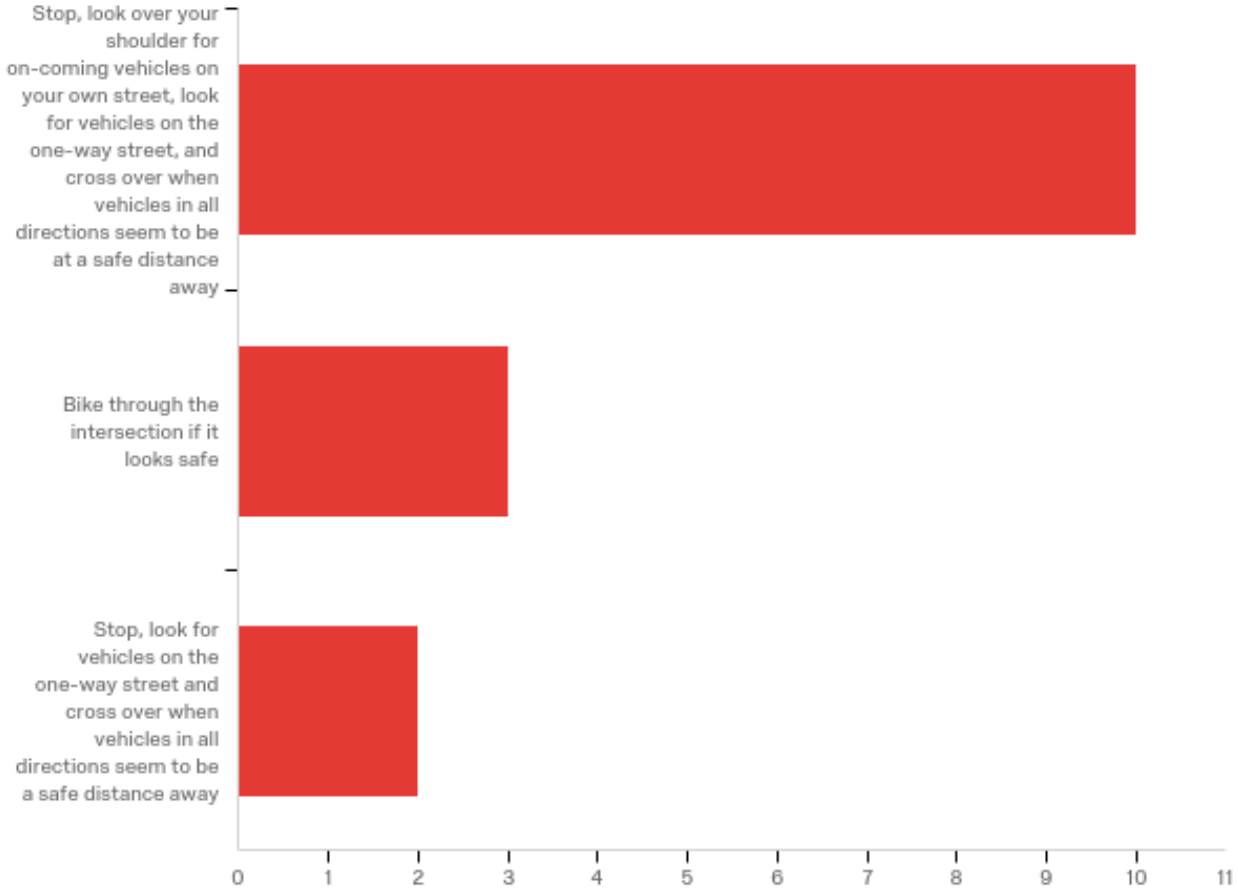
Q5 - What is the most important piece of safety information that you learned from playing the game?

What is the most important piece of safety information that you learned from playing the game?
bikes not allowed in some areas
N/A
Maybe I was supposed to read all of the statistics? I did not.
watch out for right turning cars
Be more careful with cars turning right.
Cars will turn regardless of the presence of a bicycle that clearly has the right of way in the crosswalk.
It should have been designed by kids.
some
to hit the back button to stop.
asdf
some
maybe

Q6 - Will you play the game in the future?



Q7 - You are at an intersection with a STOP sign but no vehicles are in the road/lane next to you. You want to go straight and cross the empty one-way street in front of you. You should:



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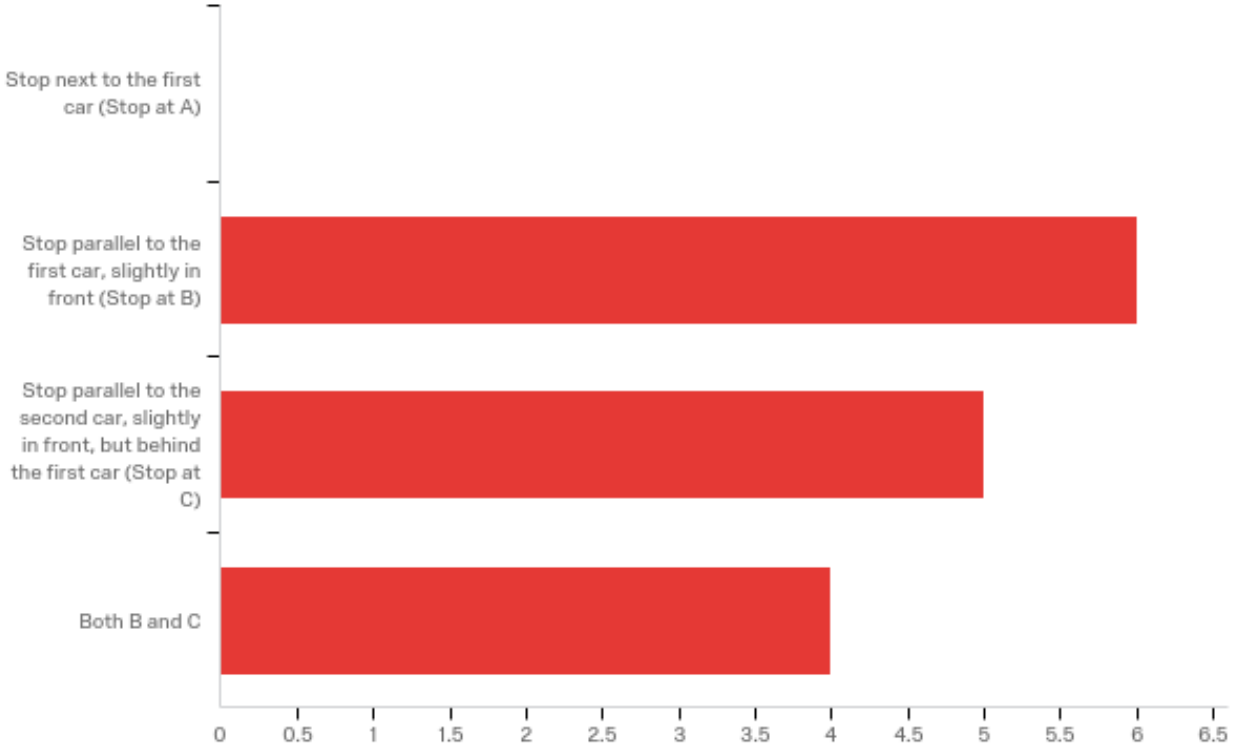
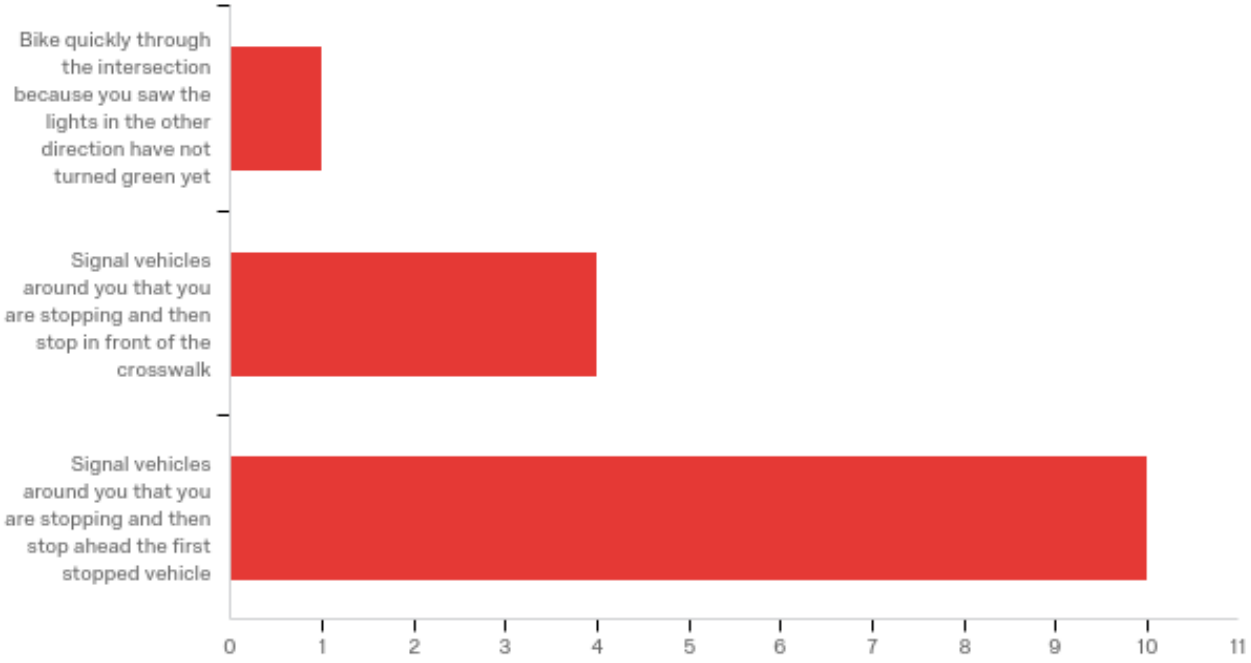


Q9 - You decide to change your route to school because traffic keeps making you late. Your new route has a 4-way intersection with lights and a walk signal. When you are almost at the intersection, you see the traffic lights for your direction turn red. You should:



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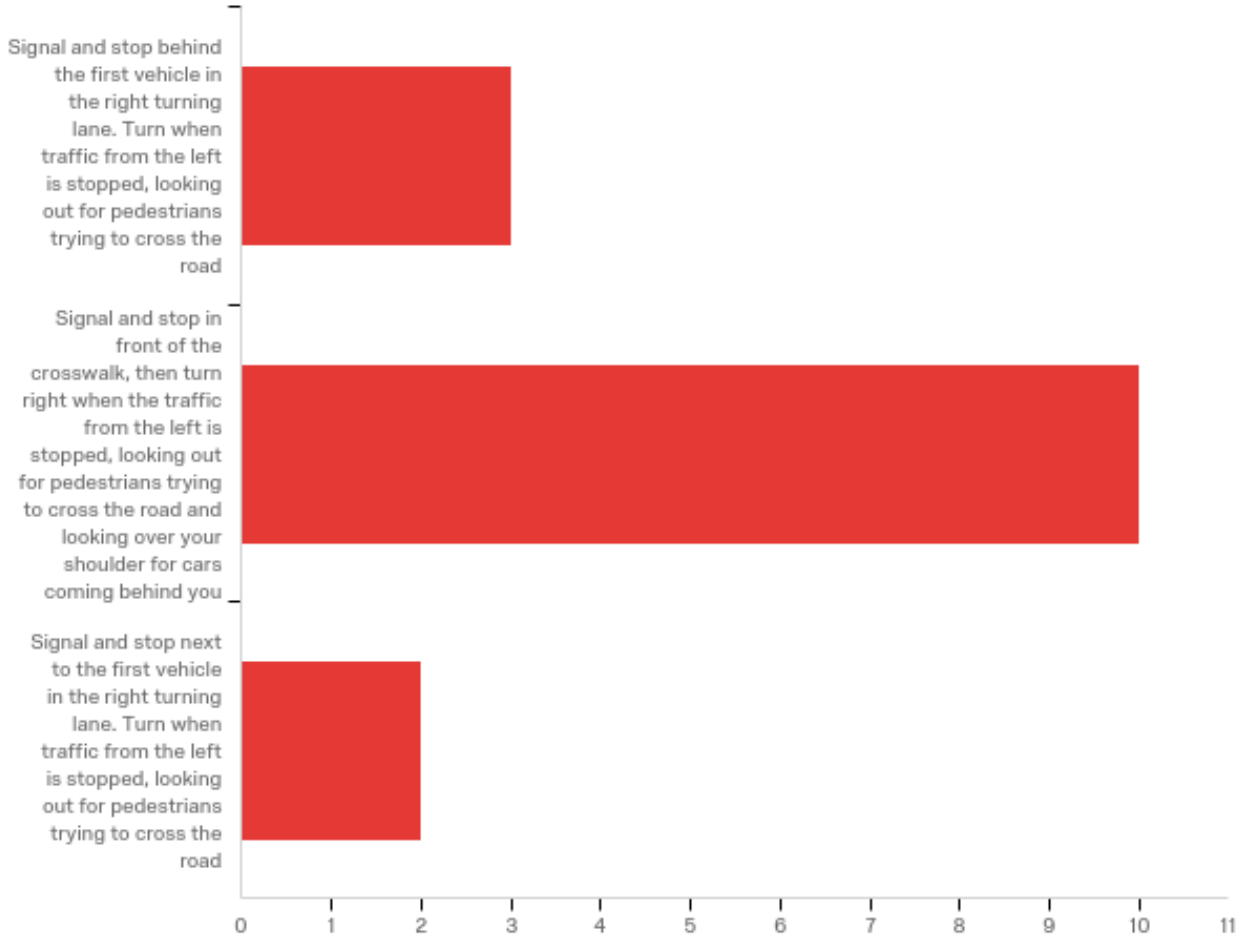
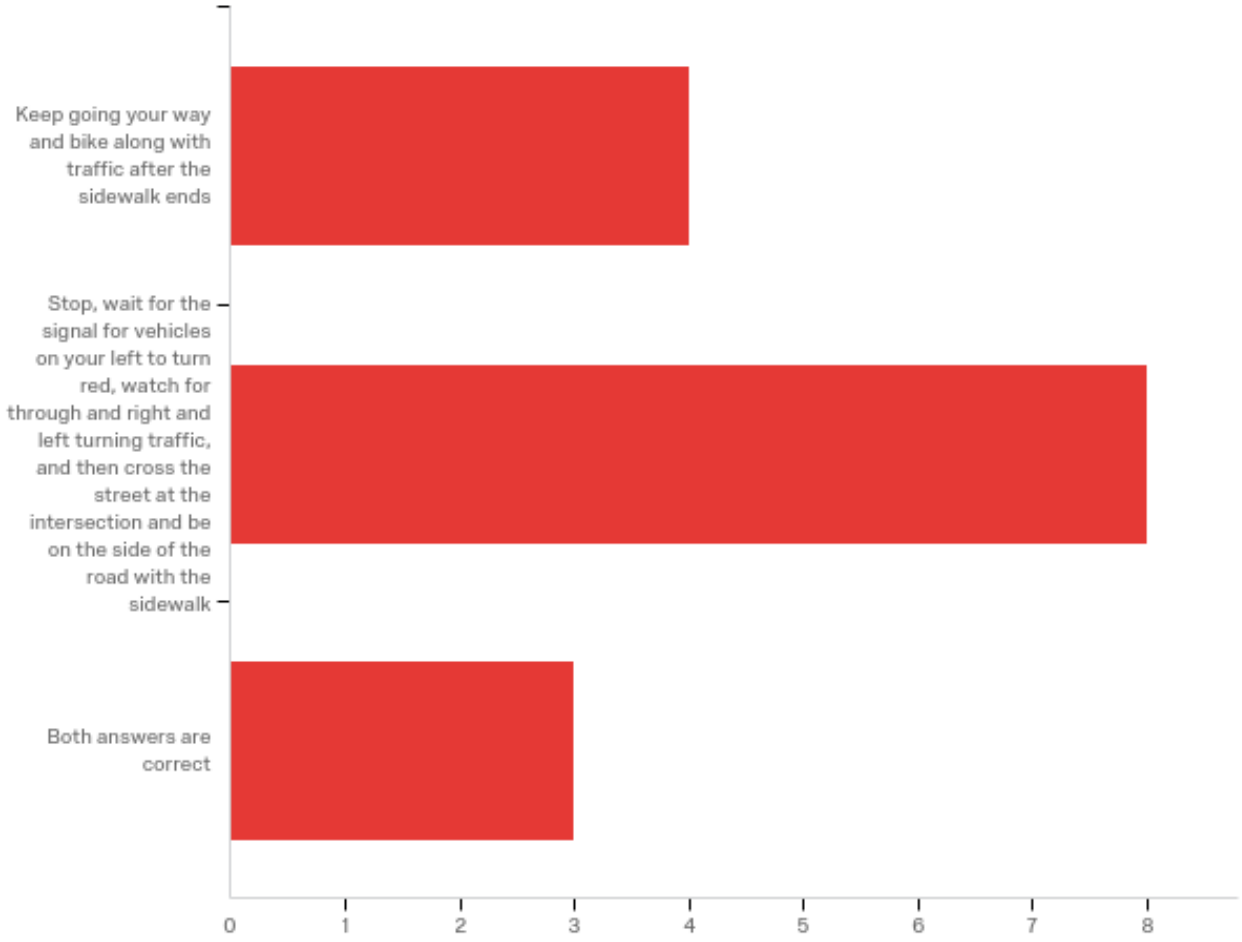
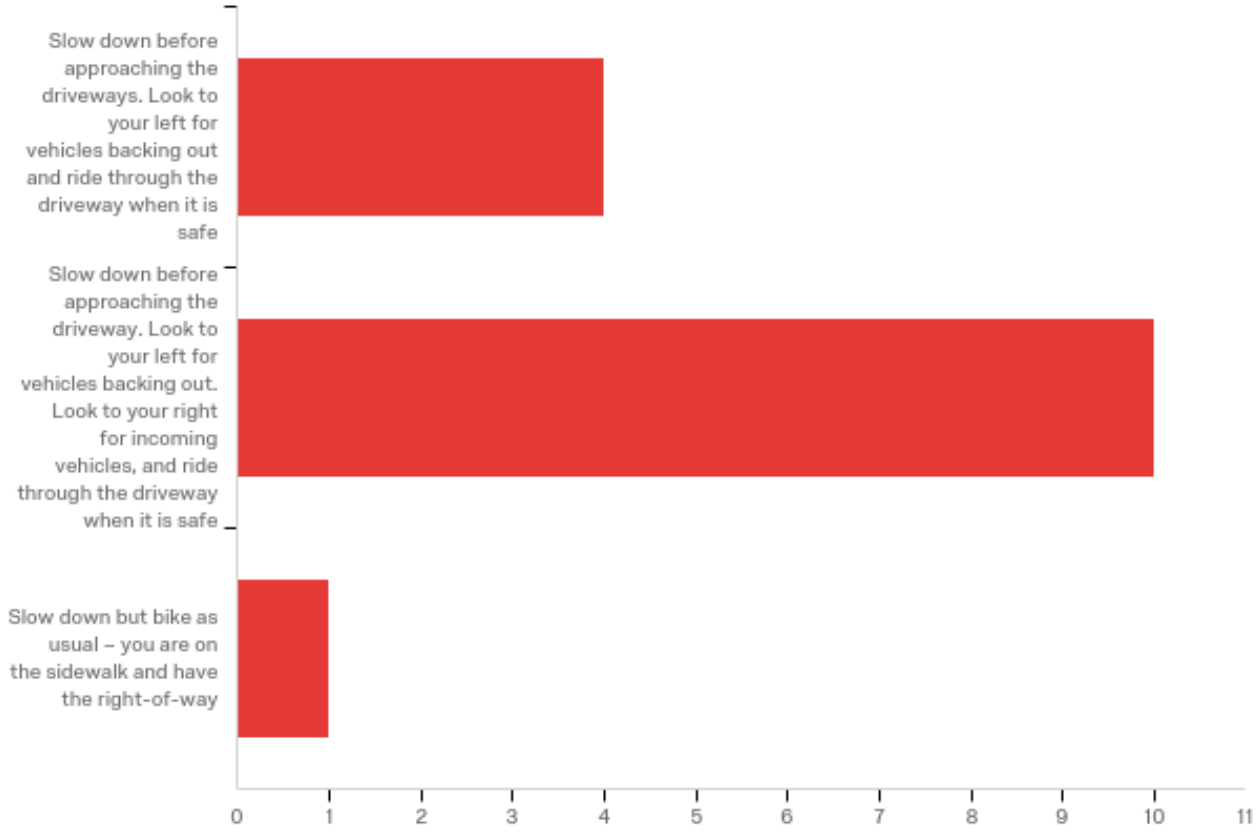


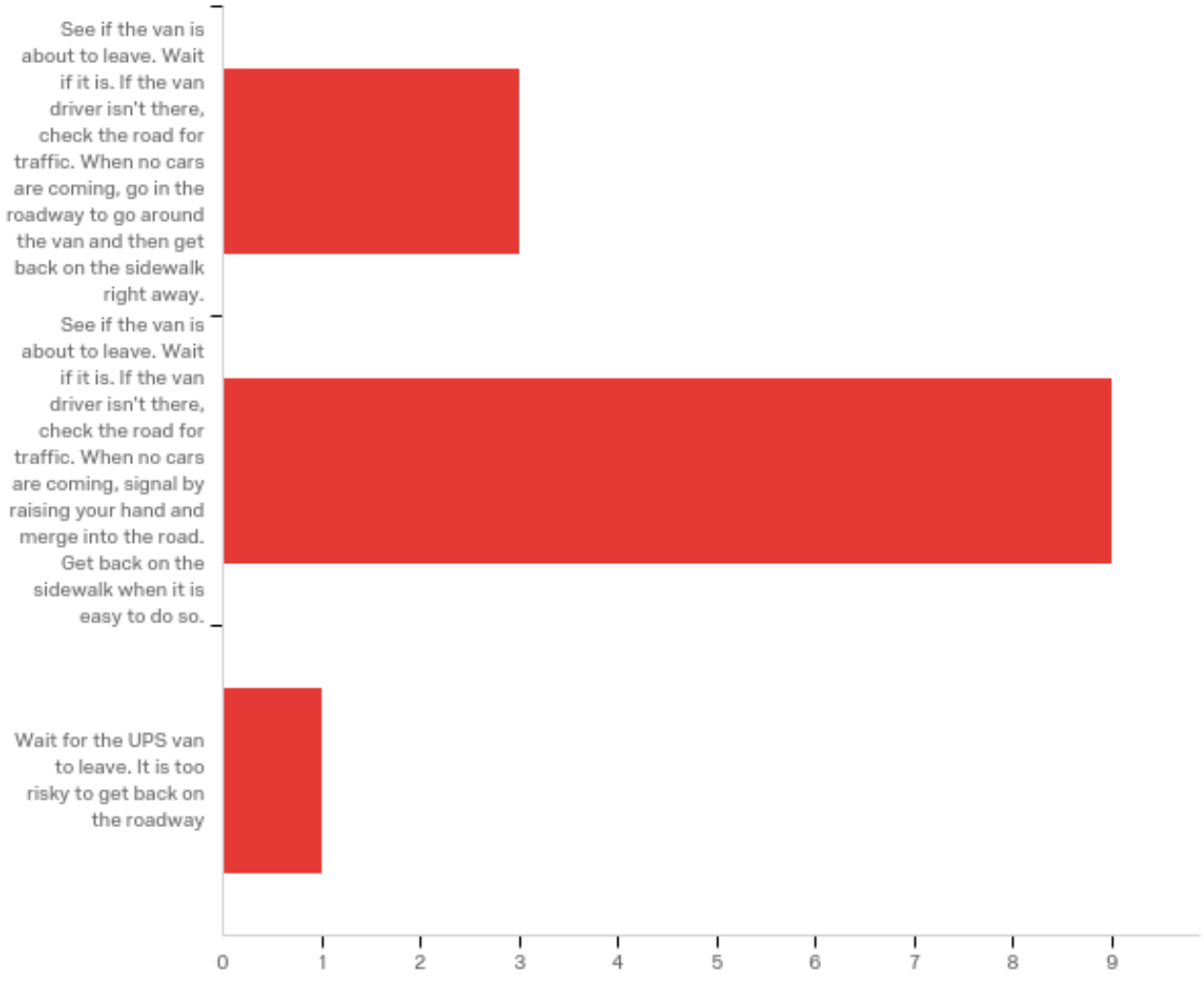
Q11 - At the next 4-way intersection, the sidewalk you are riding on ends. But there's a sidewalk on the other side of the road after the intersection (See the picture). What should you do?



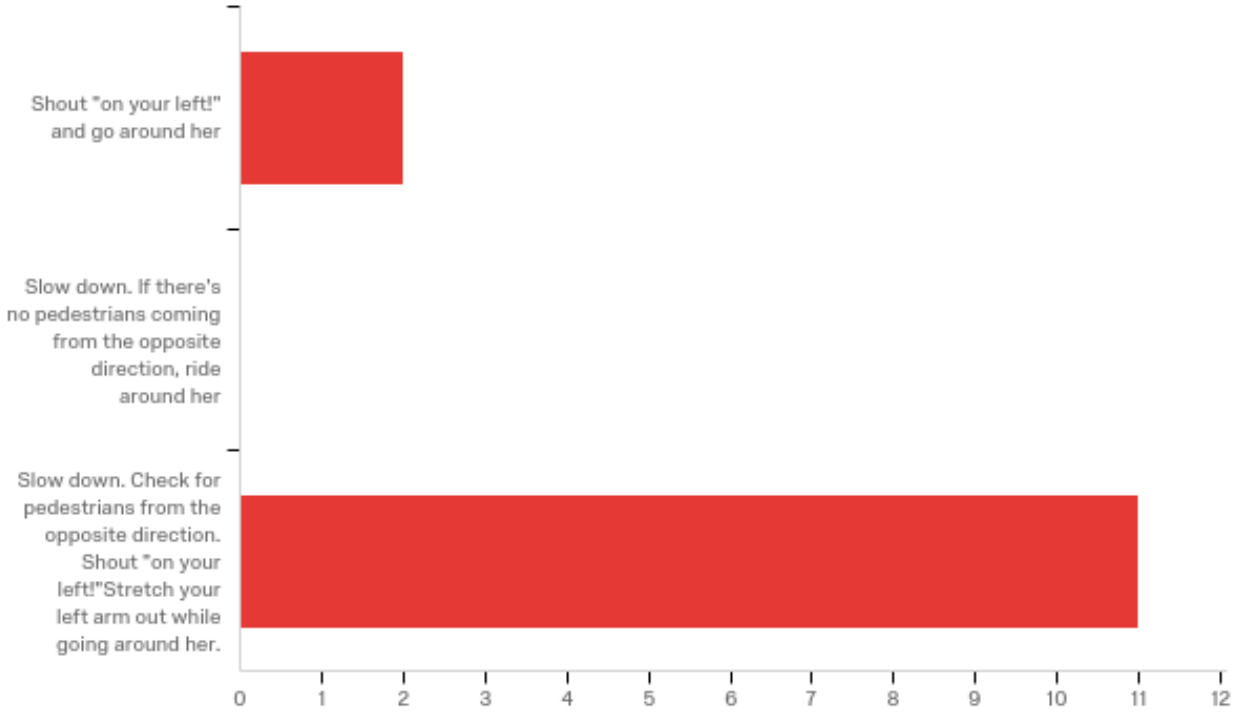
Q12 - You decide to cross to the other side of the street and continue on the sidewalk. However, this side of the street has shops and businesses. You soon approach a driveway. You should:



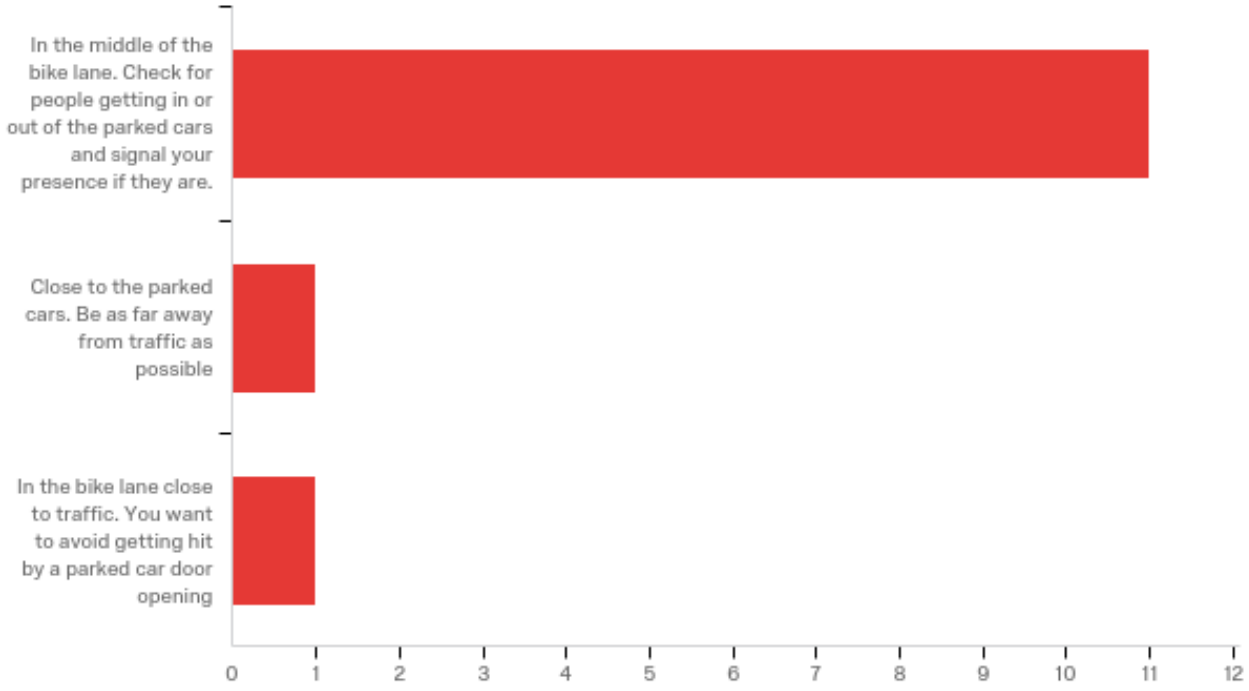
Q13 - On one of the driveways, a UPS van is parked (See the picture). You need to ride behind it because there's no space in front. You will have to go in the roadway to go around the van. What should you do?



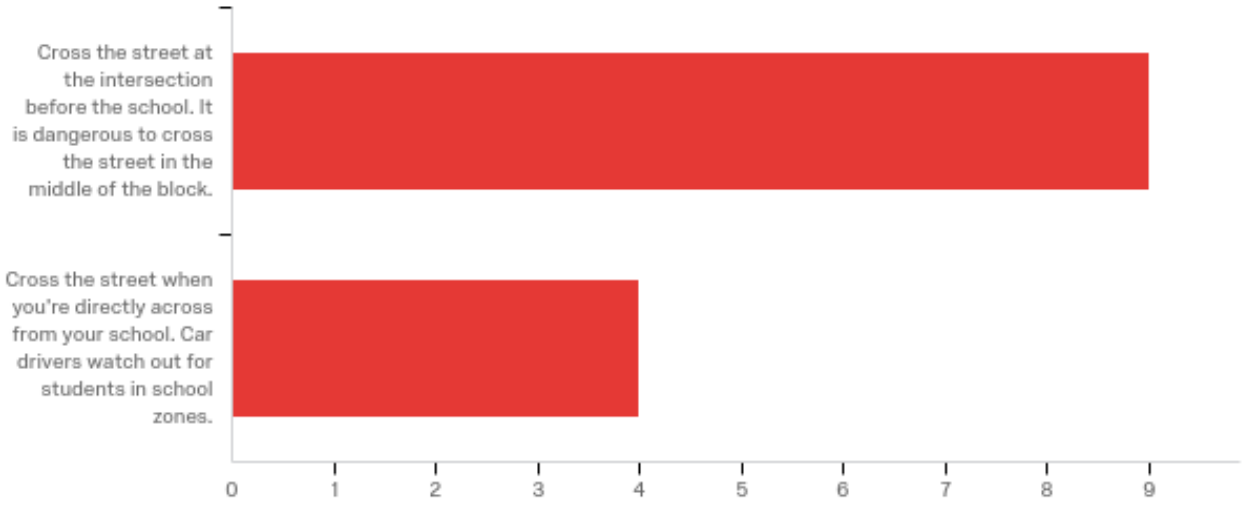
Q14 - One of your friends is walking right in front of you. She has headphones on. You need to go around her. What should you do?



Q15 - The sidewalk ends at the next cross street (See the picture). The road is a one-way street. There are parked cars, a bike lane, and a lane for traffic. Where should you ride?



Q16 - Your school is on this street but on the other side. You should:



Q18 - Did having visuals help you complete the survey?