IMPROVING DILEMMA ZONE PROTECTION CONTROL ISSUES AT SIGNALIZED INTERSECTION USING A WEB-GAME

YATISH KASARANENI

Thesis submitted to the Faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of

Master of Science
In
Civil Engineering

Montasir M Abbas, Chair
Lisa D McNair
Pamela Murray-Tuite

September 04, 2009
Blacksburg

Keywords – Assessment, Actuated Control, .NET Framework, Traffic Engineering, Web-Game

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ABSTRACT

Web games provide a platform for creative instructional activities that can capture the students' attention towards the course. These games can be used to emulate the realistic situations which can be used as effective lab experiments that could give the students a hands-on experience using real world scenarios. This thesis presents an innovative web-based game developed for the demonstration of the driver-behavior at signalized intersections that can be used as a supplementary tool for the Transportation Engineering course. The game format is carefully designed to supplement the understanding of the class learning material through a fun environment. It was designed to be widely accessible through the internet and have an attractive user interface and was improved from the feedback obtained from the pilot study. The game is programmed on the .NET Framework using the Microsoft Visual C# as a core programming language, ASP to develop the web interface, and Microsoft Access as the databases for the program. The thesis also provides a methodological framework for collecting data about student engagement in a course and in particular presents the data collection procedure used in Transportation Engineering Course (CEE 4609). The collected data was analyzed to find the student engagement in the course after the introduction of the game. The thesis gives the conclusions drawn from the research with insights into possible drawbacks and scope for future improvements.

ACKNOWLEDGEMENTS

I would like to thank my advisor, Dr. Montasir M Abbas, for granting me the opportunity to work in his research group. I am ever grateful for his guidance and support in my research. His never ending encouragement has helped me to successfully complete my Masters while at Virginia Tech.

Additionally I would like to thank Dr. Lisa D McNair, for her guidance and valuable advice in the field of Engineering Education, and Dr. Pamela Murray-Tuite, my other committee members, for constructive comments and advice through the entire research process.

I also would like to thank my friends Syam Sunder Vissamsetty, Zain M Adam, and Pengfei “Taylor” Li for their valuable guidance in my initial days of programming.

DEDICATIONS

I would like to dedicate this thesis to my parents Usha Rani and Krishnaiah Kasaraneni and my sister Lavanya. They always have supported me in my academic pursuits. Without their encouragement and support I wouldn’t have completed my studies. And finally I would like to dedicate this to all my friends who believed in me even before I did in myself.

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1. INTRODUCTION

When traffic signals change from green to yellow, drivers have to decide whether they can safely stop (at an acceptable deceleration rate) or continue and clear the stop line before the start of red. The decision mainly depends on parameters such as the distance from the stop bar, speed at which they are travelling, acceleration rates and deceleration rates, etc. Different drivers have a different perception of the right decision whether to stop or to go. For example, conservative drivers tend to stop if there is a slight doubt in their minds; if the driver is aggressive he or she will try to cross the intersection even at a slight possibility, etc. So it is hard to predict the driver decision at the onset of yellow.

The decision to be made is relatively easy when the driver is close to the intersection or far away from the intersection. But in the interim distances the driver falls into ambiguity whether to stop or go ahead. This zone of ambiguity is called the “Dilemma Zone.” The probability of accidents to occur is high in this zone. Generally two types of accidents occur: 1) rear end collision, when the driver in front decides to stop and the driver behind decides to go ahead, and 2) right angle collision, when the driver decides to cross the intersection and unknowingly runs the red light and collides with the conflicting traffic.

Students are taught about the dilemma zone in the class through conventional teaching methods. Textbook only gives a general idea of dilemma zone as a definition and at best a static pictorial representation. This research is focused on the demonstration of the Dilemma Zone concept through a web-based game.

1.1 RESEARCH OBJECTIVES:

The major objectives of this research

- To develop a demonstration tool for teaching the Dilemma Zone concept in the Transportation Engineering Course
- To assess the Engagement of students in the Transportation Engineering course after introducing the game
- To find out if the game is useful to motivate students in the Transportation Engineering course

1.2 THESIS CONTRIBUTION:

This thesis conducts a research into engagement of students in the course when a game to demonstrate a concept is used. The Dilemma Zone concept is chosen to be demonstrated through a web-game, which can be widely accessed through the World Wide Web, to the students taking the Transportation Engineering Course (CEE 4604). A questionnaire was used to find out the engagement of the students in the course after using the game.

1.3 THESIS ORGANIZATION:

The thesis is organized into five chapters. Chapter 1 presents an introduction, research objectives, and contribution of the thesis. Chapter 2 presents a pilot study conducted for the game. Chapter 3 describes the development of the game, user interface of the game and the algorithms followed in the game. Chapter 4 describes the data collection and the assessment of the students in the course after the introduction of the game. Chapter 5 presents the study conclusions and recommendations for further research. The questionnaires used in this study are attached in the Appendix.

2. A WEB-BASED GAME TO IMPROVE LEARNING OF DRIVER BEHAVIOR AND CONTROL AT SIGNALIZED INTERSECTIONS

Yatish Kasaraneni
Graduate Research Assistant, Dept. of Civil and Environmental Engineering
Virginia Tech,
Blacksburg, VA 24061
Phone: 540-231-3363
FAX: 540-231-7532
y2kneni@vt.edu

Montasir M. Abbas, Ph.D., P.E.*
Assistant Professor, Via Dept. of Civil and Environmental Engineering
Virginia Tech,
Blacksburg, VA 24061
Phone: 540-231-9002
FAX: 540-231-7532
abbas@vt.edu

Lisa D. McNair, PhD
Assistant Professor, Department of Engineering Education
Virginia Tech,
Blacksburg, VA 24061
Phone: 540-231-1144
FAX: 540-231-6903
lmcnair@vt.edu

Word Count: 4873 + 2 Tables + 7 Figures = 7123 words.
Submitted: July 31, 2008

*Corresponding Author

ABSTRACT

Web games provide a platform for creative instructional activities that can capture the students' attention towards the course. These games can be used to emulate the realistic situations which can be used as effective lab experiments that could give the students a hands-on experience using real world scenarios. This paper presents a web game that complements a Traffic Engineering course. The game format is carefully designed to supplement the class learning in a fun environment. The paper also provides a methodological framework for collecting data about student engagement in the game and their views on using different learning technologies for educational purpose.

2.1 INTRODUCTION

The field of engineering requires a high level of practical knowledge to be able to sustain and yield good results. In particular, the Transportation Engineering field requires thorough practical knowledge to build a sound understanding of the principles that are taught in the class. In general, in engineering majors, practical knowledge is imparted through carefully designed experiments conducted in the laboratories. However, it is not always easy to have practical examples that are of complex nature to be undertaken in the laboratories. Since the real time environment is totally different from the lab environment, most cases are limited by constraints. The same applies to transportation engineering. Although analysis of traffic stream and traffic signals can be done through simulation, it may be difficult for beginners to work through simulations and understand the concepts.

To bridge this gap, one viable solution is the development of a web game. The Computer-based Educational Games can be modeled to deliver specific learning objectives and paves way for adaptive learning and role-play and simulations(*1)*. It is possible to create environments that can replicate real world scenarios, which can help students to easily gain experience. Web games also provide a platform for creative instructional activities that can capture the students' attention towards the course topics. Introduction of inquiry-based learning approach in an engineering course titled Simulations and Statistical Analysis was facilitated with the help of a WebQuest, a pedagogical tool for web-enabled inquiry-based learning and was found to motivate student and achieve beneficial auxiliary outcomes(*2)*. Games can be recreational, engaging, and educational. The introduction of a game into a course can motivate students toward understanding the course material (*3)*. Well-crafted games can transfer knowledge in an efficient way and help students understand the concepts better , as shown in tests with increased scores compared to students who follow traditional text book learning (*4)*. Some courses require a lot of repetition of the same concept for different problems and this practicing is often assumed to lead to proficiency in the concept. But more often than not students tend to not like this approach. A more amicable way is to encapsulate practice in a game context. Games appear to be effective teaching tools for concepts which requires repetition for proficiency like the Statics Calculation Procedures (*5)*.

Even though games can be quite effective, motivating and simpler to administrate, it's not always good to replace the traditional textbooks with them. Games should be used as supplements that would encourage the students understand the course and enjoy the course(*6)*. Following these guidelines, this paper describes a web game that could be used in a transportation course to help the students understand basic traffic engineering concepts.

2.2 BACKGROUND

When traffic signals change from green to yellow, drivers have to decide whether they can safely stop (at an acceptable deceleration rate) or continue and clear the stop line before the start of red. The decision mainly depends on parameters such as the distance from the stop bar, speed at which they are travelling, acceleration rates and deceleration rates, etc. Different drivers have a different perception of the right decision whether to stop or to go. For example, conservative drivers tend to stop if there is a slight doubt in their minds; if the driver is aggressive he or she will try to cross the intersection even at a slight possibility, etc. So it is hard to predict the driver decision at the onset of yellow.

The decision to be made is relatively easy when the driver is close to the intersection or far away from the intersection. But in the interim distances the driver falls into ambiguity whether to stop or go ahead. This zone of ambiguity is called the "Dilemma Zone." The probability of accidents to occur is high in this zone. Generally two types of accidents occur: 1) rear end collision, when the driver in front decides to stop and the driver behind decides to go ahead, and 2) right angle collision, when the driver decides to cross the intersection and unknowingly runs the red light and collides with the conflicting traffic. Students are taught about the dilemma zone in the class through conventional teaching methods. Textbook only gives a general idea of dilemma zone as a definition and at best a static pictorial representation. These methods may sometimes be confusing to the students. The game on the other hand attempts to provide a visual representation of the dilemma zone and the traffic in the dilemma zone, which is helpful for the students to completely understand the situational meaning of the concept.

The paper is organized as follows. Section 2.3 gives the description of the game with the focus on the different functionalities of each of the components of the game including what they are aiming to achieve as an outcome. Section 2.4 gives details about the software design of the game. Section 2.5 discusses the assessment of the game, its futuristic goals and the procedure the assessment is going to take for the evaluation of the impact of the game on students. Section 2.6 includes the observations and feedback of the graduate students in the pilot study conducted for the initial evaluation of the game. Section 2.7 concludes the paper with the conclusions and scope for further research.

2.3 DESCRIPTION OF THE GAME

The game is to let the student understand what might be the drivers' decision at the onset of yellow depending upon the existing traffic conditions. The player who is playing the game has to determine the safe time to give the yellow signal so that the least number of cars in the dilemma zone exist and the hazard for the traffic is minimized. The most general zone of dilemma is considered to be 2 to 6 seconds of time to reach the intersection and these values are used in the paper as the lower and upper boundaries, respectively. When the drivers are caught in this zone at the onset of yellow their judgment cannot be clearly defined and research is being done on this issue to reduce this zone. The game is programmed so that it retrieves the decision of the driver from a pre-loaded database which is described in the later paragraphs of the paper. A hazard function is programmed as a dependent on the time to the intersection of each vehicle present in the traffic present in the dilemma zone. The hazard function calculates the hazard value for the traffic and renders it onto the screen. The game also gives a visual idea to the player about the general picture of the real world traffic and how individual drivers try to adjust their speeds depending upon the headway from the car ahead of them. The game helps the player visually recognize the basic traffic parameters that decide the signal settings like the acceleration of the traffic, deceleration of the traffic, time to stop bar, etc. The game has two databases in the background which help to collect the information and send decisions to the traffic. The GUI of the game is shown in Figure 2-1.

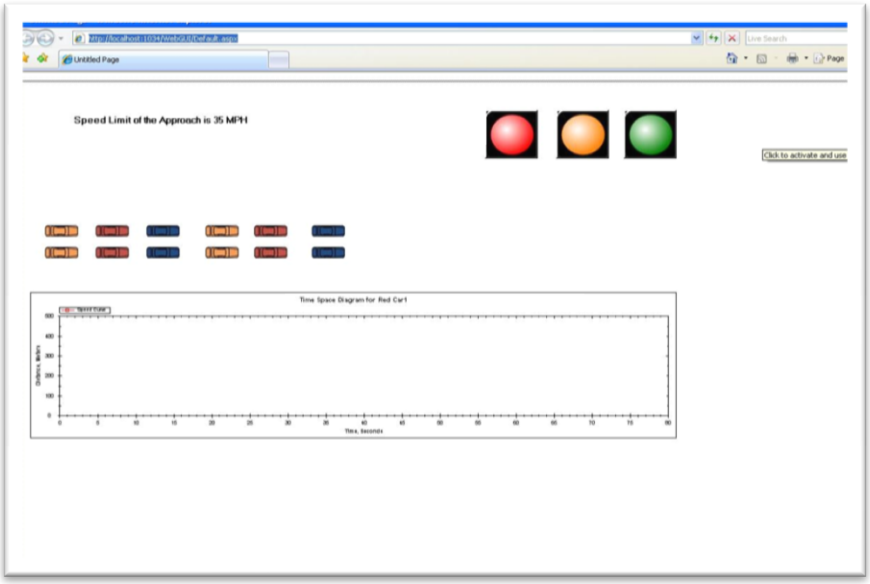

Figure 2-1 Graphical User Interface of the Web

The game is presented to the player through a web page. The player starts the game by giving the green signal to the traffic. This sets the traffic stream moving. Figure 2-2 shows the screen shot of the game when the green signal button is pressed to start the game. Traffic in the game only consists of cars that move at different speeds (random speeds) so as to bring in randomness as in real world. The player has to then decide when to set the yellow signal at the best possible instant in such a way the hazard for the traffic is minimum. When the yellow signal is given the program records the information of the traffic stream to a database. Depending on the position of each of the cars from the intersection the program decides whether the cars are in the safe zone of the approach or the dilemma zone. If a car is found to be in the safe zone, i.e, if the driver can make a deterministic decision of whether to stop or proceed to cross the intersection, the decision is sent back to the respective cars. But if a car is found to be in the dilemma zone then the program control moves to the other database where the driver decision is already stored. The probability of the drivers' stopping at the intersection is calculated from normally distributed curve which depends on variable, the time to the intersection, and stored in the database for a mentioned range of 2 to 6 seconds. This decision variable is retrieved and sent to the respective cars. Depending upon the decision variable the cars in the traffic either speed up to cross the intersection or slow down and come to a halt at the intersection. The program logic in the game is made in such a way so as to avoid the vertical stacking of the cars at the intersection which makes the game look like a real world queuing of the traffic at the intersections. Figure 2-3 shows the diagram of program control.

Figure 2-2 Screen shot of the game when in motion

An interesting part of the game is the hazard function that calculates the hazard value for the traffic present. The game provides instant feedback of the hazard value for the player by rendering it into the screen. This function is dependent on the time to the intersection of each of the cars present. The competitive part is that players must aim to bring down the hazard value for the traffic to as low as possible. This induces a sense of curiosity in the players and tries to capture their attention as to what is happening in the background. The help files provided give all the basic definitions that the hazard function is dependent upon and the variables that are considered when installing a traffic signal controller in the real world. This in turn helps the students to get acquainted with the most general traffic signal controller settings used.

The main aim of the game presented is to motivate students towards education and make the educational environment a recreational activity. To serve the purpose of imparting education through this game, help files are presented to the students in the game. The help files provide the students with definitions of the traffic stream parameters, car-following models and definitions related to the decision variables of the traffic controllers. These files provide students who play the game with an insight into what is going on in the background of the game. For example, the game presents the students with a visual display for the traffic and how each of the cars present in the traffic follow the car ahead of them without colliding into each other. In Transportation Engineering there are models developed for representing the car-following behaviors. These models are presented in the help files so that the students who play the game can get acquainted with them after playing the game (visually watching them move on the screen).

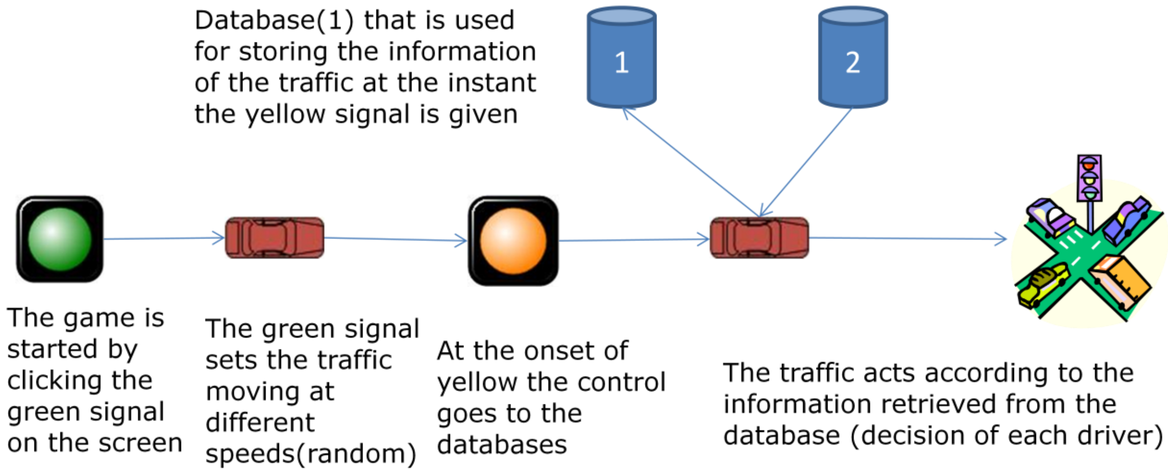

Figure 2-3 Overview of the Program Control

2.4 SOFTWARE USED TO DEVELOP THE GAME AND THE MAIN FUNCTIONALITIES

The game is programmed in C# ASP.Net. Microsoft Access was chosen to create the two databases used in the game. The game architecture used in the game is the three-tier architecture which is a part of N-tier architecture of the .NET framework(*7)*. The user interface is created using ASP. This renders the game onto the screen. The second layer is the User Control developed in Visual C#. A class library project has been programmed in such a way that it acts as a medium between the lower layer, the databases, and the upper layer, the web interface. The three tier architecture is chosen to make the databases more secured on the web. Figure (3) shows the software architecture used in the game.

The class library project that runs behind the scenes is created as a User Control that directs the actions on the screen is written in Visual C#(*8)*, a module in Visual Studio 2005. The User Control has different components programmed. Only the main components of the programmed portion are described in this section since the main aim of the paper is not about programming. As mentioned in section 3, the game is started by indicating the green signal. The green signal is created as a button and programmed to initialize different variables to default values and triggers the movement of the traffic on the screen. When the yellow signal button is clicked it will direct the program to store certain values in the database and search and retrieve the decision parameters from the database (a more detailed explanation of the database is given in the following paragraph). When the red signal button is clicked it will direct the traffic to come to a halt at the intersection. A time-space diagram for each car is rendered on to the screen through a third party graph tool (*9)*. The graph portion is programmed to be updated for every tenth of a second depending upon the movements of the cars.

As stated earlier, the program contains two databases. These databases are designed using Microsoft Access--a Microsoft database management tool. One database is used to collect the information of the traffic stream at the instant the yellow signal is given. The information collected by the database is the speed of each car, distance from the intersection of each car and the time it would take for the car to reach the intersection if it would continue at the same speed at the instant the yellow signal is given. The second database is used to send the decision to the traffic, i.e., whether to slow down, to stop at the intersection, or continue and accelerate to cross the intersection. This database is a look up table of normally distributed values which depend on the decision variable time to the intersection of each car having a range from 2 seconds to 6 seconds from the intersection. The normally distributed values are calculated from:

$$P_{stopping} = \varphi((t-a)/b)$$

where

$P_{stopping}$ = *the stopping probability of each car*

t = *the time taken to reach intersection by each car*

a & b = *constants*

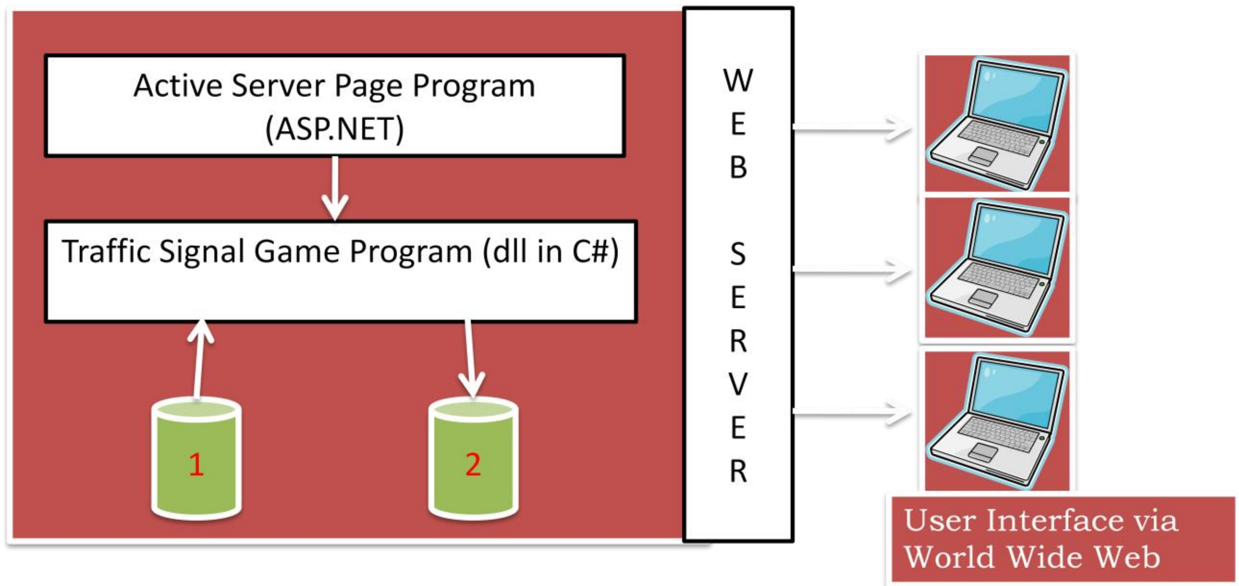

Figure 2-4 The Architecture used in the Game

The probability is retrieved from the database and checked with the random number assigned for each car. If the two numbers are found to be equal then and only then the car is supposed to speed up and cross the intersection given that it is not obstructed by the cars in front of it. Or else it has to slow down and come to a stop at the intersection. The program logic enters this database when the car is in the dilemma zone. An overview of the program structure and its availability is shown in Figure 2-4.

2.5 ASSESSMENT

The game is intended to be integrated into an undergraduate course for Traffic Engineering. To assess the effects of the traffic controller game on student engagement, we propose a three-phase survey process, combined with an end-of-term focus group.

The surveys combine the 16-question Situational Motivational Scale (SIMS) developed by Guay, Vallarand, and Blanchard *(10)*, with 6 questions adapted from the Persistence in Engineering (PIE) survey developed as part of the Academic Pathways Study of the Center for the Advancement of Engineering Education *(11, 12)*. Section 5.2.1 provides a review of SIMS; section 5.2.2 provides a summary of PIE.

2.5.1 Data Collection Plan

To assess student engagement with respect to using the game for learning about traffic engineering, we propose the following timetable for data collection Table 2-1:

Table 2-1 Timetable for Data Collection

Date	Instrument	Time required
Any time before the game is assigned	Survey 1: Engagement in using learning technologies	5-7 minutes
Class immediately following the game activity	Survey 2: Engagement in the traffic controller game technology specifically	5-7 minutes
Last week of class/exam week	Focus group interview	45 minutes

This approach will enable us to track two critical issues:

- **Student engagement in the game.** By asking students to respond both before and immediately after completing the game, we can evaluate the degree to which students saw the game as useful.
- **Student engagement in learning technologies.** While the game will not be the only factor affecting engagement, the results of this survey can provide a broader perspective on students' engagement with learning technologies. The engagement surveys, in conjunction with focus group questions, can help identify the factors affecting engagement in engineering.

2.5.2 Survey Instruments

The following paragraphs describe the instruments we are using for data collection. These surveys can easily be combined with other data collection instruments such as content knowledge tests.

2.5.2.1 Analysis of the Situational Motivation Scale

The Situational Motivation Scale (SIMS) (*10)* is designed to assess four constructs of motivation that, according to self-determination theory, underlie the initiation and regulation of human behavior. Specifically, self-determination theory conceptualizes human behavior in terms of true free choice, "a sense of feeling free in doing what one has chosen to do" (*10)*. The four types of motivation differ in their inherent levels of self-determination according to their position on a continuum that includes intrinsic motivation, identified regulation, external motivation, and amotivation. Self-determination theory further "postulates that the needs for competence, autonomy, and relatedness are central concepts" to understanding motivation (*10)*. Validation tests of the SIMS have indicated that intrinsic motivation and identified regulation lead to the most positive outcomes, such as persistence; that external motivation can lead to the decrease of intrinsic motivation; and that amotivation leads to the most negative outcomes, such as depression and feelings of incompetence. However, the SIMS is purposely designed not to assess these needs or outcomes, but rather to separately measure self-reports of motivation (*10)*.

Table 2-2 Continuum of Motivation Constructs in Self-Determination Theory*

intrinsic motivation:	performing an activity for itself, in order to experience pleasure and satisfaction inherent in the activity	Most self-determined (positive)
identified regulation:	behavior is valued and perceived as being chosen by oneself, yet is still extrinsic because the activity is not performed for itself but as a means to an end	
external motivation:	behavior is regulated by rewards or in order to avoid negative consequences	
amotivation:	individuals experience a lack of contingency between their behaviors and outcomes; their behaviors are neither intrinsically or extrinsically motivated. This behavior is the least self-determined because there is no sense of purpose and no expectations of reward or possibility of changing the course of events.	Least self-determined (negative)

*From Guay, Vallerand, and Blanchard (2000)

The SIMS is a self-report measure of situational motivation, i.e., "toward a single current situation" (*10)*. Thus, in experimental settings it has been used during and after a specific task. The authors recommend using the SIMS "either by itself or in conjunction with the time spent on the activity" (*10)*.

In terms of engagement or motivation in a general sense, the authors state that further work is needed to understand how specific effects on motivation influence behavior over time. However, Vallerand (*13)* in his Hierarchical model, proposes "that cumulative motivational changes at the situational level produce over time an effect on more general motivational aspects" (*13)*. For example, repeated instances of loss of intrinsic motivation may over time affect motivation toward a certain situation and even have a global impact on a person's everyday life (*13)*.

With our constraints in this project, we will be able to assess engagement in the game activity, using the constructs of motivation as a measure of how each individual interacts with this specific task. However, without a longitudinal study, we can only extrapolate from these situational results using prior research and theory. The self-determination theory operationalized by the SIMS has been researched and tested since 1971 (*14)*, with steady progress toward understanding how people initiate and regulate their own behavior.

2.5.2.2 Summary of the Persistence in Engineering Survey

The Persistence in Engineering Survey (PIE) was developed as part of the Academic Pathways Study of the Center for the Advancement of Engineering Education. This multi-institution, multi-year study focuses on gathering longitudinal data to investigate student learning and development in engineering programs.

The PIE survey, developed and tested in 2004, examines factors that influence students' persistence in engineering programs and, conversely, seeks to understand factors that lead students to leave (*11)*. The survey developers drew from five previously tested national surveys:

- Pittsburgh Freshman Engineering Attitudes Survey (PFEAS)
- Cooperative Institutional Research Program Freshman Survey (CIRP)
- Your First College Year 2003 survey
- National Survey of Student Engagement
- College Student Experiences Questionnaire

The survey has been used and refined in subsequent studies (*12*, *15*, *16)*. In drawing on this survey, we focus specifically on 1) motivation as related to students' perception of engineering as fostering social good, 2) knowledge of the engineering profession, and 3) confidence in open-ended problem solving. Although research using the PIE suggests limited correlation between these factors and retention (*12)*, these elements of the PIE survey are those most likely to be influenced by the game exercise.

2.6 INITIAL ASSESSMENT

To pilot the assessment of engagement with the game, we asked graduate students to play the game. After completing the game a questionnaire was given to them to find out their preferences. The students were asked to anonymously complete a questionnaire with 10 questions. The graduate students already had a basic knowledge about the traffic engineering, so this survey is mainly aimed at finding out their opinions and preferences about the game. In this questionnaire we used a Likert scale by posing a statement and asking the students whether the statement 'corresponds not all (1)', 'corresponds a very little (2), 'corresponds a little (3) ', 'corresponds moderately (4)' 'corresponds enough (5)' 'corresponds a lot (6)' or 'corresponds exactly (7)'.

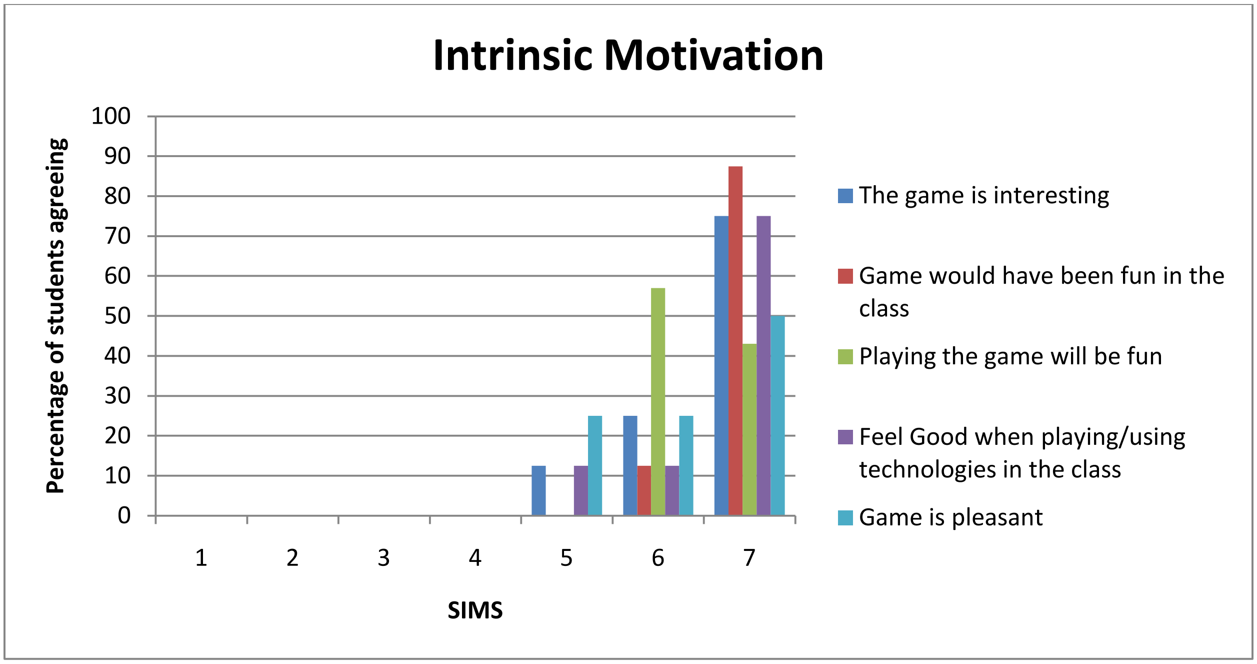

Figure 2-5 Graph showing the Intrinsic Motivation

As mentioned earlier, *intrinsic motivation* in self-determination theory describes situations in which a person is interested in performing an activity for itself, in order to experience pleasure and satisfaction inherent in the activity. The survey conducted for the pilot study which aimed at intrinsic motivation yielded positive results and is shown in the form of a bar graph in Figure 2-5. All the questions put forth to the students have been agreed upon (partially or completely) and all the answers were at the level 'corresponds enough (5)' 'corresponds a lot (6)' or 'corresponds exactly (7)', the majority being in the *corresponds exactly* category on the Situational Motivation Scale. This suggests that the students find the game interesting and would like to have a game that could supplement the course material and create a fun learning environment.

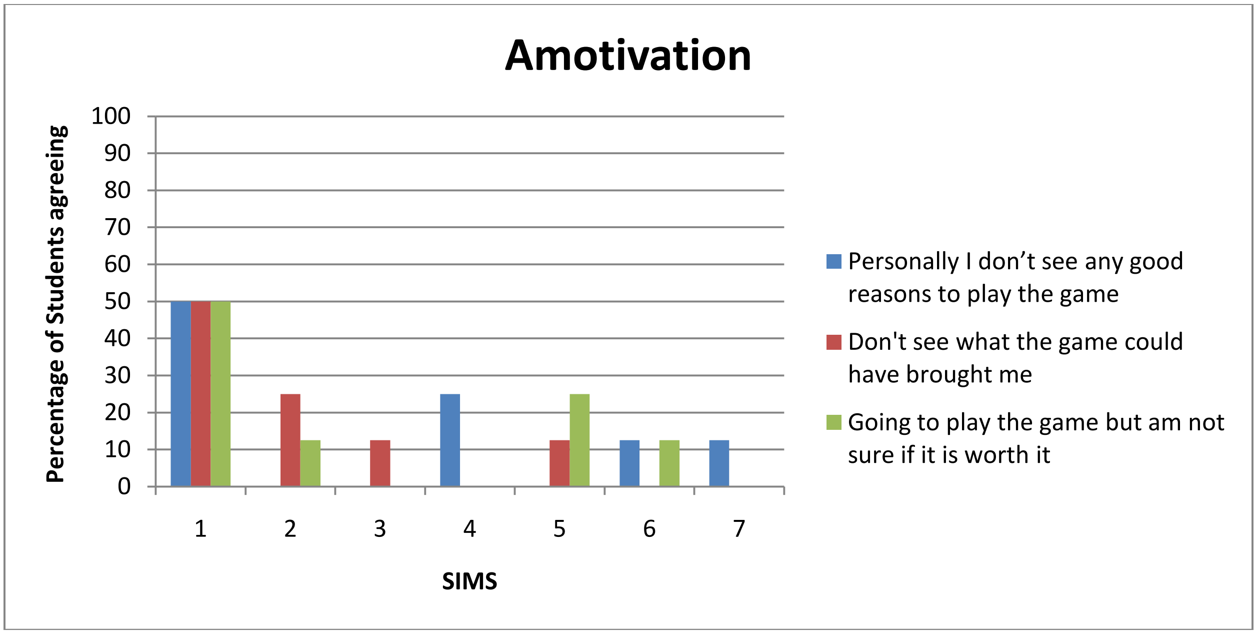

Figure 2-6 Graph showing the Amotivation factor

Amotivation describes situations in which individuals experience a lack of contingency between their behaviors and outcomes. This factor characterizes their behaviors as neither intrinsically nor extrinsically motivated. This behavior is the least self-determined because there is no sense of purpose and no expectations of reward or possibility of changing the course of events. The results for the pilot study aimed to find the amotivation factor are represented in Figure 2-6. The graph shows that the majority of the students don’t agree with the statements posed to them. This suggests that the sample group is well aware of their motivations and about perception and preferences about the game.

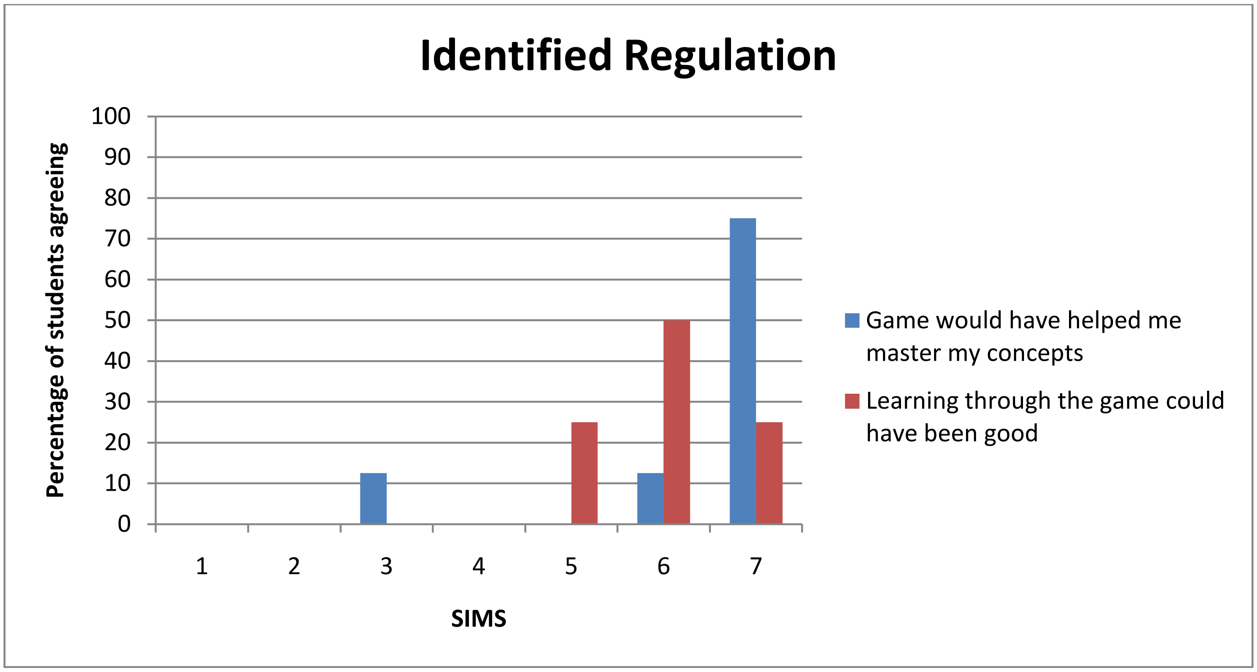

Figure 2-7 Graph showing Identified Regulation factor

Identified Regulation describes behavior that is valued and perceived as being chosen by oneself, yet is still extrinsic because the activity is not performed for itself but as a means to an end. This factor is tested in the pilot study through two questions and the results are showed in Figure 2-7. The response was clearly positive as a majority of the students thought the game would have been a good learning tool and most of the answers were at the level 'corresponds enough (5)' 'corresponds a lot (6)' or 'corresponds exactly (7)' on the Situational Motivation Scale. But a few of the students didn't agree that the games should be a teaching tool by itself. The researchers agree with this view since the game prepared will be used as a supplement for teaching and is not designed to be a stand-alone instructional tool.

The full 16-question assessment instrument will be administered to measure engagement of students who are just learning the concepts.

We also asked the students to suggest technical improvements. They gave a high priority to the improvement of the interface. This could be due to the fact that students want to see a more realistic environment that can be closely related to the real time traffic. Although the students were favoring the improvement of the interface, they were also clearly indicating for a better chance to understand the traffic engineering principles through the game rather than reading a textual material.

2.7 CONCLUSIONS AND FUTURE WORK

A web based game has been developed to help students to gain understanding of the basic concepts of a course. The game format aims to supplement the class learning and try to capture the students' attention. The game is carefully designed to emulate the realistic traffic behavior at the intersections so that the students can get a visual idea rather than just listening in the class and reading the book. The help files in the game provide students with the knowledge both required to play the game and also about the course content.

The graduate student responses on the initial assessment of the game have been positive and welcomed as a new approach for supplementing ordinary lectures. The game is planned to be tested by more students who will take the course for their perception of the game. This can indicate whether the game has been a good teaching tool and met all the learning objectives that it is designed for. The objective of motivation is also to be tested by the students who take the course. But the initial assessments clearly indicated that a game in a course might be a good motivational factor for the students to enjoy the course activities rather than an orthodox textbook teaching style.

The future work of the project is to implement the game into two Fall and Spring 2008 courses and to collect more comprehensive data on different aspects of the game, including motivation, usability, and impact on learning.

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3. DEVELOPMENT OF A WEB-BASED GAME FOR TRAFFIC SIGNAL OPERATION AND CONTROL

Yatish Kasaraneni
Graduate Research Assistant, Dept. of Civil and Environmental Engineering
Virginia Tech,
Blacksburg, VA 24061
Phone: 540-231-3363
FAX: 540-231-7532
y2kneni@vt.edu

Montasir M. Abbas, Ph.D., P.E.
Assistant Professor, Via Dept. of Civil and Environmental Engineering
Virginia Tech,
Blacksburg, VA 24061
Phone: 540-231-9002
FAX: 540-231-7532
abbas@vt.edu

ABSTRACT

Web games provide a platform for creative instructional activities that can capture the students' attention towards the course. These games can be used to emulate the realistic situations which can be used as effective lab experiments that could give the students a hands-on experience using real world scenarios. This paper presents an innovative web-based game developed for the demonstration of the driver-behavior at signalized intersections that can be used as a supplementary tool for the Transportation Engineering course. The game was designed to be widely accessible through the internet and have an attractive user interface. It is programmed on the .NET Framework using the Microsoft Access as its databases.
Index Terms – Actuated Control, .NET Framework, Traffic Engineering, Web Game

3.1 INTRODUCTION

The field of engineering requires a high level of practical knowledge to be able to sustain and yield good results. In particular, the Transportation Engineering field requires thorough practical knowledge to build a sound understanding of the principles that are taught in the class. In general, in engineering majors, practical knowledge is imparted through carefully designed experiments conducted in the laboratories.

However, it is not always easy to have practical examples that are of complex nature to be undertaken in the laboratories. Since the real time environment is totally different from the lab environment, most cases are limited by constraints. The same applies to transportation engineering. Although analysis of traffic stream and traffic signals can be done through simulation, it may be difficult for beginners to work through simulations and understand the concepts.

To bridge this gap, one viable solution is the development of a web game. The Computer-based Educational Games can be modeled to deliver specific learning objectives and paves way for adaptive learning and role-play and simulations[**1**]. A more recent move to develop computer aided learning on the World Wide Web or the Internet which can accessed widely had been sought after to reach a wide audience, the capability of it to provide access to large amount of information, the ability of the web to offer a complete course or act as a supplementary teaching tool, and finally the enhanced educational environment the internet can provide for interactive self paced learning [**2, 3**].

And also it is possible to create environments that can replicate real world scenarios, which can help students to easily gain experience. Web games also provide a platform for creative instructional activities that can capture the students' attention towards the course topics. Introduction of inquiry-based learning approach in an engineering course titled Simulations and Statistical Analysis was facilitated with the help of a WebQuest, a pedagogical tool for web-enabled inquiry-based learning and was found to motivate student and achieve beneficial auxiliary outcomes[**4**].

Games can be recreational, engaging, and educational. The introduction of a game into a course can motivate students toward understanding the course material [**5**]. Well-crafted games can transfer knowledge in an efficient way and help students understand the concepts better , as shown in tests with increased scores compared to students who follow traditional text book learning [**6**].

Some courses require a lot of repetition of the same concept for different problems and this practicing is often assumed to lead to proficiency in the concept. But more often than not students tend to not like this approach. A more amicable way is to encapsulate practice in a game context. Games appear to be effective teaching tools for concepts which requires repetition for proficiency like the Statics Calculation Procedures [**7**].

Even though games can be quite effective, motivating and simpler to administrate, it's not always good to replace the traditional textbooks with them. Games should be used as supplements that would encourage the students understand the course and enjoy the course[**8**]. Following these guidelines, this paper describes a web game that could be used in a transportation course to help the students understand basic traffic engineering concept.

3.2 BACKGROUND

When traffic signals change from green to yellow, drivers have to decide whether they can safely stop (at an acceptable deceleration rate) or continue and clear the stop line before the start of red. The decision mainly depends on parameters such as the distance from the stop bar, speed at which they are travelling, acceleration rates and deceleration rates, etc. Different drivers have a different perception of the right decision whether to stop or to go. For example, conservative drivers tend to stop if there is a slight doubt in their minds; if the driver is aggressive he or she will try to cross the intersection even at a slight possibility, etc. So it is hard to predict the driver decision at the onset of yellow.

The decision to be made is relatively easy when the driver is close to the intersection or far away from the intersection. But in the interim distances the driver falls into ambiguity whether to stop or go ahead. This zone of ambiguity is called the "Dilemma Zone." The probability of accidents to occur is high in this zone. Generally two types of accidents occur: 1) rear end collision, when the driver in front decides to stop and the driver behind decides to go ahead, and 2) right angle collision, when the driver decides to cross the intersection and unknowingly runs the red light and collides with the conflicting traffic.

Students are taught about the dilemma zone in the class through conventional teaching methods. Textbook only gives a general idea of dilemma zone as a definition and at best a static pictorial representation. These methods may sometimes be confusing to the students. The game on the other hand attempts to provide a visual representation of the dilemma zone and the traffic in the dilemma zone, which is helpful for the students to completely understand the situational meaning of the concept.

The paper is organized as follows. Section 3.3 gives the description of the game with the focus on the different functionalities of each of the components of the game including what they are aiming to achieve as an outcome. Section 3.4 gives details about the software design of the game. Section 3.5 discusses the limitations of the game and their solutions. Finally, Section 3.6 concludes the paper with the conclusions and scope for further research.

3.3 DESCRIPTION OF THE GAME

The objective of game is to help students understand what might be the drivers' decision at the onset of yellow based on the existing traffic conditions. The player who is playing the game has to determine the safe time to give the yellow signal so that the least number of cars in the dilemma zone exist and the hazard for the traffic is minimized. The most commonly used dilemma zone boundaries are 2 to 6 seconds of time to reach the intersection, and these values are used in the paper as the lower and upper boundaries, respectively. The game is programmed so that it retrieves the decision of the driver from a pre-loaded database which is described in the later paragraphs of the paper.

A hazard function is programmed as a dependent on the time to the intersection of each vehicle present in the dilemma zone. The hazard function calculates the hazard value for the traffic and renders it onto the screen. The game also provides feedback in the form of Hazard Value, Least Hazard value, and Time to Least Hazard Value.

As an instant visual feedback the cars that are caught in the dilemma zone are shown in red and the rest of the traffic is shown in green. The game also gives a visual idea to the player about the general picture of the real world traffic and how individual drivers try to adjust their speeds depending upon the headway from the car ahead of them. The game helps the player visually recognize the basic traffic parameters that decide the signal settings like the acceleration of the traffic, deceleration of the traffic, time to stop bar, etc. The game has two databases in the background which help to collect the information and send decisions to the traffic. The GUI of the game is shown in Figure 3-1.

Figure 3-1 Graphical User Interface of the Web Game

The game is presented to the player through a web page. The player is given a choice of scenarios to select from. After choosing the scenario the player starts the game by giving the green signal to the traffic. This sets the traffic stream moving. There is a countdown timer (**Counter**) starting from 40 and ends at 0. The player has to choose the time before the countdown ends to terminate the green and give the traffic the yellow. Figure 3-1 shows the screen shot of the game when the traffic is given green signal. The traffic scenarios presented to the students in the game are taken from a robust microscopic simulation, VISSIM [**10**], and modeled in the game to let the player understand the real world traffic patterns.

The player has to then decide when to set the yellow signal at the best possible instant in such a way the hazard for the traffic is minimum. When the yellow signal is given the program records the information of the traffic stream to a database. Depending on the position of each of the cars from the intersection the program decides whether the cars are in the safe zone of the approach or the dilemma zone. If a car is found to be in the safe zone, i.e, if the driver can make a deterministic decision of whether to stop or proceed to cross the intersection, the decision is sent back to the respective cars.

But if a car is found to be in the dilemma zone then the program control moves to the other database where the driver decision is already stored. The probability of the drivers' stopping at the intersection is calculated from normally distributed curve which depends on variable, the time to the intersection, and stored in the database for a mentioned range of 2 to 6 seconds. This decision variable is retrieved and sent to the respective cars. Depending upon the decision variable the cars in the traffic either speed up to cross the intersection or slow down and come to a halt at the intersection.

The program logic in the game is made in such a way so as to avoid the vertical stacking of the cars at the intersection which makes the game look like a real world queuing of the traffic at the intersections. Figure 3-2 shows the diagram of program control.

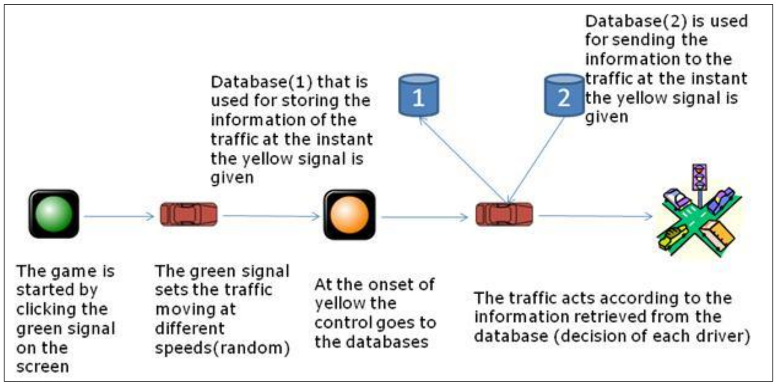

Figure 3-2 Overview of the Program Control

An interesting part of the game is the hazard function that calculates the hazard value for the traffic present in the dilemma zone. The game provides instant feedback of the hazard value for the player by rendering it onto the screen as **Hazard Value**. This function is dependent on the time to the intersection of each of the cars present in the dilemma zone. The competitive part is that players must aim to bring down the hazard value for the traffic to as low as possible and this least value for the particular scenario is is presented to the player on the web page as **Least Hazard Value** and the first possible instant of time at which this hazard value can be achieved is shown through **Time to Least Hazard Value** with respect to the **Counter**.

Figure 3-3 shows the feedback provided by the game to the player when the player terminates the green. This induces a sense of curiosity in the players and tries to capture their attention as to what is happening in the background. The help files provided give all the basic definitions that the hazard function is dependent upon and the variables that are considered when installing a traffic signal controller in the real world. This in turn helps the students to get acquainted with the most general traffic signal controller settings used. The help files provide the students with definitions of the traffic stream parameters, car-following models and definitions related to the decision variables of the traffic controllers.

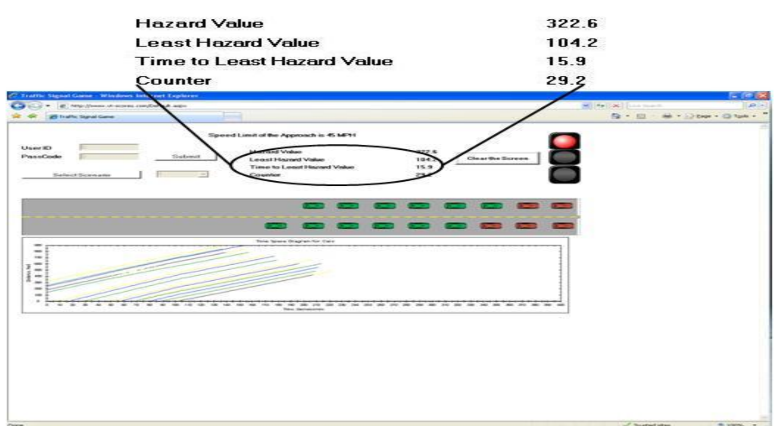

Figure 3-3 Response Upon Terminating the Green

3.4 SOFTWARE USED TO DEVELOP THE GAME AND THE MAIN FUNCTIONALITIES

The game is programmed in C# ASP.Net. Microsoft Access was chosen to create the two databases used in the game. The game architecture used in the game is the three-tier architecture which is a part of N-tier architecture of the .NET framework[**11**]. The user interface is created using ASP. This renders the game onto the screen. The second layer is the User Control developed in Visual C#. A class library project has been programmed in such a way that it acts as a medium between the lower layer, the databases, and the upper layer, the web interface. The three tier architecture is chosen to make the databases more secured on the web. The class library project that runs behind the scenes is created as a User Control that directs the actions on the screen is written in Visual C#[**12**], a module in Visual Studio 2005. The User Control has different components programmed. The flow chart for the main program developed in C# is shown in Figure 3-4. The program takes the input from the user to validate the authenticity and proceeds to the next sub-routines which are describes in the following paragraphs.

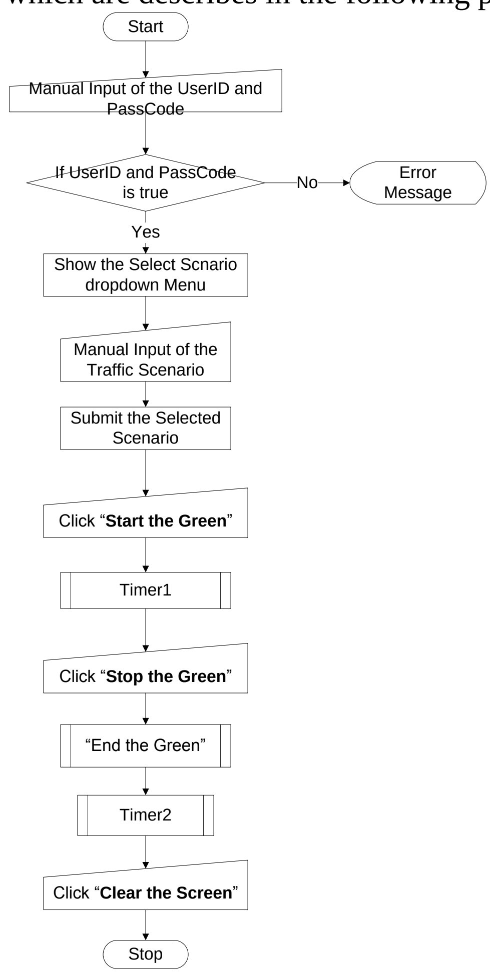

Figure 3-4 Flowchart showing the main program of the game

3.4.1 VALIDATION USED IN THE GAME

The screenshot on Figure 3-5 shows the graphical user interface that is shown to the player initially. The players/students in the case study have been provided with user identification and PassCode to distinguish them if a need arises for further analysis of the data. A user validation has been provided to the game so that the data collected through the databases can be distinguished between the students and the other users. The program has an array of values stored to check the authenticity of the players. The value provided in the user identification is checked with the PassCode and if both the terms matched only then the program proceeds. Validation is completed by clicking the “**Submit**” button. The player is given a choice of traffic scenarios to choose from a dropdown menu provided in the game. After the choice is made, the player clicks the “**Select Scenario**” button on the interface which loads the selected scenario to the game. Along with the loading of the scenario “**Start the Green**” button is activated as shown in Figure 3-6.

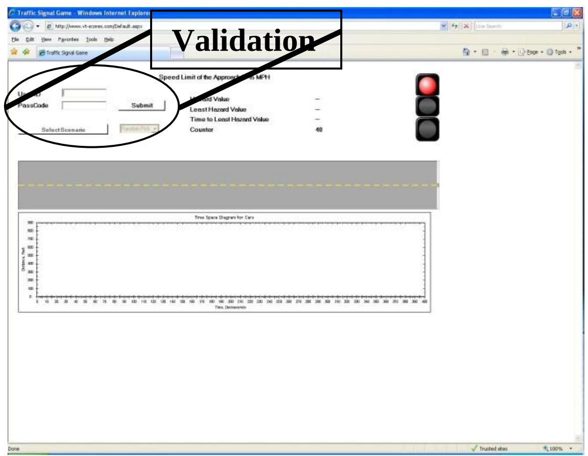

Figure 3-5 Screen shot showing the validation provided on the User Interface

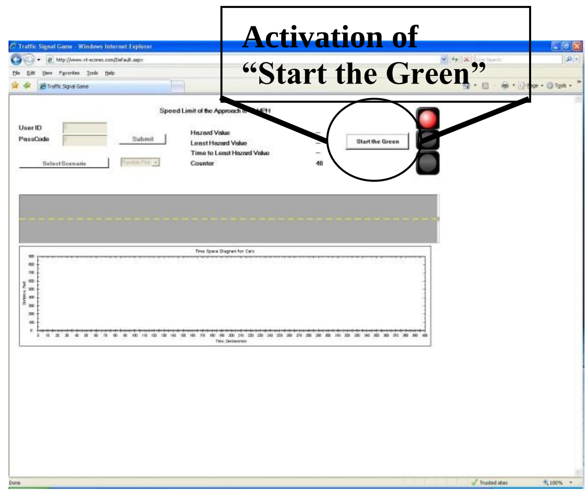

Figure 3-6 Screen shot showing the activated "Start the Green" Button

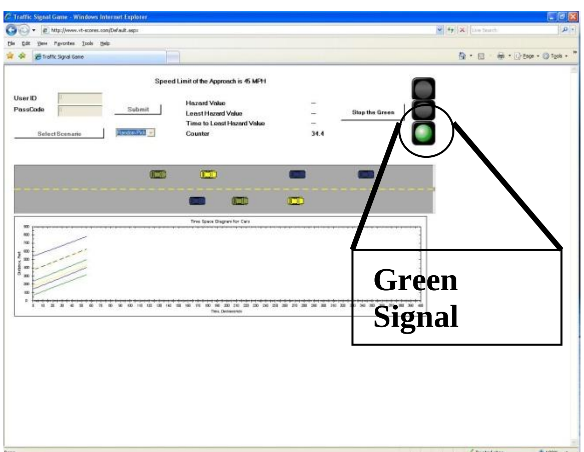

Figure 3-7 Screenshot of the User interface when the traffic is given green signal

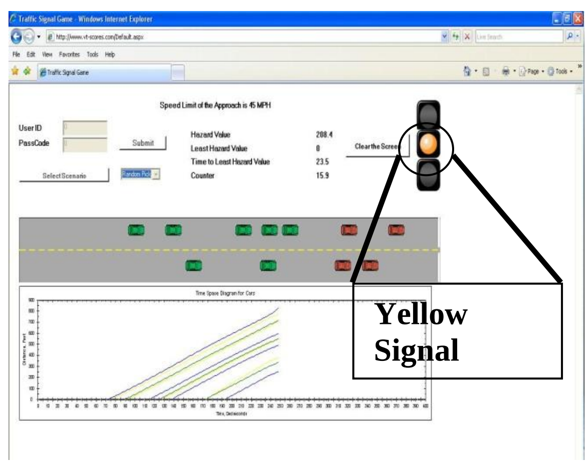

Figure 3-8 Screen shot of the User Interface when the traffic is given yellow signal

3.4.2 INITIALIZATION OF THE TRAFIC IN THE GAME

As mentioned in section 3, the game is started by indicating the green signal. The green signal is indicted to the traffic by pressing the “**Start the Green**” button. Figure 3-7 gives an illustration of how the green is shown to the traffic in the game. The "**Start the Green**" button is programmed to start the traffic scenario selected by the player. Upon clicking the "**Start the Green**" button a Timer function is invoked. The Timer function is an inbuilt function in the Visual Studio 2005 Environment that can be used for performing an action with a specified interval of time. For the game purpose a sub-routine named Timer1 is coded. Figure 3-9 shows the flow chart of the Timer1. The code checks for the total number of cars and if the condition is satisfied proceeds showing the traffic on the screen. This sub-routine also calls the draw and the clear sub-routines which are explained down further in this section. Start the Green button also starts the countdown timer which counts from 40 to 0 and activates "**Stop the Green**" button. The countdown timer represents the green extension the player is willing to provide the traffic. The player has to decide a time where he has to terminate the green in such a manner that the traffic conditions are least hazardous before the timer reaches 0. The player ends the green by clicking the "**Stop the Green**" button.

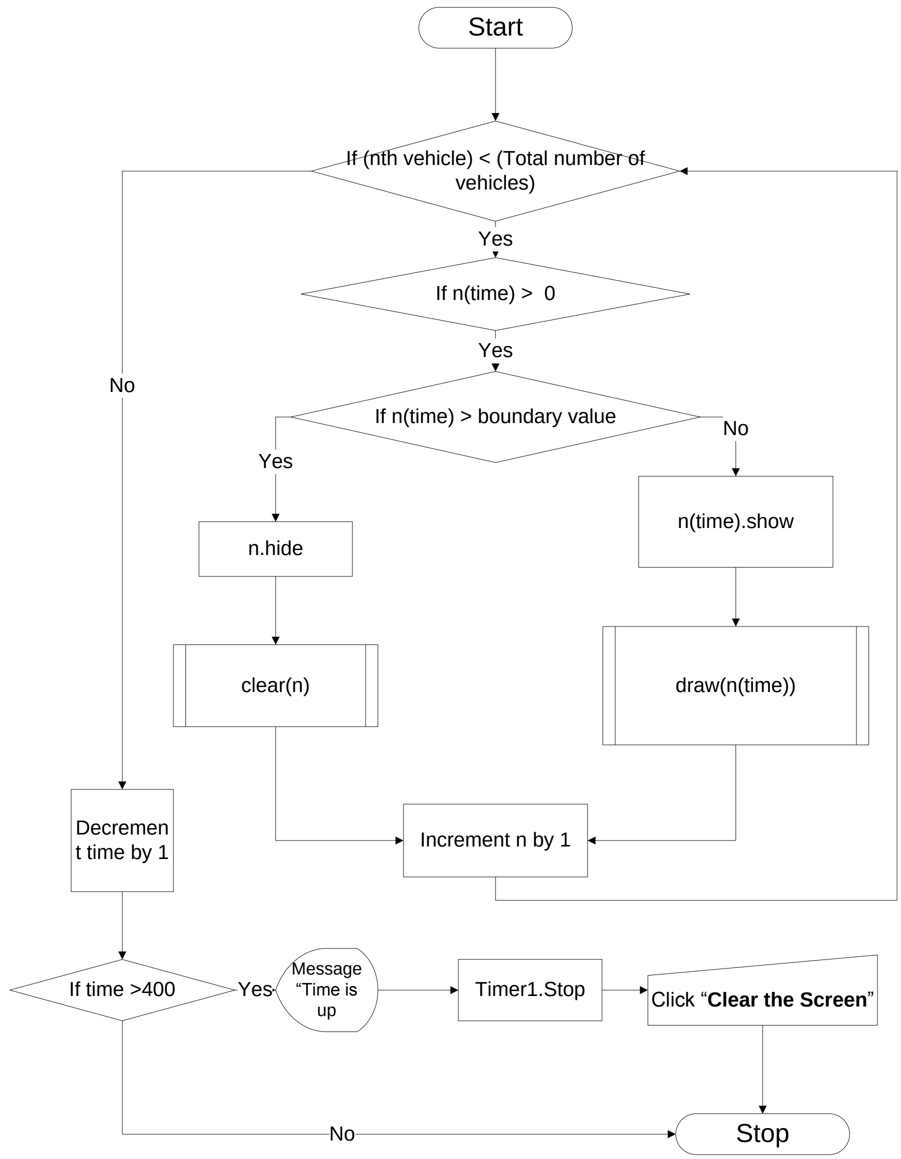

Figure 3-9 Flowchart showing the Timer1 sub-routine which gets invoked when the "Start the Green" button is clicked

3.4.3 TERMINATION OF GREEN IN THE GAME

Upon clicking the "**Stop the Green**" button yellow signal is given to the traffic as shown in Figure 3-8. Instant feedback as described in section 3 is provided to the player. Figure 3-10 shows the flowchart the of the Timer2 sub-routine that gets invoked upon clicking the "**Stop the Green**" button. The code in the Timer2 sub-routine checks for the number of cars present in the traffic and then follows with the checking of traffic beyond the dilemma zone (6 seconds from the intersection). If the traffic is out of the boundary of the dilemma zone then the cars in the traffic are made to come to a stop at the intersection. But if they are found to be inside the boundary of the dilemma zone then the code checks if the traffic is 2 seconds to the intersection. If found then the cars traffic accelerates and crosses the intersection. If the cars in the traffic are found to be between the dilemma zone boundary and 2 seconds from the intersection the program is now directs to a database where the speed of the cars caught in the dilemma zone, time to intersection of each of the car caught in the dilemma zone and the traffic scenario selected by the player are stored in a database. Upon storing the values the program control moves to search and retrieve the decision parameters from another database. A more detailed description of the databases is provided in the next paragraph.

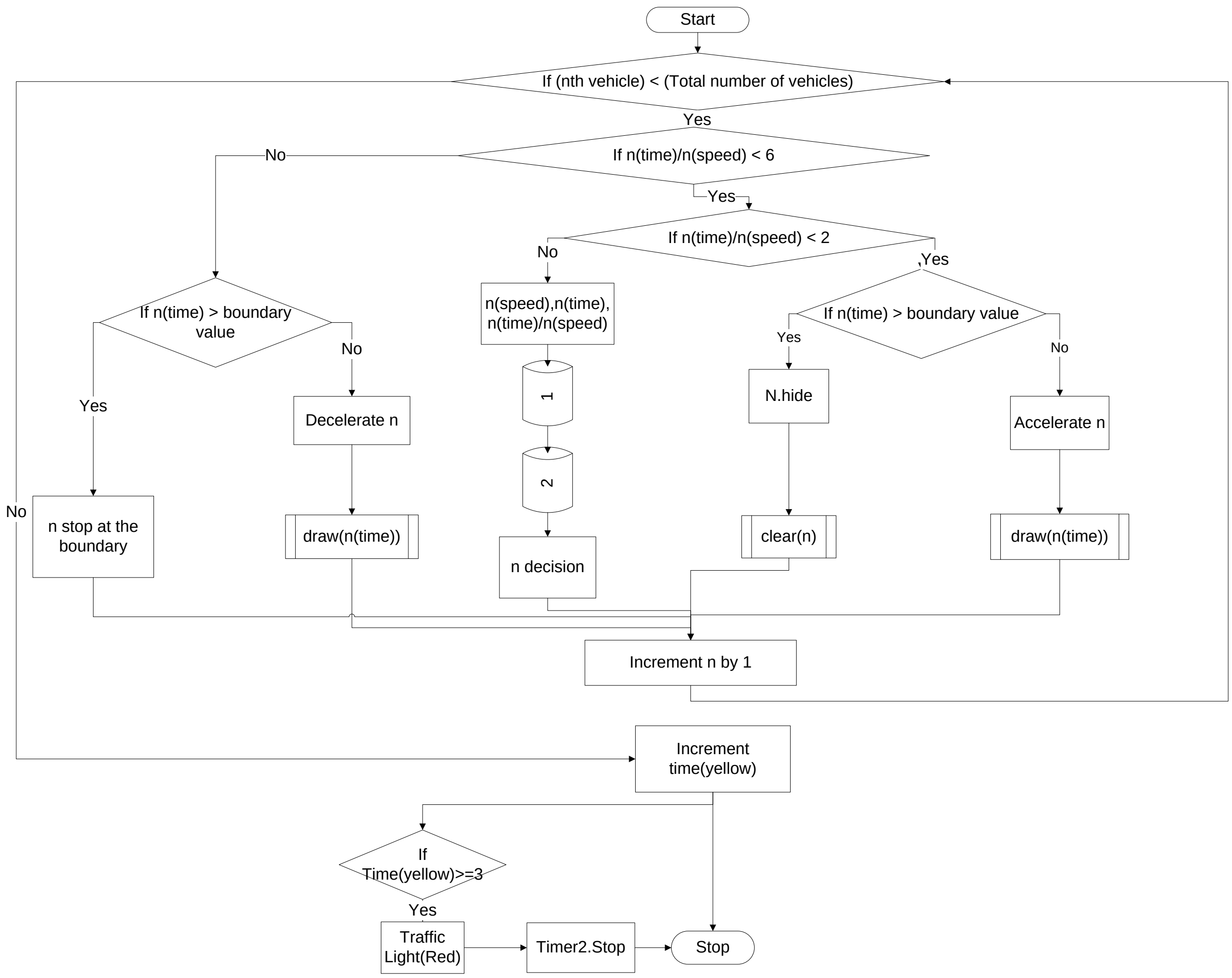

Figure 3-10 Flowchart showing the Timer2 sub-routine which gets invoked when the "Stop the Green" button is clicked

3.4.4 GRAPH TOOLS USED IN THE GAME

The decision variables are sent back to the traffic and the traffic act accordingly, either they speed up and cross the intersection or slow down and stop at the intersection. The game is programmed in such a manner that the traffic do not vertically stack up at the intersection. As shown in Figure 3-13 the traffic come to a halt mimicking the real world situation that is by stopping one behind the other. Another feature in the game is the time-space diagram. A time-space diagram for each car is rendered on to the screen through a third party graph tool [**13**]. The graph portion is programmed to be updated for every tenth of a second depending upon the movements of the cars. The curves on the graph are drawn by calling the draw function coded in the program. The flowchart for the draw function is show in Figure 3-11. The draw function takes in the car number and renders distance and time values of the corresponding car onto the screen. When the car crosses the intersection the curve of the car in the time-space diagram is coded to erase through a "clear" sub-routine. The clear sub-routine erases the corresponding car curve from the graph by hiding it on the graph. The flowchart for the draw function is shown in Figure 3-12. As shown in the Figure 3-14 the graph updates as the traffic moves in real time. The color of the line in the graph represents the color of the car on the screen. If the car crosses the intersection and disappears, the line on the graph too erases itself and disappears.

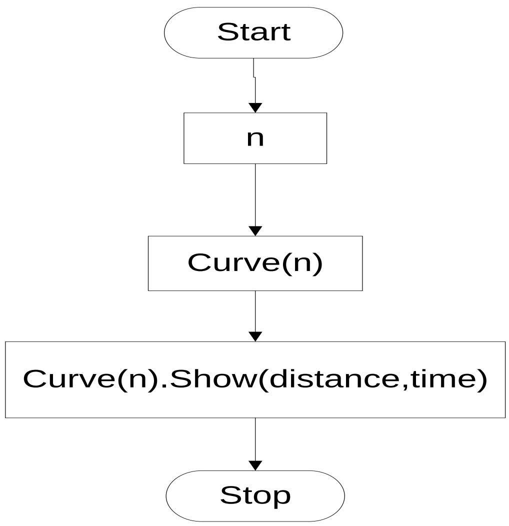

Figure 3-11 Flowchart showing the draw sub-routine of the graph

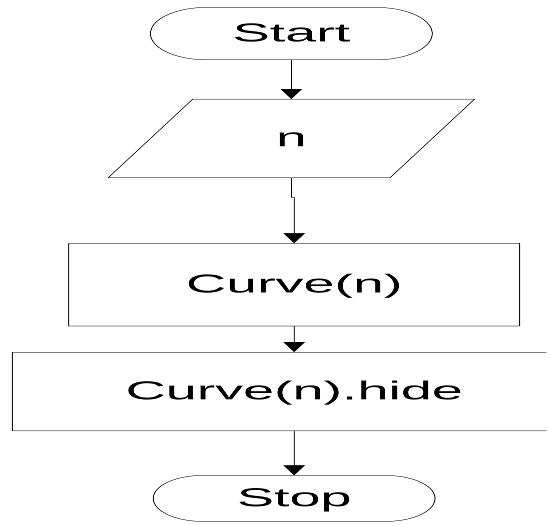

Figure 3-12 Flowchart showing the clear sub-routine of the graph

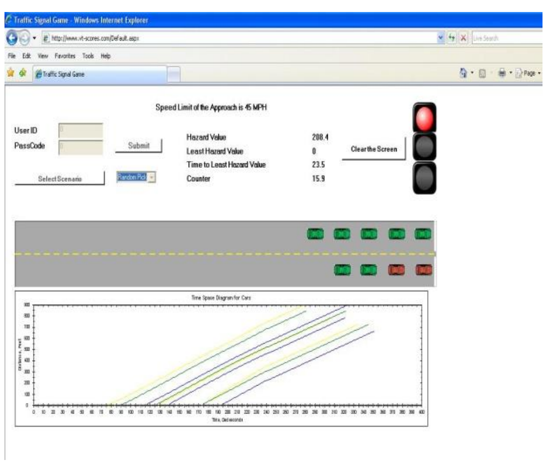

Figure 3-13 Screen shot showing the traffic coming to a halt at the intersection

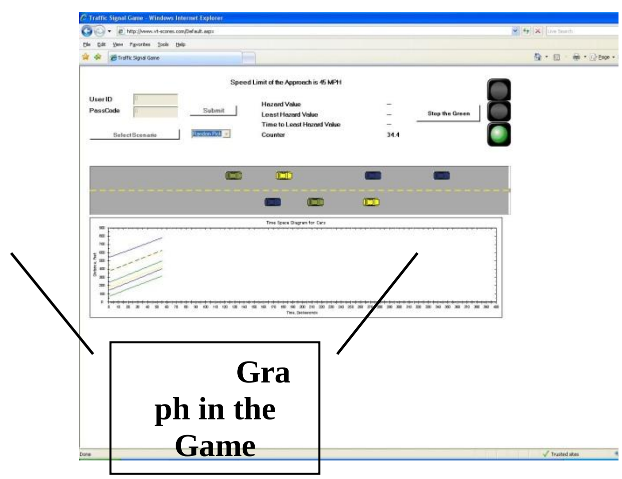

Figure 3-14 Screen shot showing the graph used in the game

3.4.5 DATABASES USED IN THE GAME

As stated earlier, the program contains two databases. These databases are designed using Microsoft Access--a Microsoft database management tool. One database is used to collect the information of the traffic stream at the instant the yellow signal is given. The information collected by the database is the speed of each car, distance from the intersection of each car and the time it would take for the car to reach the intersection if it would continue at the same speed at the instant the yellow signal is given. The second database is used to send the decision to the traffic, i.e., whether to slow down, to stop at the intersection, or continue and accelerate to cross the intersection. This database is a look up table of normally distributed values which depend on the decision variable time to the intersection of each car having a range from 2 seconds to 6 seconds from the intersection. The database connectivity is programmed using the E**x**tensible **M**ark-up **L**anguage (XML). It is programmed to establish a communication between the dll on the client machine and the databases on the server machine. An overview of the program structure and its architecture is shown in Figure 3-15.

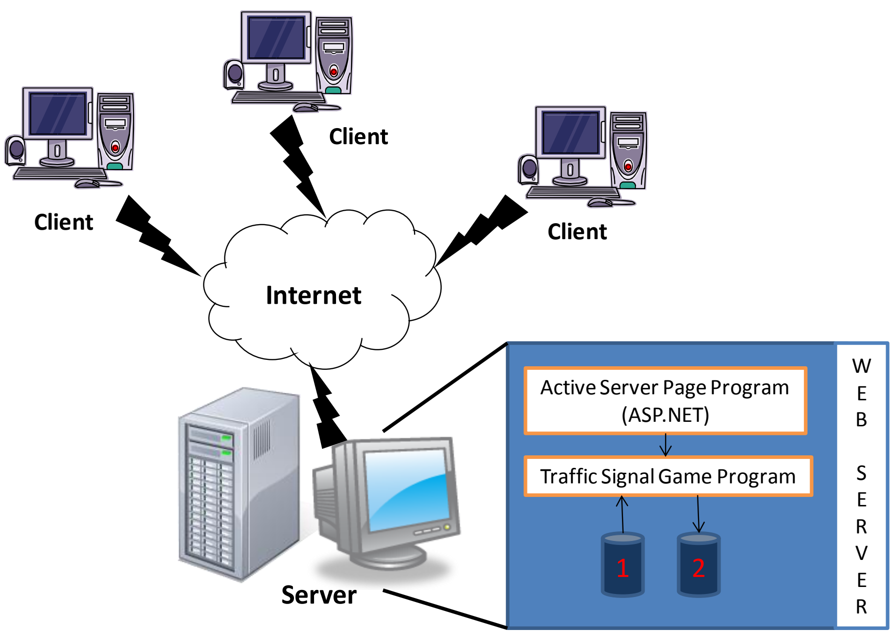

Figure 3-15 Architecture of the Game

3.5 LIMITATIONS:

The use of Microsoft .NET Framework for the development of the game had come with a certain limitation on its usage. The game requires certain pre-requisites to run on individual PC's. The basic requirements are the browser and the .NET Framework on the client machine. The game requires an Internet Explorer to run with all the designed features and animations. Secondly the game requires .Net Framework 2.0 installed on the client machine to open the game onto the browser

Once the basic requirements are met, special security settings are to be set up on the client machine for the game to open on a browser. This is because internet being one of the easiest ways to corrupt important files on a computer, malicious software try install automatically if proper precautions are not being taken. .NET Framework, a robust and secured framework, tends to be protective regarding this aspect. The game being developed as a dll has to therefore pass the trust of the client machine in order to be displayed on the browser which requires special security settings for the game.

To make this task easier for the students a very clear documentation about the steps to followed to set up the security environment for the game is provided to the students outlining a step by step procedure along with the actual screen shots.

3.6 CONCLUSION:

The web-based game developed has met its objective of attracting students towards learning the concept. The development of the game utilizes Visual C# programming using the .NET Framework to present the concepts of the Dilemma Zone at signalized intersections a creative, informative, and interactive way. The game was able to serve as a supplementary tool for teaching the driver behavior at the signalized intersections in the Transportation Engineering Course CEE 4609. The graphical user interface of the game is developed in such a way that it is easy to follow and quick to play the game. The game have help files to make students understand what is the theory going in the game, which in turn make the students realize the conceptual meanings of their actions and response the game is providing. The instant feedback the game provides helped students understand the results of their actions and evolve from their mistakes to achieve better results, in the process grabbing the attention towards the topic. Lastly the limitations of the web-based game have been discussed along with how these have been overcome.

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4. GAME-AIDED PEDAGOGY TO IMPROVE STUDENTS' LEARNING OUTCOMES AND ENGAGEMENT IN TRAFFIC ENGINEERING

Yatish Kasaraneni
Graduate Research Assistant, Dept. of Civil and Environmental Engineering
Virginia Tech,
Blacksburg, VA 24061
Phone: 540-231-3363
FAX: 540-231-7532
y2kneni@vt.edu

Montasir M. Abbas, Ph.D., P.E.
Assistant Professor, Via Dept. of Civil and Environmental Engineering
Virginia Tech,
Blacksburg, VA 24061
Phone: 540-231-9002
FAX: 540-231-7532
abbas@vt.edu

Lisa D. McNair, Ph.D.
Assistant Professor, Department of Engineering Education
Virginia Tech,
Blacksburg, VA 24061
Phone: 540-231-1144
FAX: 540-231-6903
lmcnair@vt.edu

ABSTRACT

Web games provide a platform for creative instructional activities that can capture the students' attention towards the course. These games can be used to emulate the realistic situations which can be used as effective lab experiments that could give the students a hands-on experience using real world scenarios. This thesis presents an innovative web-based game developed for the demonstration of the driver-behavior at signalized intersections that can be used as a supplementary tool for the Transportation Engineering course. The game format is carefully designed to supplement the understanding of the class learning material through a fun environment. The paper also provides a methodological framework for collecting data about student engagement in a course and in particular presents the data collection procedure used in Transportation Engineering Course (CEE 4609). The collected data was analyzed to find the student engagement in the course after the introduction of the game. The paper shows the conclusions drawn from the research with insights into possible drawbacks and scope for future improvements.

4.1 INTRODUCTION

The engineering field requires a high level of realistic expertise and theoretical knowledge. In particular, the Transportation Engineering field requires a thorough practical knowledge to build a sound understanding of the principles taught in the class. In general, in engineering majors, carefully designed experiments conducted in the laboratories are used to impart practical knowledge to the students.. The same applies to transportation engineering. Although analysis of traffic stream and traffic signals can be done through simulation, it may be difficult for beginners to work through simulations and understand the concepts.

To bridge the gap between the theoretical concepts and high level traffic simulation, a viable solution is the development of a web game. Specific learning objectives can be modeled and delivered using the Computer-based Educational Games. These games also pave way for adaptive learning and role-play and simulations(*1)*. It is possible to create environments that can replicate real world scenarios, which can help students to easily gain experience. Web games also provide a platform for creative instructional activities that can capture the students' attention towards the course topics. WebQuest, a pedagogical tool for web-enabled inquiry-based learning, was used in an engineering course titled Simulations and Statistical Analysis to test the inquiry-based learning approach on students and was found to motivate student and achieve beneficial auxiliary outcomes(*2)*.

Games can be recreational, engaging, and educational. The introduction of a game into a course can motivate students toward understanding the course material (*3*). Well-crafted games can transfer knowledge in an efficient way and help students understand the concepts better , as shown in tests with increased scores compared to students who follow traditional text book learning (*4)*.

Courses like Engineering Statics require application of the same concept to solve different problems making the underlying assumption that repetition/practicing leads to proficiency in the concept. But more often than not students tend to not like this approach. A more amicable way is to encapsulate practice in a game context. Games appear to be effective teaching tools for concepts which requires repetition for proficiency like the Statics Calculation Procedures (*5)*.

Even though games can be quite effective, motivating and simpler to administrate, it's not always good to replace the traditional textbooks with them. Games should be used as supplements that would encourage the students understand the course and enjoy the course(*6)*. Following these guidelines, this paper describes a web game that was used in a transportation course to help the students understand basic traffic engineering concepts.

4.2 BACKGROUND

When traffic signals change from green to yellow, drivers have to make a decision as to whether they can safely stop (at an acceptable deceleration rate) at the intersection or continue and clear the intersection. Parameters such as distance from the intersection, speed at which they are travelling, acceleration rates and deceleration rates, headway from the other vehicles, etc help the drivers decide on what action to be carried out on approaching an intersection. But all the drivers may not have the same perception. Different drivers have a different opinion of what the right decision will be. Whether to stop or to go. For example, conservative drivers tend to stop if there is a slight doubt in their minds; if the driver is aggressive he or she will try to cross the intersection even at a slight possibility, etc. So it is hard to predict the driver decision at the onset of yellow.

The decision to be made by the drivers becomes deterministic when the driver is close to the intersection or far away from the intersection. But in the interim distances the driver falls into ambiguity whether to stop or go ahead. This zone of ambiguity is called the "Dilemma Zone." The probability of accidents to occur is high in this zone. Generally two types of accidents occur: 1) rear end collision, when the driver in front decides to stop and the driver behind decides to go ahead, and 2) right angle collision, when the driver decides to cross the intersection and unknowingly runs the red light and collides with the conflicting traffic.

The dilemma zone concept is taught to the students through conventional teaching methods. Textbook, being the medium only gives a general idea of dilemma zone as a definition and a static pictorial representation. These methods may sometimes be confusing to the students. The game on the other hand attempts to provide a visual representation of the dilemma zone and the traffic in the dilemma zone, which is helpful for the students to completely understand the situational meaning of the concept.

The paper is organized as follows. Section 4.3 gives the description of the game with the focus on the different functionalities of each of the components of the game including what they are aiming to achieve as an outcome. Section 4.4 gives details about the software design of the game. Section 4.5 discusses the assessment of the game. Section 4.6 includes the observations and feedback of the undergraduate students. Section 4.7 concludes the paper with the conclusions and scope for further research.

4.3 DESCRIPTION OF THE GAME

The game is aimed to help students to understand what might be the drivers' decision at the onset of yellow signal based on the existing traffic conditions. The player who is playing the game has to determine a safe time to terminate the green signal and present the yellow signal to the traffic so that there are least number of cars in the dilemma zone exist and the hazard for the traffic is minimized. The most commonly used dilemma zone boundaries in the field are 2 to 6 seconds of time to reach the intersection, and the same values are used in the research as the lower and upper boundaries, respectively. The game is programmed so that it retrieves the decision of the driver from a pre-loaded database which is described in the later paragraphs of the paper.

A Hazard Value is shown as a feedback with a hazard function in the background which is programmed as a dependent on the time to the intersection of each vehicle present in the dilemma zone. The game provides feedback in the form of Hazard Value, Least Hazard value, and Time to Least Hazard Value. As a visual feedback the cars that are caught in the dilemma zone are shown in red and the rest of the traffic is shown in green.

The game gives a visual illustration to the player about the general picture of the real world traffic and how individual drivers try to adjust their speeds depending upon the headway from the car ahead of them. The game helps the player visually recognize the basic traffic parameters that decide the signal settings like the acceleration of the traffic, deceleration of the traffic, time to stop bar, etc. The game has two databases programmed which help to collect the information about the traffic and send decisions to the traffic. The GUI of the game is shown in Figure 4-1.

Figure 4-1 Graphical User Interface of the Web Game

The game can be accessed widely through World Wide Web and is presented to the player through a web page. A choice of scenarios is given to the player to choose from. Upon selecting the scenario of the player starts the game by giving the green signal to the traffic. This sets the traffic stream moving. A countdown timer (Counter) starts ticking down from 40.

The player has to choose a time before the countdown ends to terminate the green and give the traffic the yellow signal. Figure 4-1 shows the screen shot of the game when the traffic is given green signal. The choice of traffic scenarios presented to the students in the game are adapted from the data obtained from a robust microscopic simulation, VISSIM *(7)*, and modeled in the game to let the player understand the real world traffic patterns.

The player has to decide when to terminate the green and set the yellow signal to the traffic at the best possible instant in such a way the hazard for the traffic is minimum. When the player terminates the green signal the program records the information of the traffic stream to a database. Based on the position of each of the cars from the intersection the program decides if the cars are in the safe zone of the approach or the dilemma zone. If a car is found to be in the safe zone, i.e, if the driver can make a deterministic decision of whether to stop or proceed to cross the intersection, the decision is sent back to the respective cars.

But if a car is found to be in the dilemma zone then the program control moves to the second database where the driver decision caught in the dilemma zone is stored which is dependent on the time to intersection of the driver. The probability of the drivers' stopping at the intersection is calculated from normally distributed curve which depends on variable, the time to the intersection, and stored in the database for a mentioned range of 2 to 6 seconds. This decision variable is retrieved from the database and sent to the respective cars. Depending upon the decision variable sent to the cars in the traffic, they either speed up to cross the intersection or slow down and come to a halt at the intersection. The program logic in the game is made in such a way so as to avoid the vertical stacking of the cars at the intersection which makes the game look like a real world queuing of the traffic at the intersections. Figure 4-2 shows the diagram of program control.

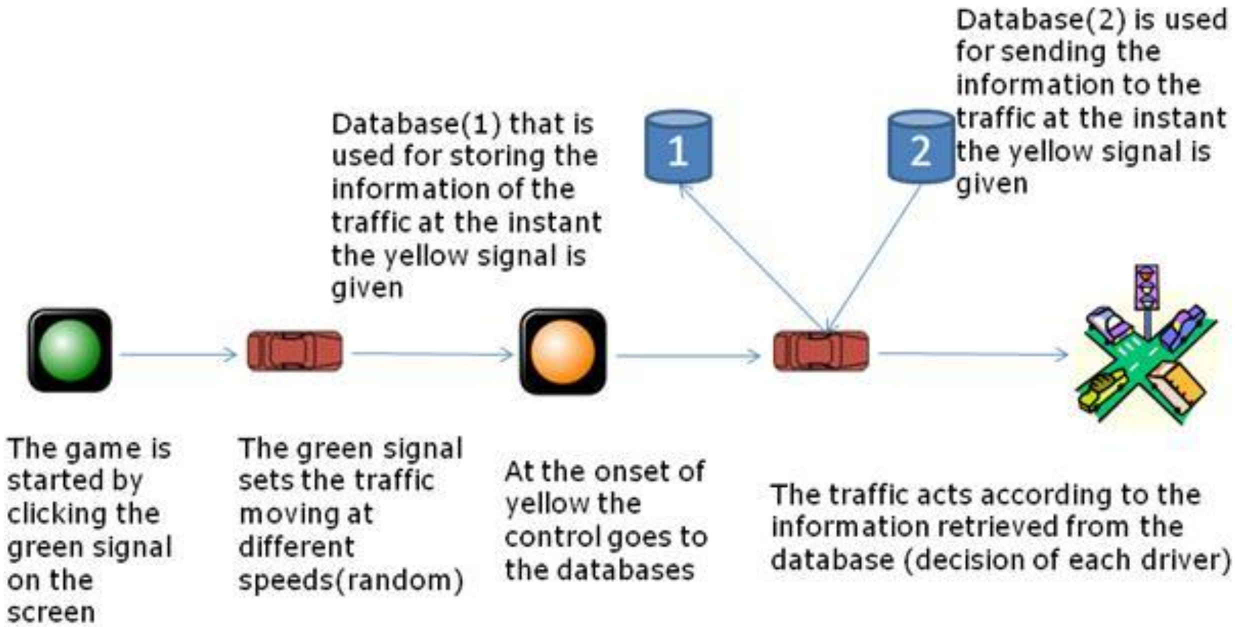


Figure 4-2 Overview of the Program Control

An appealing feature of the game is the hazard function, which calculates the hazard value of the traffic present in the dilemma zone when the player terminates the green. An instant feedback of the hazard value for the player is provided through rendering it onto the screen as **Hazard Value**. The hazard function is dependent on the time to the intersection of each of the cars caught in the dilemma zone.

The competitive part in the game is that players must aim to bring down the hazard value for the traffic to as low as possible and this least value for each of the particular scenarios is presented to the player on the web page as **Least Hazard Value** and the first possible instant of time at which this hazard value can be achieved is shown through **Time to Least Hazard Value** with respect to the **Counter**. The Least Hazard Value and Time to Least Hazard Value are shown to the player as feedback along with Hazard value.

Figure 4-3 shows the feedback provided by the game to the player when the player terminates the green. The feedback induces a sense of curiosity in the players and tries to capture their attention as to what actions are taking place in the background. The help files provided in the game give all the basic definitions that the hazard function is dependent upon and the variables that are considered when installing a traffic signal controller in the real world. This in turn helps the students to get acquainted with the most general traffic signal controller settings used.

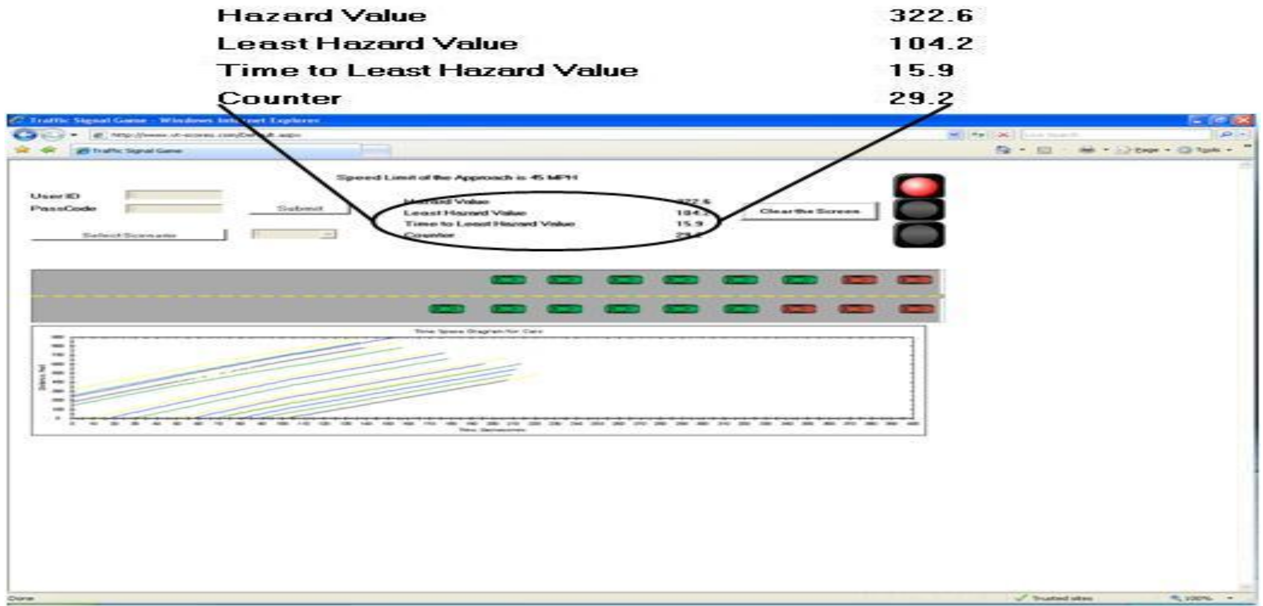


Figure 4-3 Response upon termination of Green

The help files provide the students with definitions of the traffic stream parameters, car-following models and definitions related to the decision variables of the traffic controllers.

4.4 SOFTWARE USED TO DEVELOP THE GAME AND THE MAIN FUNCTIONALITIES

The game is programmed in C# ASP.Net. Microsoft Access was chosen to create the two databases used in the game. The game architecture used in the game is the three-tier architecture which is a part of N-tier architecture of the .NET framework(*8*). The user interface is created using ASP. This renders the game onto the screen. The second layer is the User Control developed in Visual C#. A class library project has been programmed in such a way that it acts as a medium between the lower layer, the databases, and the upper layer, the web interface. The three tier architecture is chosen to make the databases more secured on the web. Figure 5 shows the software architecture used in the game.

The class library project that runs behind the scenes is created as a User Control that directs the actions on the screen is written in Visual C#(*9*), a module in Visual Studio 2005. The User Control has different components programmed. Only the main components of the programmed portion are described in this section since the main aim of the paper is not about programming. As mentioned in section 3, the game is started by indicating the green signal. The green signal is indicted to the traffic pressing the "**Start the Green**" button. This button is programmed to start the traffic scenario selected by the player. When "**Stop the Green**" button is clicked, yellow signal is given to the traffic and also it will direct the program to store speed of the cars caught in the dilemma zone, time to intersection of each of the car caught in the dilemma zone and the traffic scenario selected by the player in the database and search and retrieve the decision parameters from the database. A time-space diagram for each car is rendered on to the screen through a third party graph tool (*10*). The graph portion is programmed to be updated for every tenth of a second depending upon the movements of the cars.

As stated earlier, the program contains two databases. These databases are designed using Microsoft Access--a Microsoft database management tool. One database is used to collect the information of the traffic stream at the instant the yellow signal is given. The information collected by the database is the speed of each car, distance from the intersection of each car and the time it would take for the car to reach the intersection if it would continue at the same speed at the instant the yellow signal is given. The second database is used to send the decision to the traffic, i.e., whether to slow down, to stop at the intersection, or continue and accelerate to cross the intersection. This database is a look up table of normally distributed values which depend on the decision variable time to the intersection of each car having a range from 2 seconds to 6 seconds from the intersection. normally distributed values are calculated from:

$$P_{stopping} = \varphi((t-a)/b)$$

where

$P_{stopping}$ = *the stopping probability of each car*

t = *the time taken to reach intersection by each car*

a & b = *constants*

The probability is retrieved from the database and checked with the random number assigned for each car. If the two numbers are found to be equal then and only then the car is supposed to speed up and cross the intersection given that it is not obstructed by the cars in front of it. Or else it has to slow down and come to a stop at the intersection. The program logic enters this database when the car is in the dilemma zone. An overview of the program structure and its availability is shown in Figure 4-4.

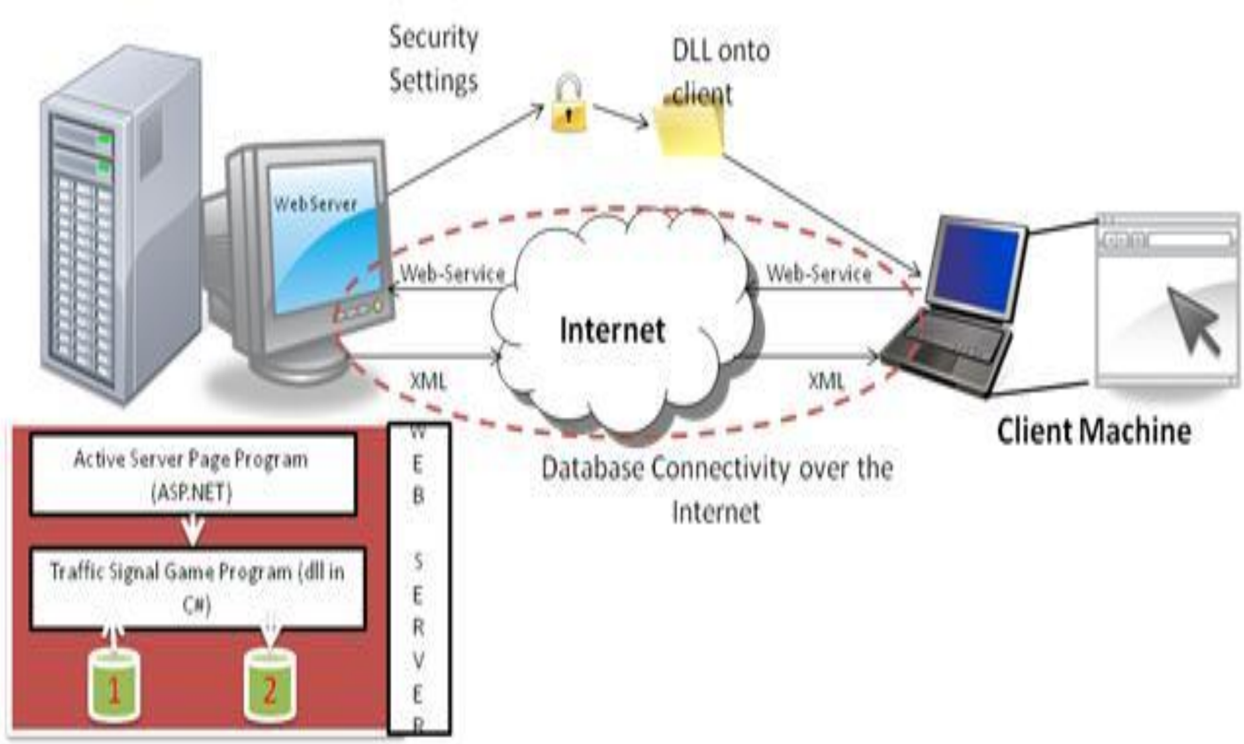


Figure 4-4 The Architecture used in the Game

4.5 ASSESSMENT

The game is intended to be integrated into an undergraduate course for Traffic Engineering. To assess the effects of the traffic controller game on student engagement, we used a four-phase survey process, combined with an end-of-term focus group. This paper focuses on the results of the first three surveys—the baseline survey, the survey administered after completing the first part of the homework, and the survey administered after the completing the second part of the homework by the students.

For the assessment of the game the students are divided into two groups that completed different homework assignments, one mainly focusing on the lecture delivered in the class and the other specifically designed to assess the understanding of the student learning through the game. After attending the lecture in the class, each group was asked to complete a different assignment: Group-1 was asked to complete the game homework (after playing the game) and Group-2 was asked to complete the lecture homework. Afterward, each group was given the other homework respectively. After each activity the students were asked to fill out a survey form to assess the student engagement (The surveys used for the study are shown in Appendix 1).

The surveys combine the 16-question Situational Motivational Scale (SIMS) developed by Guay, Vallarand, and Blanchard (*11)*, with 6 questions adapted from the Persistence in Engineering (PIE) survey developed as part of the Academic Pathways Study of the Center for the Advancement of Engineering Education (*12, 13)*. Section 5.2.1 provides a review of SIMS; section 5.2.2 provides a summary of PIE.

4.5.1 Data Collection Plan

To assess student engagement with respect to using the game for learning about traffic engineering, we propose the following timetable for data collection Table 4-1:

Table 4-1 Timetable for Data Collection

Date	Instrument	Time required
Any time before the lecture is delivered	Survey 1: Engagement in using learning technologies	5-7 minutes
Class following the distribution of Homework I (Group 1 game homework and Group 2 lecture homework)	Survey 2: Engagement in the driver behavior at signalized intersections concept in the Transportation Engineering Course	5-7 minutes
Class following the distribution of Homework II (Group 1 lecture homework and Group 2 game homework)	Survey 3: Engagement in the driver behavior at signalized intersections concept in the Transportation Engineering Course	5-7 minutes
Class following the completion of both the homeworks	Survey 4: Engagement in the driver behavior at signalized	5-7 minutes

	intersections concept in the Transportation Engineering Course	
Last week of class/exam week	Focus group interview	45 minutes

This approach enabled us to track two critical issues:

- Student engagement in the game. By asking students to respond both before and immediately after completing the game, we can evaluate the degree to which students saw the game as useful.
- Student engagement in learning technologies. While the game will not be the only factor affecting engagement, the results of this survey can provide a broader perspective on students' engagement with learning technologies. The engagement surveys, in conjunction with focus group questions, can help identify the factors affecting engagement in engineering.

4.5.2 Survey Instruments

The following paragraphs describe the instruments we are using for data collection. These surveys can easily be combined with other data collection instruments such as content knowledge tests.

4.5.2.1 Analysis of the Situational Motivation Scale

The Situational Motivation Scale (SIMS) (*11)* is designed to assess four constructs of motivation that, according to self-determination theory, underlie the initiation and regulation of human behavior. Specifically, self-determination theory conceptualizes human behavior in terms of true free choice, "a sense of feeling free in doing what one has chosen to do" (*11)*. The four types of motivation differ in their inherent levels of self-determination according to their position on a continuum that includes intrinsic motivation, identified regulation, external motivation, and amotivation. Self-determination theory further "postulates that the needs for competence, autonomy, and relatedness are central concepts" to understanding motivation (*11)*. Validation tests of the SIMS have indicated that intrinsic motivation and identified regulation lead to the most positive outcomes, such as persistence; that external motivation can lead to the decrease of intrinsic motivation; and that amotivation leads to the most negative outcomes, such as depression and feelings of incompetence. However, the SIMS is purposely designed not to assess these needs or outcomes, but rather to separately measure self-reports of motivation (*11)***.**

The SIMS is a self-report measure of situational motivation, i.e., "toward a single current situation" (*11)*. Thus, in experimental settings it has been used during and after a specific task. The authors recommend using the SIMS "either by itself or in conjunction with the time spent on the activity" (*11)*.

In terms of engagement or motivation in a general sense, the authors state that further work is needed to understand how specific effects on motivation influence behavior over time. However, Vallerand (*14)* in his Hierarchical model, proposes "that cumulative motivational changes at the situational level produce over time an effect on more general motivational aspects" (*14)*. For example, repeated instances of loss of intrinsic motivation may over time affect motivation toward a certain situation and even have a global impact on a person's everyday life (*14)*.

With our constraints in this project, we will be able to assess engagement in the game activity, using the constructs of motivation as a measure of how each individual interacts with this specific task. However, without a longitudinal study, we can only extrapolate from these situational results using prior research and theory. The self-determination theory operationalized by the SIMS has been researched and tested since 1971 (*15)*, with steady progress toward understanding how people initiate and regulate their own behavior.

Table 4-2 Continuum of Motivation Constructs in Self-Determination Theory*

intrinsic motivation:	performing an activity for itself, in order to experience pleasure and satisfaction inherent in the activity	Most self-determined (positive)
identified regulation:	behavior is valued and perceived as being chosen by oneself, yet is still extrinsic because the activity is not performed for itself but as a means to an end	
external motivation:	behavior is regulated by rewards or in order to avoid negative consequences	
amotivation:	individuals experience a lack of contingency between their behaviors and outcomes; their behaviors are neither intrinsically or extrinsically motivated. This behavior is the least self-determined because there is no sense of purpose and no expectations of reward or possibility of changing the course of events.	Least self-determined (negative)

*From Guay, Vallerand, and Blanchard (2000)

4.5.2.2 Summary of the Persistence in Engineering Survey

The Persistence in Engineering Survey (PIE) was developed as part of the Academic Pathways Study of the Center for the Advancement of Engineering Education. This multi-institution, multi-year study focuses on gathering longitudinal data to investigate student learning and development in engineering programs.

The PIE survey, developed and tested in 2004, examines factors that influence students' persistence in engineering programs and, conversely, seeks to understand factors that lead students to leave (*12)*. The survey developers drew from five previously tested national surveys:

- Pittsburgh Freshman Engineering Attitudes Survey (PFEAS)
- Cooperative Institutional Research Program Freshman Survey (CIRP)
- Your First College Year 2003 survey
- National Survey of Student Engagement

- College Student Experiences Questionnaire

The survey has been used and refined in subsequent studies (*13, 16, 17)*. In drawing on this survey, we focus specifically on 1) motivation as related to students' perception of engineering as fostering social good, 2) knowledge of the engineering profession, and 3) confidence in open-ended problem solving. Although research using the PIE suggests limited correlation between these factors and retention (*13)*, these elements of the PIE survey are those most likely to be influenced by the game exercise.

4.6 STUDENT ASSESSMENT

4.6.1 Student Engagement

As already introduced in Table 4-1 the students in the class were divided into two groups. Group 1 played the game as their first activity and group 2 played the game as the second part of the activity, and then the game activity and other homeworks are completed by each group. The assessment of Engagement in the driver behavior at signalized intersections concept in the Transportation Engineering Course was conducted by filling a questionnaire with 16 questions framed on the guidelines from the SIMS and 5 questions adopting from the PIE survey. In this questionnaire we used a Likert scale by posing a statement and asking the students whether the statement 'corresponds not all (1)', 'corresponds a very little (2), 'corresponds a little (3) ', 'corresponds moderately (4)' 'corresponds enough (5)' 'corresponds a lot (6)' or 'corresponds exactly (7)' for the SIMS questions and a scale from 'strongly disagree (1)', 'disagree (2)', 'neutral(3)', 'agree (4)', 'strongly agree (5)' for the PIE survey questions.

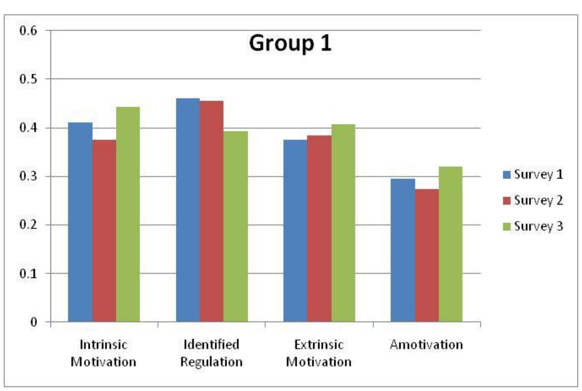
The results of the survey are presented in Figure 4-5. The figure shows two different graphs, one for each group, elaborating the four different motivating constructs in self determination theory, namely intrinsic motivation, identified regulation, extrinsic motivation and amotivation.

Intrinsic motivation in self-determination theory describes situations in which a person is interested in performing an activity for itself, in order to experience pleasure and satisfaction inherent in the activity. The graph for Group 1, Intrinsic Motivation in the Figure 4-5, show that on an average there has been a marginal decrease in the intrinsic motivation of the students after playing the game (response to Survey 2) and as shown there is an increase in the intrinsic motivation of the students after completing the traditional homework (response to Survey 3). Although the students responded well to the game in learning their concepts and were interested in playing the game the students showed more inclination for some reward as an outcome for doing their game homework. The survey 3 is an even further indicative that the students are motivated to do traditional homework rather than a playing a game. The students in group 1 felt that the experience gained from the traditional homework might more beneficial that performing a game activity. The graph for Group 2 shows an increase in intrinsic motivation for the response of survey 2 and decrease for survey 3, which implies that students are doing their traditional homework to in order to have the satisfaction of learning about the Dilemma Zone concept in the Transportation Engineering Course.

Identified Regulation describes behavior that is valued and perceived as being chosen by oneself, yet is still extrinsic because the activity is not performed for itself but as a means to an end. The graph for Group 1, Identified Regulation in the Figure 4-5, show a decrease after both the game activity and traditional homework activity. This implies the students in group 1 got a clear idea about the concept of dilemma zone and were able to decide if they want to pursue the topic. But it is unclear whether the students realized this after the game activity or the homework activity since the perception can be carried on after the completing the first activity i.e., game activity. The graph for Group 2, Identified Regulation in the Figure 4-5, show an increase in after performing the traditional homework activity and a decrease after completing the game activity. Figure 4-5 shows that, after playing the game and doing the traditional homework, the students in both groups got a clear idea of the concepts and are able to judge by themselves if they want to pursue this topic.

Extrinsic Motivation is the behavior regulated by rewards or in order to avoid negative consequences. The graph for Group 1, Extrinsic Motivation in the Figure 4-5, shows that there is an increase in students' motivation given additional rewards. There is a slight increase in the extrinsic motivation for students in group 1 in response to survey 2 which implies that the game requires additional incentives to attract the students and there is an even more increase in response to survey 3 suggesting that the traditional homework activity is performed majorly for reward than compared to the game activity. The graphs for Group 2 for Extrinsic Motivation connote the same conclusions as that for Group 1. The response of students of Group 2 to survey 2 (after completing the traditional homework activity) show that rewards are the driving force for the students whereas game activity also require rewards but not as much compared to the traditional homework activity. By observing the both the graphs in Figure 4-5 it can be seen that there is an increase in the percentage of students that might need external motivating factors, like grades or extra credit, for learning the concepts. This suggests that a game coupled with additional rewards can be a useful tool for increasing the interest of the students in a course.

Amotivation describes situations in which individuals experience a lack of contingency between their behaviors and outcomes. This factor characterizes behaviors that are neither intrinsically nor extrinsically motivated. This behavior is the least self-determined because there is no sense of purpose and no expectations of reward or possibility of changing the course of events. The graph for Group 1 in Figure 4-5 shows a decrease in amotivation after the game activity but an increase after the traditional homework activity. This suggests that the game was able to attract the students in group 1 to learn the concept. The graph for Group w in Figure 4-5 shows an increase in amotivation both after completing the traditional homework activity and the game activity suggesting that the students in the group 2 are neither intrinsically motivated not extrinsically. Based on the the graphs in Figure 4-5 about the amotivation, the results implies that a visualization of a concept can attract more attention from a student than traditional lecture-based homework and hence can perform as an effective supplemental tool.



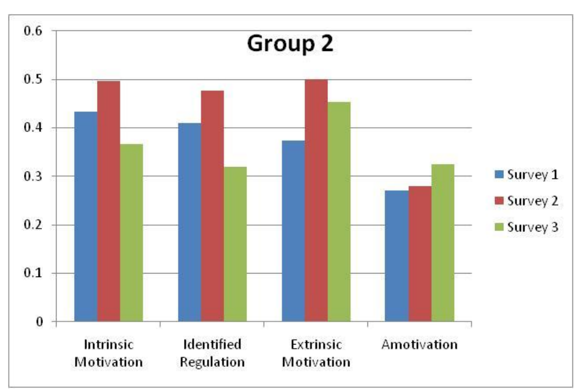


Figure 4-5 Graphs Showing the results of the Survey 1, Survey 2, and Survey 3 for Group1 and Group2

4.6.2 Measurement and Analysis of the Students' Learning Outcomes

A testing was conducted of the hypothesis that students who played the game before solving the lecture homework assignment had a deeper understanding for the subject and scored better in the homework questions. The motivation behind this analysis is to evaluate the game's effectiveness and assess its value for improving content knowledge in any given aspect of the topic. For this purpose, we show an example of how the increase in students' learning outcomes could be tested and how the effectiveness of certain game-aided pedagogy is evaluated.

We tested the effect of the game in improving students' scores in the following questions shown below:

Question 1: *From your lecture notes, The D-CS system minimizes the number of vehicles caught in the dilemma zone at the onset of yellow by extending the green phase as long as vehicles exist in the dilemma zone. What could the limitations of the D-CS be? i.e., what would limit the effectiveness of the D-CS?*

Question 2: *Assume that a D-CS system is being implemented in two sites having the same average traffic volume. In one site, the D-CS is very effective and is catching zero vehicles in dilemma zone per hour. In the other site, the system can rarely find a time when there are zero vehicles in dilemma zone to end the phase. What could the reason be?*

Question 3*: A high-speed signalized intersection is operating on a fixed-time mode, where the green lasts for exactly 30 seconds on the major approach. What is the impact of this control method as far as dilemma zone protection is concerned?*

Question 4*: Using the equation for the start and end of the dilemma zone in your class notes, sketch an intersection approach and draw the dilemma zone boundaries corresponding to different calculation methods for speed limit of 45 mph.*

Table 3 shows the statistical analysis of the students' scores in the above said four questions by group and game total (GT) score (and the interaction term). Group 1 is the group of students who played the game before solving the homework assignment while Group 2 is the group of students who solved the assignment before playing the game. The first column is the question number on which the statistical analysis is carried out. The second column "Source" is the parameter on which the analysis is carried out. "DF" is the degrees of freedom. Type I is the Type I squared sum. And the last column is the p-value.

The statistical analysis helps us decide whether the parameter has significant impact on the outcome for each of the questions as indicated in the "Homework Question" column. It can be seen in the table that there was a significant difference in the results by group total for the third question only.

Table 4-3 Statistical Analysis of Students' Scores

Homework Question	Source	DF	Type I SS	Mean Square	F Value	Pr > F
1	Group	1	1.35131965	1.35131965	0.30	0.5880
	GT	1	9.93289989	9.93289989	2.24	0.1527

	GT*Group	1	0.11397642	0.11397642	0.03	0.8745
2	Group	1	0.89208211	0.89208211	0.15	0.6999
	GT	1	5.36178699	5.36178699	0.92	0.3500
	GT*Group	1	0.01757325	0.01757325	0.00	0.9568
3	Group	1	0.08445748	0.08445748	0.04	0.8481
	GT	1	24.43662991	24.43662991	10.95	**0.0041**
	GT*Group	1	0.06152176	0.06152176	0.03	0.8701
4	Group	1	0.6582111	0.6582111	0.05	0.8276
	GT	1	1.3146866	1.3146866	0.10	0.7584
	GT*Group	1	39.0027117	39.0027117	2.90	0.1068

4.6.3 Insights gained from a student focus group

We also conducted a student focus group at the end of the semester to hear feedback from students. Regarding the assessment protocols, students indicated that the number of surveys conducted during playing the games should be reduced, and that students should be asked to stay in the class after the lecture for long enough time to complete the surveys thoroughly. They stated that the game was relevant to learning in general in the course, which was good. Compared to a "virtual stock exchange" game they played in another engineering course, this one was "very relevant to the class," and they were more motivated to do the homework associated with the course module. One student inferred that game modules dealing with more complicated subjects would be even more effective, and stated that this game would be very useful in an introductory course on Transportation Engineering.

4.7 CONCLUSION AND FUTURE WORK

A web-based game has been developed to help students to gain understanding of the basic concepts of a transportation course. The game format aims to supplement the class learning and try to capture the students' attention. The game is carefully designed to emulate the realistic traffic behavior at the intersections so that the students can get a visual idea rather than just listening in the class and reading the book. The help files in the game provide students with the knowledge both required to play the game and also about the course content.

A general framework for assessing a game implemented in a course had been developed. This framework was tested in the transportation engineering course. A good feedback had been obtained to fine tune the framework and implement it in the future studies.

The survey instruments developed were used to assess the students' engagement in the Dilemma Zone concept of the Transportation Engineering Course. The students' responses to the survey suggest that the game has been marginally successful as a motivating tool for the students and with helping them to understand the concepts better. The results from the survey implied that a visualization of a concept can attract more attention from a student than traditional lecture-based homework and hence can perform as an effective supplemental tool. These results also suggest that a game coupled with additional rewards can be a useful tool for increasing the interest of the students in a course.

Combined with data from the student focus group, this marginality can be attributed to the fact that the game was implemented for senior-year students who might already know the concepts or already have chosen their field of specialization. Further study is planned to assess the impact of the game on freshman and sophomore year students, where the game might be more relevant in an introductory context. Also, the same work will be further tested by reversing the order of the activities and observing the impact. The study also indicated that the survey tools used for studying the impact of the game had been over used and there is a need for fine-tuning the survey for future work. Also, as one of the participants in the focus group indicated, the students should be given sufficient time to complete the survey. Nevertheless, the assessment indicates that a well-crafted game in a course might be a fun activity for students as well as help them meet the learning objectives of the course.

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5. SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

This thesis first described a pilot study of the game. At the end of the pilot study it has been concluded that the graduate student responses on the initial assessment of the game have been positive and welcomed as a new approach for supplementing ordinary lectures. As a feedback the graduate students gave a high priority to the improvement of the interface. This could be due to the fact that students want to see a more realistic environment that can be closely related to the real time traffic. Even though the students were favoring the improvement of the interface, it was understood that they were also clearly indicating for a better chance to understand the traffic engineering principles through a game rather than reading a textual material.

Chapter 3 of the thesis described about the interface of the game, algorithms followed in the game. It is concluded that the web-based game developed, has met its objective of attracting students towards learning the concept. The development of the game utilized Visual C# programming using the .NET Framework to present the concepts of the Dilemma Zone at signalized intersections in a creative, informative, and interactive way. The game was able to serve as a supplementary tool for teaching the driver behavior at the signalized intersections in the Transportation Engineering Course CEE 4609. The graphical user interface of the game is developed in such a way that it is easy to follow and quick to play the game. The game have help files to make students understand what is the theory going in the game, which in turn make the students realize the conceptual meanings of their actions and response the game is providing. The instant feedback the game provides helped students understand the results of their actions and evolve from their mistakes to achieve better results, in the process grabbing the attention towards the topic. Chapter 3 gave an insight into the limitations of the developed web-based game and possible solutions for the limitations.

Chapter 4 of the thesis described about the procedure used to capture the engagement of the students in the Transportation Engineering course after the game was introduced. The students' responses to the survey suggested that the game has been marginally successful as a motivating tool for the students and with helping them to understand the concepts better. Combined with data from the student focus group, this marginality can be attributed to the fact that the game was implemented for senior-year students who might already know the concepts or already have chosen their field of specialization. Further study is planned to assess the impact of the game on freshman and sophomore year students, where the game might be more relevant in an introductory context. Also, the same work will be further tested by reversing the order of the activities and observing the impact. The study also indicated that the survey tools used for studying the impact of the game had been over used and there is a need for fine-tuning the survey for future work. Also, as one of the participants in the focus group indicated, the students should be given sufficient time to complete the survey. Nevertheless, the assessment indicates that a well-crafted game in a course might be a fun activity for students as well as help them meet the learning objectives of the course.

6. APPENDIX

SURVEY TO BE ADMINISTERED FOR THE PILOT STUDY

☐ By checking this box, I agree that investigators Abbas, McNair and Kasaraneni may use my survey responses for studying the effectiveness of the web-based traffic controller game. I understand that my responses will be coded in order to preserve my anonymity.

Major:____

Academic Level (circle one): Freshman Sophomore Junior Senior Other_______

Ethnicity: American Indian or Alaska Native Asian African American Native Hawaiian or Other Pacific Islander White Hispanic or Latino Other_______

Gender: Female Male

Read each item carefully. Using the scale below, please circle the number that best describes your responses to using the game.

1: corresponds not all
2: corresponds very little
3: corresponds a little
4: corresponds moderately
5: corresponds enough
6: corresponds a lot
7: corresponds exactly

a. I think that the game is interesting							
b. I think that learning through this game could have been good for me							
c. I think that the game is pleasant							
d. There may be good reasons to play the game, but personally I don't see any							
e. I think that playing the game in a class would have been fun							
f. I think that the game would have helped me to master my concepts							
g. I don't know; I don't see what the game could have brought me							
h. I am going to play the game but I am not sure if it is worth it							
i. I think that playing the game will be fun							
j. I feel good when playing with/using learning technologies like this game							

SURVEY 1

Question 1: Read each item carefully. Using the scale below, please circle the number that best describes your responses to learning about driver behavior at signalized intersections.

1: corresponds not all 3: corresponds a little 5: corresponds enough
2: corresponds very little 4: corresponds moderately 6: corresponds a lot 7: corresponds exactly

Why are you learning about driver behavior at signalized intersections?

a.	I think that the topic is interesting							
b.	I am doing it for my own good							
c.	I am supposed to do it							
d.	There may be good reasons to learn about driver behavior at signalized intersections, but personally I don't see any							
e.	Because I think that driver behavior at signalized intersections is interesting							
f.	Because I think that learning about this topic will be good for me							
g.	Because it is something that I have to do							
h.	I am going to learn about driver behavior at signalized intersections, but I am not sure if it is worth it							
i.	Because learning about driver behavior at signalized intersections is fun							
j.	By personal decision							
k.	Because I don't have any choice							
l.	I don't know; I don't see what learning about this topic brings me							
m.	Because I feel good when learning about driver behavior							
n.	Because I believe that learning about driver behavior is important for me							
o.	Because I feel that I have to do it							
p.	I am going to learn about driver behavior at signalized intersections, but I am not sure it is a good thing to pursue							

Question 2: Please answer the next three questions using the following 5-point scale
1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree

a.	Technology plays an important role in solving society's problems					
b.	Engineers have contributed greatly to fixing problems in the world.					
c.	I am familiar with what a practicing engineer does					
d.	I am skilled at solving problems that can have multiple solutions					
e.	I am confident in my critical thinking skills					
f.	Creative thinking is one of my strengths					

☐By checking this box, I agree that investigators Abbas, McNair and Kasaraneni may use my survey responses for studying the effectiveness of the web-based traffic controller game. I understand that my responses will be coded in order to preserve my anonymity.

Name:____

Major:____

Academic Level (circle one): Freshman Sophomore Junior Senior Other_______

Ethnicity: American Indian or Alaska Native Asian African American
Native Hawaiian or Other Pacific Islander White Hispanic or Latino Other_______

Gender: Female Male

SURVEY 2

Question 1: Read each item carefully. Using the scale below, please circle the number that best describes your reasons for learning about driver behavior at signalized intersections.

1: corresponds not all 3: corresponds a little 5: corresponds enough
2: corresponds very little 4: corresponds moderately 6: corresponds a lot 7: corresponds exactly

Why did you complete the driver behavior at signalized intersections exercise?

a. Because I think that this topic is interesting							
b. Because I am doing it for my own good							
c. Because I am supposed to do it							
d. There may be good reasons to learn about driver behavior at signalized intersections, but personally I don't see any							
e. Because I think that driver behavior at signalized intersections is interesting							
f. Because I think that learning about this topic will be good for me							
g. Because it is something that I have to do							
h. I have learned about driver behavior at signalized intersections, but I am not sure if it is worth it							
i. Because learning about driver behavior at signalized intersections is fun							
j. By personal decision							
k. Because I don't have any choice							
l. I don't know; I don't see what learning about this topic brings me							
m. Because I feel good when learning about driver behavior							
n. Because I believe that learning about driver behavior is important for me							
o. Because I feel that I have to do it							
p. I have learned about driver behavior at signalized intersections, but I am not sure it is a good thing to pursue							

Question 2: Please answer the next three questions using the following 5-point scale

1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree

a. Technology plays an important role in solving society's problems					
b. Engineers have contributed greatly to fixing problems in the world.					
c. I am familiar with what a practicing engineer does					
d. I am skilled at solving problems that can have multiple solutions					
e. I am confident in my critical thinking skills					
f. Creative thinking is one of my strengths					

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Name:____

Major:____

Academic Level (circle one): Freshman Sophomore Junior Senior Other_______

Ethnicity: American Indian or Alaska Native Asian African American
Native Hawaiian or Other Pacific Islander White Hispanic or Latino Other_______

Gender: Female Male

SURVEY 3

Question 1: Read each item carefully. Using the scale below, please circle the number that best describes your reasons for learning about driver behavior at signalized intersections.

1: corresponds not all 3: corresponds a little 5: corresponds enough
2: corresponds very little 4: corresponds moderately 6: corresponds a lot 7: corresponds exactly

Why did you complete the driver behavior at signalized intersections exercise?

a.	Because I think that this topic is interesting							
b.	Because I am doing it for my own good							
c.	Because I am supposed to do it							
d.	There may be good reasons to learn about driver behavior at signalized intersections, but personally I don't see any							
e.	Because I think that driver behavior at signalized intersections is interesting							
f.	Because I think that learning about this topic will be good for me							
g.	Because it is something that I have to do							
h.	I have learned about driver behavior at signalized intersections, but I am not sure if it is worth it							
i.	Because learning about driver behavior at signalized intersections is fun							
j.	By personal decision							
k.	Because I don't have any choice							
l.	I don't know; I don't see what learning about this topic brings me							
m.	Because I feel good when learning about driver behavior							
n.	Because I believe that learning about driver behavior is important for me							
o.	Because I feel that I have to do it							
p.	I have learned about driver behavior at signalized intersections, but I am not sure it is a good thing to pursue							

Question 2: Please answer the next three questions using the following 5-point scale

1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree

a.	Technology plays an important role in solving society's problems					
b.	Engineers have contributed greatly to fixing problems in the world.					
c.	I am familiar with what a practicing engineer does					
d.	I am skilled at solving problems that can have multiple solutions					

e.	I am confident in my critical thinking skills					
f.	Creative thinking is one of my strengths					

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Name:____

Major:____

Academic Level (circle one): Freshman Sophomore Junior Senior Other_______

Ethnicity: American Indian or Alaska Native Asian African American
Native Hawaiian or Other Pacific Islander White Hispanic or Latino Other_______

Gender: Female Male

SURVEY 4

Question 1: Read each item carefully. Using the scale below, please circle the number that best describes your reasons for learning about driver behavior at signalized intersections.

1: corresponds not all 3: corresponds a little 5: corresponds enough
2: corresponds very little 4: corresponds moderately 6: corresponds a lot 7: corresponds exactly

Why did you complete the driver behavior at signalized intersections exercise?

a.	Because I think that this topic is interesting							
b.	Because I am doing it for my own good							
c.	Because I am supposed to do it							
d.	There may be good reasons to learn about driver behavior at signalized intersections, but personally I don't see any							
e.	Because I think that driver behavior at signalized intersections is interesting							
f.	Because I think that learning about this topic will be good for me							
g.	Because it is something that I have to do							
h.	I have learned about driver behavior at signalized intersections, but I am not sure if it is worth it							
i.	Because learning about driver behavior at signalized intersections is fun							
j.	By personal decision							
k.	Because I don't have any choice							
l.	I don't know; I don't see what learning about this topic brings me							
m.	Because I feel good when learning about driver behavior							
n.	Because I believe that learning about driver behavior is important for me							
o.	Because I feel that I have to do it							
p.	I have learned about driver behavior at signalized intersections, but I am not sure it is a good thing to pursue							

Question 2: Please answer the next three questions using the following 5-point scale

1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree

a.	Technology plays an important role in solving society's problems					
b.	Engineers have contributed greatly to fixing problems in the world.					
c.	I am familiar with what a practicing engineer does					
d.	I am skilled at solving problems that can have multiple solutions					
e.	I am confident in my critical thinking skills					
f.	Creative thinking is one of my strengths					

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Name:____

Major:____

Academic Level (circle one): Freshman Sophomore Junior Senior Other_______

Ethnicity: American Indian or Alaska Native Asian African American
Native Hawaiian or Other Pacific Islander White Hispanic or Latino Other_______

Gender: Female Male