ABSTRACT OF DISSERTATION

Borchyi Lin

The Graduate School

University of Kentucky

2005

A HYPERMEDIA SIMULATION THAT TEACHES DEFENSIVE DRIVING SKILLS

ABSTRACT OF DISSERTATION

A dissertation submitted in partial fulfillment of the
requirements for the Doctor of Philosophy in the
College of Education
at the University of Kentucky

By
Borchyi Lin

Lexington, Kentucky

Director: Dr. Henry P. Cole, Professor of Educational Psychology

Lexington, Kentucky

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A HYPERMEDIA SIMULATION
THAT TEACHES DEFENSIVE DRIVING SKILLS

Because of increased commuter traffic volume on rural roadways collisions between motor vehicles and farm equipment have increased in frequency and severity over the last several years. This study investigated the effects of a multimedia narrative simulation program that taught hazard recognition and promoted defensive driving on rural roadways shared by farm equipment. A companion animated driving game allowed users to practice reaction/stopping time distances with a simulated automobile on a simulated highway when objects appeared suddenly in the path of the automobile. The program and game were delivered by an objective-oriented client/server computer program that also recorded and stored student pre-test, performance, and posttest data.

Prior to the main study a user test and pilot study were conducted. Fifteen instructional systems design graduate students completed the user test to evaluate the study procedures and debug the program. Then, a pilot study sample of 17 rural high school students completed the narrative simulation exercise, the reaction/stopping time game, and the study measures that included a demographic survey, pre- and post measures of predicted reaction/stopping time, recognition of collisions hazard cues, numerical performance scores for the simulation exercise, and tracking logs of each student's performance during the animated reaction/stopping time game.

The main study sample included 123 students age 16 years and older who attended four rural and suburban county high schools. The schools were randomly assigned to the four treatment conditions, one control and three treatment groups. The treatment group students completed either (a) the multimedia narrative simulation only, (b) the animated reaction time/stopping time game only, or (c) both the multimedia simulation and the reaction time/stopping time game.

As hypothesized, students in the groups that completed the hazard recognition and defensive driving skills performed significantly better on posttests of those skills than students in groups that did not complete the simulation. Compared to students that did not complete the reaction/stopping time game, significantly more students that did complete the game became aware that they could not stop the simulated automobile before hitting an object in its pathway. Yet there was no difference across the four groups in students' estimates of reaction/stopping time distances.

Limitations of the study are noted and discussed. Recommendations for future studies are proposed.

KEYWORDS: Computer Learning, Farm Safety, Defensive Driving, Web-based Training, Multimedia Instruction, Instructional Design

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September 1, 2005

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RULES FOR THE USE OF DISSERTATIONS

<u>Name</u>	<u>Date</u>

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To my father.

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A HYPERMEDIA SIMULATION THAT TEACHES DEFENSIVE DRIVING SKILLS

Background and Significance

Collisions between motor vehicles and farm equipment have increased in frequency and severity over the last several years as indicated from multi-year studies in Iowa (Flynn, 1994) and Ohio (Glasscock, Bean, Wood, Carpenter, & Holmes, 1995; Glasscock, Wood, Carpenter, & Holmes, 1993), and investigations of highway collisions by the Kentucky Fatality Assessment and Control Evaluation (FACE) project (KY FACE, 2001). These collisions frequently result in severe injuries and fatalities, one third of which involve the occupants of the motor vehicles. Murphy and Shufran (1998) reported that from 1994 through 1996 there were 319 farm equipment crashes on Pennsylvania roads. Reed and Struttmann (2000) reported that between 1994 and 1997 there were 281 fatal crashes between farm equipment and other vehicles on U.S. roadways.

The frequency of these types of collisions is increasing for multiple reasons. Automobiles travel faster and quieter, and resurfaced rural highways invite speeding while remaining dangerous because of blind hills and curves. Many people unfamiliar with farming are moving to rural areas. Farms are increasingly being split by highways resulting in increased travel of farm equipment on public roads. Collectively these conditions present a serious problem for drivers and farmers. Farmers' work requires that they move farm equipment along highways. Much rural highway travel by drivers of motor vehicles is related to commuting to and from work. Thus this public health problem is also an occupational health hazard (Costello, Schulman, & Luginbuhl, 2003; Garvey, 2003; Luginbuhl, Jones, & Langley, 2003; Pinzke & Lundqvist, 2004).

In a recent research study (Cole, Lehtola, Westneat, Piercy, Struttmann, & Bean, 2000), both young and adult drivers were found to have misconceptions regarding stopping distance, reaction time, and the role speed plays in the severity of the collision. In addition to these three misconceptions, the study revealed a serious decision error made by both the youth and adults in the sample, especially those with little knowledge of farming. During the simulation exercise study, many people chose the option of not slowing down, but instead approaching a slow moving hay wagon from the rear at 60 mph and passing as quickly as possible. The problem is that just as the car attempts to pass, the tractor driver (who because of the wagon cannot hear or see the car approaching from the rear) turns left into his farmyard; a deadly high-speed collision results. The Iowa and Ohio studies found that 50% of actual motor vehicle and farm equipment collisions occur as depicted in the simulation (Flynn, 1994; Glasscock et al., 1995; Glasscock et al., 1993).

Teenage drivers are a special concern; crash rates during the teenage years are higher than at any other age, for both males and females (Williams, 2003). In that report, it also states that the crash rates were particularly low in some situations (e.g., driving with learning permit) and particularly high in others (e.g., right after getting a license, late at night, and with passengers present).

Narrative Simulations

Narrative simulation exercises have long been used for safety training in a variety of occupational settings. In these types of exercises, participants read and solve problems detailed in a life-like story with a plot, characters, and a safety risk situation similar to what might be encountered at their worksite.

The theoretical basis for the narrative simulation is the use of case-based and rate-based surveillance data to construct interactive narrative simulations that both teach and assess critical thinking and decision-making skills (Britt, Chrislip, Bayer, Cole, Kidd, Parshall, Isaacs, Struttmann, Colligan, & Scharf, 1999; Cole, 1994, 1997; Cole, Kidd, Isaacs, Parshall, & Scharf, 1997a; Cole, Vaught, Wiehagen, Haley, & Brnich, 1998; Passaro, Cole, & Wala, 1994).

Multimedia Instruction

Multimedia instruction is a method of instruction that uses the computer to present information with text, graphics, audio and/or video. It is also referred to as computer-based training (CBT) or Web-based training (WBT). It can take the form of skill training, informative presentations, software simulation, job simulation, testing, reference, or online help. Since multimedia instruction is often delivered over the Internet, it can look like a set of Web pages, but it also can be delivered on CD-ROM, on diskette, or over a local area network (LAN) or company intranet.

Multimedia instruction works well for a wide range of content. Both very complex material and very simple information can be delivered this way. For instruction that involves procedures that are dangerous or sensitive, multimedia instruction can safely allow trainees to "practice" on the computer. When the user makes an error, he or she gets immediate feedback and an opportunity to correct the error. Multimedia instruction provides advantages like interactive learner control and efficacy. In addition, multimedia instruction is easier to update and can be delivered over the Internet. This is advantageous when content is kept up to date by changing the information on a central server, and changes made to one copy are immediately made available to all learners.

Components of This Study

There are five components for this study, the Multimedia No Way to Meet a Neighbor Exercise (MM NWX), Reaction Time/Stopping Time (RTST) game, Collision

Hazard Cue Identification (HAZCUE) Test, Perceived Reaction Time and Stopping Time (PRTST) test, and User Evaluation.

The MM NWX simulation deals with the step-by-step progression of a typical daylight highway collision between an automobile and a farm tractor through the pre-event, the event, and post-event stages The purpose is to (a) asses the user's current level of awareness of defensive driving cues and actions needed to avoid the collision, and (b) provide a realistic interactive story that is memorable and may help the user drive with more awareness and more defensively in the future when traveling on highways shared with slow-moving and large farm tractors and machinery.

The RTST game is a simulated automobile traveling at various velocities along a simulated highway where various objects suddenly pop-up into the path of the car. Its purpose is to let the user attempt to stop the vehicle before it collides to the object by hitting the computer keyboard space bar (the simulated brake) to slow and stop the vehicle. The game displays graphically the user's time to hit the space bar after an object pops up in the path of the motor vehicle (reaction time/distance) as well as the time/distance it takes for the simulated vehicle to stop once the brakes are applied. The user plays this game many times by selecting different velocities with a random array of objects including children, animals, and adults popping into the path of the simulated vehicle at various distances from the simulated vehicle. The game is designed to teach the user that motor vehicles traveling at highway speed travel long distances during reaction time and even greater distances during braking (stopping) time.

The HAZCUE Test is a posttest only measure that measures students' ability to recognize cues of potential collision hazards and selection of defensive driving alternatives to avoid collisions (such as slowing down, dropping back, not passing near a left turn access road or driveway, etc.). This test consists of multiple-choice, multiple-answers questions.

The PRTST test consists of a side view of a simulated automobile moving in a straight line at three varied and proportionally correct velocities (35, 45, and 55 mph) with objects suddenly appearing in the path of the automobile at various distances ahead of the vehicle. As soon as the object pops up in the path of the vehicle, the animation stops and the display becomes static. The user is then asked three questions about whether they can stop to avoid a collision, their perceived reaction distance/time, and their perceived stopping distance/time.

The Multimedia No Way to Meet a Neighbor narrative simulation teaches defensive driving cues and strategies in the context of a typical highway collision between an automobile and a farm tractor. The HAZCUE test is designed to reveal how much hazard recognition and defensive driving the users have learned from the Multimedia No Way to Meet a Neighbor Simulation exercise.

The RTST game simulates the time and distance it takes to stop a car traveling at highway speed. It visually demonstrates the distance the simulated car travels during the time required to step on the brake (reaction time) and the additional distance the car travels once is brakes are applied (braking time). The RTST game teaches the users to accurately understand reaction times/distance and stopping time/distance needed to stop a moving vehicle. The PRTST test measures the degree to which users have learned from the RTST game and can accurately predict reaction times/distance and stopping time/distance.

The User Evaluation is a questionnaire administered to users who receive the treatments (MM NWX and/or RTST game) after they completed the study. The questions identify users' perceptions about (a) the ease of completion and use of the interactive features of the simulation; (b) the scenario quality, accuracy, and authenticity; and (c) the self-reported impact of the study on users' learning and behavioral intentions.

Purpose of This Study

This study was designed to investigate the effectiveness of using multimedia narrative simulation to teach adolescents hazard recognition and the efficacy of interactive computer game to help understand the time/distance required to react and stop a vehicle. Students in this study were divided into four groups, Control, NWX, RTST, and NWX + RTST, with incremental treatments. The control group received only the PRTST test and HAZCUE test. The NWX group received PRTST test, MM NWX simulation, HAZCUE test, and user evaluation. The RTST group received PRTST test, RTST game, HAZCUE test, and user evaluation. The NWX + RTST group received PRTST test, MM NWX simulation, RTST game, HAZCUE test, and user evaluation.

The primary research questions were:

- Will students in groups who completed a reaction time/stopping computer simulation game perform more accurately on a reaction time and stopping time test than students who did not play the game?
- Will students in NWX + RTST Group who have practiced a reaction time/stopping computer simulation game and who completed an interactive story depicting a highway collision between an automobile and a farm tractor perform more accurately on a test of collision hazards than students in other three groups?

- Will students in RTST Group who have practiced a reaction time/stopping computer simulation game perform more accurately on a reaction time and stopping time test than students in NWX group and control group?
- Will the Control Group students who receive neither the reaction time/stopping time game or the interactive story depicting a highway collision between an automobile and a farm tractor perform less accurately on both the collision hazard recognition (HAZCUE) test and the reaction time/stopping time (PRTST) test than students in treatments groups?

The study sample included students age 16 years and older attending rural and suburban county high schools in Kentucky. Students in these schools were recruited through their interest in the simulation, and were approved for participation by the school administrators and teachers. Intervention and control schools were randomly selected. School administrators were then contacted. Teachers were then assigned to the study by the school administrators.

The apparatus for the study consisted of two independent but closely linked components: a data collection server and a standalone CDROM program. The data collection server used programs (MySQL® and Coldfusion®) to receive students' data as they completed the simulations. An Excel® spreadsheet generated by the server was then imported into SPSS® for analysis. The CDROM program contained the multimedia narrative simulation No Way to Meet a Neighbor Exercise and the reaction time/stopping time game.

CHAPTER II

THEORETICAL BACKGROUND

Background and Significance

Approximately 60 million people, 21 percent of the nation's population, live in rural communities in the United States. Rural areas are defined by the Census Bureau as open country and settlements with fewer than 2,500 residents (USDA, 2003). The U.S. Department of Agriculture notes that many rural areas have experienced significant recent growth as a result of the arrival of people who have moved into a region for non-economic reasons (USDA, 2004). There are several reasons for the recent growth in rural populations. The lower cost of living, the proximity to natural resources such as lakes and mountains, and a less stressful quality of life are significant attractions to many Americans and recent immigrants. Although some of the recent arrivals to rural areas are retired, most of them are still of working age. The increased geographic flexibility for many workers has also allowed them to move to or build second homes in rural areas that are close to desirable recreation areas.

The National Highway Traffic Safety Administration's Fatality Analysis Reporting System (FARS) of the National Center for Statistics and Analysis (NCSA) includes data for fatal motor vehicle collisions on public roads within the 50 states, the District of Columbia, and Puerto Rico. Based on the statistics from FARS during the period of 1999 to 2003, the roads that had the highest rate of traffic fatalities were the rural, non-Interstate roads. Collisions on the rural, non-Interstate routes accounted for 52 percent of the nation's traffic fatalities (FARS, 2005). However, while more than half of the nation's traffic fatalities from 1990 to 2003 occurred on rural, non-Interstate routes, only 29 percent of the nation's total vehicle travel occurred on these routes during this period (FHWA, 2005) (see Table J1 in Appendix J).

Slow moving farm vehicles traveling on roads shared with high-speed motor vehicles creates a significant problem. An analysis of FARS data from the period of 1988 to 1993 found that farm-vehicle travel on roadway contributed to 65% of the fatalities to farm-vehicle occupants during collisions. Among the fatal collisions with farm vehicles, 58% of the total fatalities were involved with non-farm vehicles. In nearly 36% of the total collision fatalities, farm vehicles were trailing one or more units (Gerberich, Robertson, Gibson, Robert, & Renier, 1996). The frequency of these types of collisions is increasing for multiple reasons. Automobiles travel faster and quieter, and resurfaced rural highways invite speeding while remaining dangerous because of blind hills and curves (Costello et al., 2003; Hughes & Rodgman, 2000). Many people unfamiliar with farming are moving to rural areas. Farms are increasingly being split by highways resulting in increased travel of farm equipment on public roads (Lacy, Hunter, & Huang, 2001).

A study by Cole et al. (2000) reported that tractor/motor vehicle collisions are increasing because (a) many people moving to rural areas and commuting to work, (b) driving at excessive speed on rural roads, and (c) many parcels of farm lands can be accessed only by public roads. Collisions between motor vehicles and farm equipment have increased in frequency and severity over the last several years as indicated from multi-year studies in Iowa (Flynn, 1994) and Ohio (Glasscock et al., 1995; Glasscock et al., 1993), and investigations of highway collisions by the Kentucky Fatality Assessment and Control Evaluation (FACE) project (KY FACE, 2001). These collisions frequently result in severe injuries and fatalities. Many of these collisions occurred during daylight hours (Costello et al., 2003; Flynn, 1994; Glasscock et al., 1995; Glasscock et al., 1993; Hughes & Rodgman, 2000; KY FACE, 2001; Lacy et al., 2001). The difference between the high speeds of other motor vehicles and slow moving farm tractors contributes to collisions on rural highways. For example, consider a car traveling at 50 mph encountering at 100 feet ahead a second motor vehicle traveling at 35 mph. The closure time is about 7.3 seconds. However, suppose a motor vehicle is traveling at 15 mph 100 feet ahead of a following car that is traveling at 50 mph. The closure time is now only 3.1 seconds. The bigger the difference between the speeds of the two motor vehicles the shorter the closure time will be. As stated by Lacy et al., when a tractor/motor vehicle collision occurs, the automobile driver's failure to recognize slow moving farm vehicles and reduce speed accordingly was the number one cause of collision in North Carolina (Costello et al., 2003).

Traffic collisions are the number one cause of death among young drivers age 15 to 20. More than 3,800 young drivers are killed every year in traffic collisions. Young drivers are involved in fatal collisions at over twice the rate of the rest of the population (MMWR, 2003; NSC, 2004). As Williams (2003) pointed out, collision rates during the teenage years are higher than at any other age, for both males and females. His research also showed that the collision rates were particularly low in some situations (e.g., driving with learning permit) and particularly high in others (e.g., just after getting a driver's license, driving late at night, and with passengers present).

A recent research study (Cole et al., 2000) conducted in three states, administered a paper version of a simulation exercise to 146 youthful drivers age 16 to 24, and 81 adults age 25 years and older. About 60% of the research sample failed to recognize easily apparent cues that could have been used to initiate defensive driving maneuvers in order to avoid a collision with a farm tractor towing a hay wagon. The study participants also made errors in judgments that frequently occur in actual farm equipment and motor vehicle highway collisions. Analysis of the study participants' errors identified three shortcomings. First, participants demonstrated a lack of awareness of the additive nature of reaction time and braking time on stopping distance. The study participants failed to recognize that at a speed of 60 mph a typical reaction time of 0.5 seconds means that a motor vehicle will travel 44 feet before the driver can make the decision to lift his or her foot and apply the brake. Second, they demonstrated inadequate understanding of the time required to stop a speeding vehicle after the brakes are applied. They failed to understand that at a speed 60 mph, from the time the brakes are applied, the motor vehicle will require from 3.0 to 8.0 additional seconds and more than 150 feet to come to a full stop even on a dry highway surface (Auto Stopping Distance, 2002). And finally, the participants demonstrated inadequate awareness of the role speed plays in the severity of the collision. They failed to comprehend that as velocity doubles, the force of collision impact quadruples.

In addition to these three misconceptions, the simulation exercise performance data revealed a serious decision error made by both the youth and adults in the sample, especially those with little knowledge of farming. When confronted with a situation where the motor vehicle driver is afraid of being "stuck" behind a large hay wagon and tractor traveling at 12 mph, many people chose the option of not slowing down, but approaching the wagon from the rear at 60 mph and passing as quickly as possible. The problem is that just as the car attempts to pass, the tractor driver (who because of the wagon cannot hear or see the car approaching from the rear) turns left into his farmyard; a deadly high-speed collision results. The Iowa and Ohio studies found that 50% of actual motor vehicle and farm equipment collisions occur as depicted in the simulation (Flynn, 1994; Glasscock et al., 1995; Glasscock et al., 1993).

Farmers' work requires that they move farm equipment along highways. Much of the rural highway travel by drivers of motor vehicles is related to commuting to and from work (Luginbuhl et al., 2003). As described by Lam (2003), young drivers tended to have a greater risk of collision injury due to special road features (e.g., railroad crossing, hazardous road condition, road work, etc.). Increasing number of farm vehicles on rural highways also increase the complexity of road conditions due to the speed difference between motor vehicles and farm vehicles. Based on the pyramid of injury presented by (Saldana, Herrero, del Campo, & Ritzel, 2003), for every one fatal injury in a collision there are 10 minor injuries and 300 or 400 "close calls." A "close call" is an event that does not produce injuries or material damages. Collectively these hazard conditions on rural highway present a hazardous environment for young drivers and farmers.

Hazard Perception

Sanders & McCormick (1993) stated that, "Driving behavior relies almost exclusively on visual perceptions of the environment as the primary source of information. A critical aspect of that process is the visual-scan patters of drivers. Drivers cannot see what they do not look at" (p. 700). Consequently, it is important to teach young drivers hazard perception to become defensive drivers. As described by Wickens (1992), Hazard perception, like decision-making skills, can be improved through practice. Fitzgerald and Harrison (1999) acknowledged that hazard perception is a skill with cognitive and behavioral aspects that include cognitive workload, automation, and attention. Wickens states that humans possess only finite cognitive resources, and anything that requires attention takes a portion of these resources. While driving, there are many situations both within and external to the vehicle that require the attention of the driver, such as reading the instrumentation panel to maintain a legal speed, analyzing the movements of the surrounding traffic, and navigation through a complex highway system.

A safe driver must concentrate on all of the space around the vehicle, not just in the direction of travel. In order to "sense" potential hazards the driver needs to continuously redirect attention all around the vehicle in an ever-changing environment by scanning and recognizing potential hazards and devoting extra attention to these without ignoring the rest of the scene. With sufficient practice, the skills involved in driving a car become automatic (LaBerge, 1973; Shiffrin & Schneider, 1977; Steinman, 1987). When automaticity is acquired, little cognitive attention is required for each of the component skills. For example, to avoid hitting an object on the road requires skills of emergency braking, keeping control of the vehicle, analyzing the scene for new obstacles, and then regaining control. When a hazardous situation occurs suddenly and unexpectedly this reflex-like skill may not be able to respond in time. Avoiding a collision depends in part upon the driver's recognition of cues to an impending hazardous situation. If the driver recognizes the cues, his or her defensive driving strategies provide additional time to act to avoid the collision.

Hazard perception is an important aspect of safe driving. However, just focusing on recognizing hazards to avoid a collision does not necessarily make the driver safer. After perceiving the hazard, the driver has to make a decision to implement an appropriate response in order to avoid a collision (Fitzgerald & Harrison, 1999). Fitzgerald and Harrison stated that hazard perception is involved only at the situation recognition stage of the Recognition-Primed Decision model (RPD) developed by Klein

(Klein, 1989; Klein, Orasanu, Calderwood, & Zsambok, 1993). Klein's et al. RPD model depicts how experienced people make decisions in natural settings. The RPD model emphasizes the recognition of situational dynamics as one of the key factors in selecting an alternative. The RPD model describes how decision makers can rely on their experience to recognize a situation and identify suitable alternatives without comparing the relative benefits or liabilities of multiple alternatives.

One key issue noted by Fitzgerald and Harrison is that hazard perception depends on visual scanning effectiveness but not the effectiveness of the cognitive process of testing and evaluating potential responses. For example, if the driver is engaged in the cognitive process of evaluating a potential hazardous situation to avoid a collision, the cognitive workload increases the driver's reaction time. In situations like these, a collision is more likely to occur. Therefore, Fitzgerald and Harrison suggest that hazard recognition may require particular attention when determining methods of training for novice drivers.

Narrative Simulation

As described by Bruner (Bruner, 1986, 1990), there are two modes of cognitive representation or thinking: the paradigmatic and the narrative.

> The imaginative application of the narrative mode leads instead to good stories, gripping drama, believable (though not necessarily "true") historical accounts. It deals in human or human-like intention and action and the vicissitudes and consequences that mark their course. It strives to put its timeless miracles into the particulars of experience, and to locate the experience in time and place. Joyce thought of the particularities of the story as epiphanies of the ordinary. The paradigmatic mode, by contrast, seeks to transcend the particular by higher and

> higher reaching for abstraction, and in the end disclaims in principle any explanatory value at all where the particular is concerned. (Bruner, 1986, p. 13)

Stories are universal and powerful tools for understanding our own and others' behavior. Through narrative thinking, one can achieve meaningful understanding from the incomplete information and inconsistencies that are normal to our daily life that is full of ambiguities, inconsistencies, and predicaments (Cole, 1997; Cole et al., 1997a; Howard, 1991). Narrative thinking involves knowing through stories; stories we hear, stories we live by, and stories we are told. Cole described how narrative thinking serves as mental models that direct one's attitudes, judgments, decisions, and behavior.

Narrative simulation exercises have long been used for safety training in a variety of occupational settings. In these types of exercises, participants read and solve problems detailed in a life-like story with a plot, characters, and a safety risk situation similar to what might be encountered at their worksite. These interactive narrative simulation exercises use case-based and rate-based surveillance data to construct scenarios that both teach and assess critical thinking and decision-making skills (Britt et al., 1999; Cole, 1994, 1997; Cole et al., 1997a; Cole, Lehtola, Thomas, & Hadley, 1997b; Cole, Lineberry, Wala, Haley, Berger, & Wasielewski, 1991; Cole et al., 1998; Morgan, Cole, Struttmann, & Piercy, 2002; Passaro et al., 1994).

"No Way to Meet a Neighbor" (Cole et al., 1997b) is a narrative simulation exercise that is based on data from two multi-year studies of collisions between farm equipment and motor vehicles in Iowa and Ohio (Flynn, 1994; Glasscock et al., 1995; Glasscock et al., 1993), as well as investigations of highway tractor and motor vehicle collisions by the Kentucky Fatality Assessment and Control Evaluation (FACE) project (KY FACE, 2001). The simulation depicts the pre-event, event, and post-event aspects

(Haddon, Suchman, & Klein, 1964) of a typical collision between an automobile driver with little knowledge of farming and an experienced farmer who is hauling farm equipment on a public road. The simulation deals primarily with the pre-event stage of motor vehicle and farm equipment collisions. It teaches those who complete the exercise to recognize cues to prevent collisions by avoiding typical “hurry and pass” decisions and selecting defensive driving choices.

Multimedia Instruction

Multimedia instruction uses the computer to present information with text, graphics, audio and/or video. It is also referred to as computer-based training (CBT) or Web-based training (WBT). CBT has been proven to be a powerful tool in classroom teaching (Hayes & Robinson, 2000; Janda, 1992; Jones & Smith, 1992; Poirot, 1992). WBT, like distance education (McIsaac & Blocher, 1998; Offir, 2000), the Internet (Cohen, 1999; Gray, 1998; Wiens & Gunter, 1998); and web-based instruction (Berge, 1998; Gillani, 1998; Hartley, 1999; Johnson, 1998; Khan, 1998), has become popular because educators are realizing that traditional methods of teaching (e.g., lecturing) are no longer sufficient to challenge or actively stimulate all students.

Multimedia instruction works well for a wide range of content including museums or retail store kiosks (Misanchuk & Schwier, 1992) and for human-computer interaction research (Bodker, Knudsen, Kyng, Ehn, & Madsen, 1988; Ehn, 1989; Greenbaum & Kyng, 1991). Both very complex material and very simple information can be delivered this way. For instruction that involves procedures that are dangerous or sensitive, multimedia instruction can safely allow trainees to "practice" on the computer. When the user makes an error, he or she gets immediate feedback and an opportunity to correct the error (Gay & Mazur, 1993; Lin, 1996, 2002; Mazur & Lin, 1996). The advantages of Multimedia instruction include interactivity, learner control, effective and efficient learning. It also makes it easy to keep the content up to date for delivery through the Internet. With Internet delivery (Cohen, 1999; Gray, 1998; Wiens & Gunter, 1998), changes made to one copy are immediately available to all users. Keeping the content up to date is facilitated by changing the information on a central server.

Multimedia instruction has been used very effectively as a method to increase motivation and alertness (Nelson, Watson, Ching, & Barrow, 1996) and can improve the quality of student responses (Mayer, 1997). Its wide variety of formats such as text, graphics, film, video, hypermedia, and other interactive formats are thought to engage more senses than conventional teaching methods (Mayer, 1997; Najjar, 1996; Nelson et al., 1996; Pea, 1991) and thus facilitate better learning.

Paivio's dual coding theory (Clark & Paivio, 1991; Paivio, 1986) argues that individuals possess two interdependent memory coding systems, a visual system for processing visual knowledge and a verbal system for processing verbal knowledge. Each system encodes and regulates the processing and storing of information for which it is adapted. Coordinated simultaneous presentation of verbal and visual materials that address the same concepts allows students to encode subject materials in more than one manner, thereby facilitating learning and memory (Mayer, 1997; Mayer & Sims, 1994).

Current Study on Farm Safety

As suggested by (Runyan, 1993), in order to achieve effective safety communication, four elements should be included in any safety communication:

"(a) the nature of hazard; (b) the level of seriousness of the hazard; (c) how to practically avoid the hazard; and (d) the potential consequences of not avoiding the hazard" (Aherin, Murphy, & Westaby, 1990).

Concern about the continued high rates of farm injuries led to demands from farming and public health communities for an increase in farm injury prevention measures and additional research. Most farm safety education has been provided by safety fairs, day camps, publications, certification programs, workshops, and courses for farm families, youth, and agricultural workers. Most interventions have targeted farm operators and generally involve farm safety audits, followed by recommendation for environmental or equipment changes and/or safety education. Few studies have evaluated the effectiveness of farm safety interventions for changing attitudes, problem solving, and behavior (Landsittel, Murphy, Kiernan, Hard, & Cathy, 2001). There have been few evaluations of interventions to determine what types of programs are most effective in reducing injuries (DeRoo & Rautiainen, 2000; Morgan et al., 2002).

This study was designed to assess the benefits of using a multimedia narrative simulation program to teach high school students defensive driving skills to avoid collisions with farm machinery. This study must be considered exploratory because of the lack of prior research about multimedia narrative simulation dealing with farm safety and young drivers. This author predicted that the use of a multimedia narrative simulation program would significantly improve hazard perception, which should, in turn, lead to improved hazard recognition and defensive driving in situations where drivers encounter slow moving farm tractors on rural highways.

CHAPTER III

METHOD

This chapter describes the participants, treatment materials, experimental measures, experimental design, and hypotheses for the study.

Participants

A power analysis determined that in order to achieve 80% power, with a critical effect size of .44 and a 5% significance level, a minimum of 20 participants per experimental cell was required (Kraemer & Thiemann, 1987). Thus, a sample consisting of 123 high school students from four different high schools was utilized for this study. The study sample was selected to include students age 16 years and older who attended Kentucky rural and suburban county high schools.

Prior to beginning the study the researcher visited each school to explain the purpose of the study to administrators and teachers. School administrators and teachers then assisted in recruiting student participants. The four rural high schools were randomly assigned to the four treatment conditions. Prior to their participation in the study the researcher and the teachers explained the study activities and purpose to the students. Students' assent to have their performance data used by the researcher was obtained as a first step in the online administration of the instructional treatments. Those students who did not consent to having their data collected were allowed to complete all components of the online program experimental group to which they were randomly assigned, but no data from these students were collected or transmitted to the researcher by the program. Student data were collected for only those students who consented to submit their data for analysis. These arrangements were approved by the University of Kentucky, Office of Research Integrity under Human Subjects IRB Number 01-0749-P1B.

These rural high school participants were selected for the following reasons. First, Kentucky schools are equipped with high-speed Internet connections and provide an ideal place in which to conduct this study whose treatment intervention and measures all were administered online by high-speed Internet connections. Second, Kentucky curriculum standards require the teaching of civic and community life and well being. Curriculum materials with this focus that are particularly relevant for rural communities are generally not available. The rural setting and content of the study materials is attractive to both teachers and students in these rural Kentucky schools. Third, approximately 30% to 40% of students in rural Kentucky communities live or work on farms. Other rural non-farming students in these communities have friends and family members involved in farming. All students and their family members are involved in commuting to and from work and school through farmland on highways shared by tractors and other farm machinery. Many students and adults have little awareness of farm equipment operation, or the defensive driving cues and strategies that could help them to avoid collisions with slow-moving farm equipment traveling on public highways (Cole et al., 2000).

Treatment Materials

This section includes descriptions of a Reaction Time and Stopping Time (RTST) Animation Game, the Multimedia No Way to Meet a Neighbor (MM NWX) simulation exercise, the user test and pilot study, and the data collection methods.

Definition of Terms

Table 1 lists the names, descriptions, and abbreviations for each of the four experimental conditions and the various independent and dependent variables.

Table 1

Independent and Dependent Variable Names, Abbreviations and Descriptions

Item Name	Abbreviation	Description
	Independent Experimental Treatment Variables	
Control group	Control	One of four experimental independent variables – the no treatment condition
Simulation exercise group	NWX	The multimedia No Way to Meet a Neighbor simulation of a highway collision between a motor vehicle and farm tractor. The second independent variable
Reaction Time and Stopping Time Animation Game	RTST	A game where the user attempted to stop a simulated automobile traveling across a computer monitor screen to avoid colliding with objects that pop up in front of the vehicle. The simulation game measures both the users' reaction time and distance traveled to step on the brake (by hitting the space bar) and the stopping time and distance of the vehicle once the brakes are applied.
Combined Simulation exercise and Reaction Time and Stopping Time Game	NWX + RTST	The users in this group completed both the MWX simulation exercise and the RTST game

(*table continues*)

Table 1. (continued)

Independent and Dependent Variable Names, Abbreviations and Descriptions

Item Name	Abbreviation	Description
	Dependent Variable Measures	
Collision Hazard Cue Identification Test	HAZCUE	A test that measured the user's ability to recognize a variety of cues, related to likely or impending movement or turns of farm equipment, that would prompt the user to engage in defensive driving actions (such as slowing down, dropping back, not passing near a left turn access road or driveway, etc.)
Perceived Reaction Time and Stopping Time Test	PRTST	A test consisting of a side view of a simulated automobile moving forward at three different speeds (35, 45, and 55 mph) with objects suddenly appearing in the path of the automobile at various distance ahead of the vehicle. As soon as the object popped up, the user was then whether he or she could stop in time and then to estimates reaction and stopping distance.

Reaction Time and Stopping Time (RTST) Animation Game

One experimental condition in the main study included a braking and stopping time animation game. This simple animation task uses the space bar on the computer keyboard as a simulated "brake." By hitting the space bar, the user attempts to stop a simulated automobile traveling across the monitor screen at varying simulated but proportionally correct velocities (35, 45, and 55 mph). At the beginning of each braking animation trial, the user can select one of the three speeds of the simulated vehicle that appears on the computer screen. As the simulated automobile travels across the screen at the selected speed an object suddenly and unexpectedly pops into its path. The user attempts to avoid a collision by hitting the space bar to stop the simulated car. A diagram then appears on the screen displaying the relationship between the time the user "stepped on the brake" (reaction time) and the distance between the object and vehicle at the time the user applied the brake (stopping time). The diagram shows whether or not the user's reaction time combined with the vehicle braking distance resulted in a stopping time sufficient to avoid a collision. The exercise is repeated as many times as the user wishes with varying vehicle speeds and varying distances from the vehicle to the object that pops into its path. In each trial, the computer program measures the user's reaction time and calculates the vehicle stopping time. The stopping time calculations are based on data from a website that provides empirical data for stopping times and distances (Auto Stopping Distance, 2002). These interactive reaction times, stopping times and distances cannot be simulated in the paper and pencil version of the simulation exercise.

The MM NWX Simulation Exercise

The No Way to Meet a Neighbor (NWX) simulation exercise is an interactive story about a high-speed collision between a commuter in an automobile and a tractor that is hauling a loaded hay wagon and hay baler on a rural public highway. The simulation scenario includes the key risk factors for such collisions as determined by large studies of actual farm equipment and motor vehicle collisions (Flynn, 1994; Glasscock et al., 1995; Glasscock et al., 1993; KY FACE, 2001). This simulation scenario follows the Haddon matrix approach through the pre-event, event, and post event aspects of the collision (Haddon et al., 1964).

The simulation scenario describes two characters, Sam and Jake. Sam, a 38-year-old worker who has been living in the city for most of his life, has moved to a farming community with his family about two month ago. Each day Sam commutes 70 miles round trip to work. The highway is a well-maintained two-lane asphalt road with a speed limit of 55 mph. Sam has little knowledge about farming. Jake, a 52-year-old farmer, lives and works on a farm that is located about 2 miles away from Sam's house. Jake has raised three children, has two grandchildren, and has been a full time farmer for 30 years.

The scenario begins on a Friday evening. Sam has worked overtime and is late for a family picnic, is anxious to get home, and is speeding. Jake has been baling hay all day. He has just pulled out from his hayfield with his square baler and the loaded hay wagon behind his tractor. His tractor does not have a cab and has no rollover protective structure (ROPS) or seat belt. Jake is in a hurry to get home to see his wife and grandchildren. The children are visiting and staying for dinner.

As Sam rounds a bend in the road at 65 mph, he sees a large loaded hay wagon 400 feet ahead of him. As Sam approaches the wagon, he sees that the short straight road section ahead of the wagon and tractor is clear. Sam pulls into the left lane and starts to pass the hay wagon and tractor. Sam does not know Jake is towing a baler because the loaded hay wagon blocks his view. Meanwhile, Jake cannot see or hear what is behind him because of the hay wagon and the roar of the tractor engine. Just as Sam speeds up to pass, Jake arrives at his farm and makes a left turn into his driveway. Sam's car hits the baler and tractor at full speed. Both Sam and Jake are killed instantly in the collision.

The simulation story is told in three screens of brief text along with three illustrations and an animated sequence of the pre event, event, and post event features of the collision. As the story unfolds, users are asked to select among the alternative decisions that Sam or Jake might make. At the end of the scenario an additional screen asks the users to select who else was at risk from the collision and why. The last screen asks the users what Sam and Jake could have done to avoid the collision.

The multimedia version of the NWX simulation presents the unfolding scenario in the same sequence as the earlier paper and pencil version from which it was developed. Unlike the paper version, the MM NWX simulation provides the user with immediate feedback at each decision alternative. It also provides the user with a choice of audio as well as text presentation. In addition, the actual collision event is depicted with an animated sequence of the pre-collision, collision, and post-collision from the automobile driver's and by stander's perspectives.

The User Test and Pilot Study

Sample

A user test was conducted before the main study to evaluate the procedures for the study and to debug the CDROM program. Dr. Joan Mazur and 15 graduate students (age 25 and above) enrolled in her classes in the Instructional System Design Program conducted a content, interface, tracking, and navigation critique of the hypermedia program. These users' comments, but no performance data, were collected during the user test. A second sample consisted of 17 high school students recruited from a rural high school (age 16 and older) to pilot test the program. The preliminary data from the user test and the pilot study were used to modify and improve the program.

The pilot study data collected included students' scores on the pre-measures, the Reaction Time and Stopping Time (RTST) animation game, the Multimedia No Way to Meet a Neighbor Exercise (MM NWX) simulation exercise, and the post-intervention measures. All data collected identified students only by randomly assigned identification numbers. No personal identifiers were collected or reported.

The User Test

The purpose of the user test was to collect information about the interface design and to perform a final debugging of the computer program. No performance data were collected. No instructions given during this session. The plan was to collect as much information about the interface design as possible to determine if it provided users with sufficient direction. Table 2 describes the issues addressed by the graduate students involved in the user test and the modifications made to the program to accommodate their requests.

Table 2

User Test Suggestions and Program Corrections

Suggestion	Correction
Password field visible	Rewrite the password input procedure
Too much time on the pre/post test	Reduce test items from 15 to 9
Navigational Map	Implement access points from the menu bar
Hard to move the simulated car for answering the pre/post test PRTST measure	Rewrite the car moving procedure
Unable to detect what answer been chosen	Indicate answers selected with toggled graphic buttons
No instructions on how to use the program	Implement the help menu
Too many questions on the HAZCUE	Rewrite the questions and reduce number of test items
Need a measurement for the RTST game to show how far the simulated car moves to indicate reaction time and stopping distance	Add a window to display the distance the simulated card moves during reaction time and stopping time
Programming glitches	Fixed

The Pilot Study

During the pilot study, the computer program was set to NWX + RTST Group (the full treatment condition) as described in Table 1. Three measurements were collected during the pilot study: the performance score of MM NWX simulation, the Perceived Reaction Time and Stopping Time (PRTST) test scores, and the Reaction Time and Stopping Time (RTST) game data. In particular, students' responses to the RTST game were monitored with a tracking program to determine how many replications of the game students completed during the pilot study. This was an important issue because, in the interest of uniform treatment and a tighter experimental design; students in the MM NWX Simulation + RTST game condition could not be expected to learn from the RTST game unless they completed multiple replications of the task for each of the three vehicle velocities.

Data Collection Method

The data collection method used was a technique called client and server (Client Server, 2004). It consisted of a client program running on an IBM PC and a server program running on a remote database server. The task of the client software (the CDROM program) was to collect data from the research measures (described in the Measures section) and the student-activity tracking log. When students logged off the program, the data were sent to the server via the Internet. The task of the server programs (MySQL® and Coldfusion®) were to receive data sent by the client program and generate an Excel spreadsheet that imported the data into SPSS® for analysis.

The client program was developed using Macromedia® Director®. Choosing Director® as the programming tool provided a scripting language environment that allowed incorporating media files such as sounds, movies, and text into the MM NWX simulation exercise and into the RTST game programs. In addition, Macromedia® Director® provided program plugins ("extras") that allow third party programs to interact with Director-based program.

Before students entered the client program they were presented with an initial screen that requested their consent to have their demographic and performance data collected and analyzed. The student was required to indicate if he or she agreed. The student was then able to log in with his or her name and a self-selected four-digit personal identification number (PIN). For students who agreed to have their data collected, the program created a unique encryption string based on the name and PIN provided by the participant. This encryption string could only be decrypted with two decryption keys: participant's name and PIN (known only to the student). This unique encryption string was then used as the identifier for the participants whose demographic and performance data was included in the database. This encryption method ensured complete student anonymity. It is demonstrated in Table 3.

Table 3

Encryption Procedure for Ensuring Student Anonymity

User Name (of the student)	PIN (4-digit number selected by the student)	Encrypted string (assigned by the computer program)	User ID (assigned by the program)
Henry Cole	1111	]<#;V\2%]L;1P```	1
Borchyi Lin	1234	_\G%S]7?WHSQS]D`	2

When the participant completed the research activities, the data collected by the client program was transmitted via the Internet to the server. After receiving data from the client program, the data were distributed into three tables: (a) user demographic information, (b) MM NWX simulation performance data, and (c) the RTST game results. The user information table consisted of the encrypted code and total time spent for each session (e.g., Demographic information, MM NWX simulation, etc.). The performance data table pooled all the data except the pre-/posttest and RTST game statistics. The RTST game statistics table contained the pre-/posttest data and summarized the RTST game results. In the pre-/posttest and RTST game, the distance on screen for the simulated car is proportional to real life. One pixel on the screen equals 0.253 feet.

The Data Collection Server used Macromedia® Coldfusion® 6.1 hosted by a Linux® server running the RedHat® 9.0 Linux operating system. As the data arrived at the Linux® server via the Internet, Coldfusion® acted as the intermediary program as it received data from the client software and then forwarded the information to the Sequential Query Language (SQL) server program called MySQL®. Once the data collection process was completed, ColdFusion® generated the summary reports for the data set. The reports were then converted into a spreadsheet that was inputted into SPSS for data analysis.

The benefit of using ColdFusion® as the database server was that it not only provided the tally results for each student, it also provided a microscopic view of the data set. For example, in the MM NWX simulation session, all the students' answers for each question were logged. Therefore, not only could we perform analysis on each student's total performance score, but we could also determine the percentage of students that answered correctly on each particular question. In addition, as long as the participant was connected to the Internet, the data were transmitted directly into the data collection server. There was no need for data entry and thus data entry errors were eliminated.

Experimental Measures

A series of pre- and post intervention measures were used to assess the performance of participants before and after their exposure to (a) no intervention (Control Group), (b) a Multimedia (MM) and animated version of the NWX simulation

(NWX Group), and (c) a MM and animated version of the NWX simulation plus a post-simulation exposure to a RTST game. The RTST game involved the user in a series of simple animated reaction time and stopping distance tasks (RTST Group) that required the student to use the space bar on a computer keyboard as a simulated brake in an attempt to stop the simulated automobile as it traveled across the monitor screen at varying velocities.

The following measures were used for the study:

Demographics questionnaire: age, farm and tractor driving experience, driver license status and duration.

Exposure questionnaire: history of involvement of self or family members in tractor/motor vehicle collisions, injury related outcomes; history of close calls for such events, and vehicle (tractor or automobile) in which participant was riding at the time of the collision or close call.

Perceived Reaction Time and Stopping Time (PRTST) test: This test consisted of a side view of a simulated automobile moving in a straight line at three varied and proportionally correct velocities (35, 45, and 55 mph) with objects suddenly appearing in the path of the automobile at various distances ahead of the vehicle. As soon as the object popped up in the path of the vehicle, the animation stopped and the display became static. The user was then asked three questions in this order.

1. Can you stop the car before striking the object? ___Yes ___No
2. Click on the car and move it forward along its path to show how far the car would travel before you would have time to step on the brake.

3. Now click on the car and move it forward to show how far the car would travel before stopping after you applied the brake.

No feedback was provided during the PRTST test. There were nine questions based on unique combinations of the three different distances between the objects popping up in the path of the simulated car and the three velocities at which the car was traveling. In some of these cases it was impossible for the participants' Reaction Time (RT) and Stopping Time (ST) to be fast enough to avoid a collision. At other times there was sufficient time and distance for RT to allow application of the brakes and deceleration of the simulated car, but not sufficient ST. In other cases the velocities and distances allowed adequate time for both RT and ST.

Reaction Time and Stopping Time (RTST) Animation game: This "game" was basically the same as the PRTST test except that the animation action did not stop when an object appeared in the pathway of the simulated automobile. Rather, the user had to hit the space bar to stop the simulated automobile. The distance the car traveled from the time the user hit the space bar after the object popped up was the measure of RT. The distance the simulated car traveled from the time the space bar was hit until it stopped was the ST. This version of the animation (simulated task) involved proportional velocities and stopping distances and times for five popup objects in the vehicle pathway, at three varied distances, for each of three different proportionally displayed vehicle velocities (35, 45, and 55 mph). Audio and visual cues of stopping distances and times and collisions were included in the animation (e.g., visual deceleration of the vehicle, screeching brakes, impact crashes).

Collision Hazard Cue Identification (HAZCUE) Test: This posttest measured the user's ability to recognize a variety of cues, related to likely or impending movement or turns of farm equipment, that would prompt the user to engage in defensive driving actions (such as slowing down, dropping back, not passing near a left turn access road or driveway, etc.) This test consisted of both multiple-choice/multiple-answer items.

User Evaluation (USEREVAL): This questionnaire was administered to users after they completed the study. The questions identified users' perceptions about (a) the ease of completion and use of the interactive features of the simulation; (b) the scenario quality, accuracy, and authenticity; and (c) the self reported impact of the study on users' learning and behavioral intentions.

Experimental Design and Hypotheses

It was hypothesized that NWX Group students who received the MM NWX simulation exercise would score higher on recognizing cues of an impending collision and to implement defensive driving decisions (as measured by the HAZCUE posttest) than would the RTST game only (RTST Group) students or the Control Group no intervention students. Conversely, it was hypothesized that the RTST game students (RTST Group) would score more realistically on the PRTST posttest measure than would the control group or the NWX simulation group. The students who received both the MM NWX simulation and the RTST game (NWX + RTST Group) were expected to perform well on both the recognition of cues of collision hazards and defensive driving decisions (HAZCUE posttest) as well as to make more realistic estimates of reaction and stopping time estimates as measured by the PRTST posttest. The four hypotheses formulated were:

H1: RTST Group and NWX + RTST Group participants that received the RTST game would perform significantly better on the PRTST posttest than (Control Group and NWX Group) that did not receive the RTST game.

H2: NWX + RTST Group participants that received both the RTST game and the MM NWX simulation would score significantly higher on the HAZCUE test than NWX and RTST Groups that received only one (i.e. the MM NWX simulation or the RTST game respectively) and also better than the Control Group participants.

H3: RTST Group participants who received only the RTST game would perform significant better on PRTST test item than NWX Group that received only the NWX simulation and better than the Control Group participants.

H4: Control group participants that received neither RTST game nor MM NWX simulation would perform worse than groups NWX only, RTST only, and the NWX + RTST group on both the HAZCUE and PRTST test.

The study hypotheses stated in logical alternatives form were as follows. The RTST braking animation game measures both the user's reaction time (RT) to hit the space bar (the simulated brake pedal) and the car's stopping time (ST). It was expected that the NWX Group and the NWX + RTST Group participants that completed both the NWX simulation and the RTST game would perform significantly better than the Control Group participants on the HAZCUE dependent measure. This HAZCUE measure assessed the participants' recognition of collision hazard cues and selection of defensive driving decisions. It was also expected that the NWX + RTST Group participants who received both the MM NWX simulation and the RTST game would perform significantly better on the perceived reaction time and stopping distance (PRTST) posttest than NWX Group participants who completed only the MM NWX simulation and not the RTST game. Likewise, it was expected that the NWX + RTST Group participants would perform significantly better on the HAZCUE and defensive driving posttest than RTST Group participants who completed only the RTST game and not the MM NWX simulation. The study experimental design is depicted in Table 4.

Table 4

Main study experimental design, pre- and post measures, and instructional treatments

Group	Condition	Pretests	Intervention	Posttests
Control	Control	Demographics Exposure PRTST pretest	None	PRTST posttest HAZCUE test
NWX	MM NWX simulation	Demographics Exposure PRTST pretest	MM NWX simulation alone	PRTST posttest HAZCUE test NWX PER score USEREVAL
RTST	RTST Game	Demographics Exposure PRTST pretest	RTST Game alone	PRTST posttest HAZCUE test USEREVAL
NWX + RTST	MM NWX + RTST Game	Demographics Exposure PRTST pretest	MM NWX simulation + RTST game	PRTST posttest HAZCUE test NWX PER score USEREVAL

* Measure and intervention treatments listed in this table are described in the measures section.

The preferred inferential statistical testing method is to randomly assign participants to one of the four conditions. However, if participants within the four school sites had been randomly assigned to each of the four experimental groups the internal validity of the study would have been compromised. Students in any given school could have communicated or even collaborate in completion of the simulation. Cross contamination of treatments would have resulted. Because schools were used as the unit of analysis, cross contamination was eliminated. However, because treatment conditions were randomly assigned to schools it was important that schools be selected to be as equivalent as possible.

For the PRTST pre- and posttest, an appropriate analysis was determined to be a repeated measures ANOVA across treatment group schools followed by planned contrast comparisons where $M_{NWX + RTST} > M_{NWX >} M_{Control}$.

The experimental design and statistical analysis procedure for PRTST test is depicted in Figure 1. This experiment had four study groups: control, NWX only, RTST game only, and NWX + RTST game. The four groups all received the PRTST pre- and posttest. The subscale items for the PRTST test are depicted in Table 4. A 2 x 2 x 2 repeated measures ANOVA was conducted to address the following research questions:

- Is there a pre to post intervention difference across the four experimental groups in the proportion of "yes" responses to the question, Could you stop in time to avoid colliding with the object?
- Is there a difference in students' estimate of RT distance across the four treatment groups?

- Is there a difference in students' estimate of ST distance across the four treatment groups?

Table 5

Subscale Items for the Perceived Reaction Time and Stopping Time Test

	Metric	Statistic
1. Could you stop No = 0, Yes = 1	Proportion(Yes)	Mean
2. Direct measure of estimated reaction time (RT) distance	$Feet_1$	Mean
3. Direct measure of estimated stopping time (ST) distance	$Feet_2$	Mean

For the HAZCUE posttest measure a 1 x 4 ANOVA was conducted followed by planned contrast comparisons (e.g. $M_{NWX + RTST} > M_{Control}$, $M_{NWX} > M_{Control}$, $M_{NWX} > M_{RTST}$).

For the MM NWX performance score (both total score and question scores) Student's t-tests were used to examine differences in mean scores for NWX Group and NWX + RTST Group (e.g. $M_{NWX} \neq M_{NWX + RTST}$). For the student evaluation of the exercise (USEREVAL) score a planned contrast for each variable was performed.

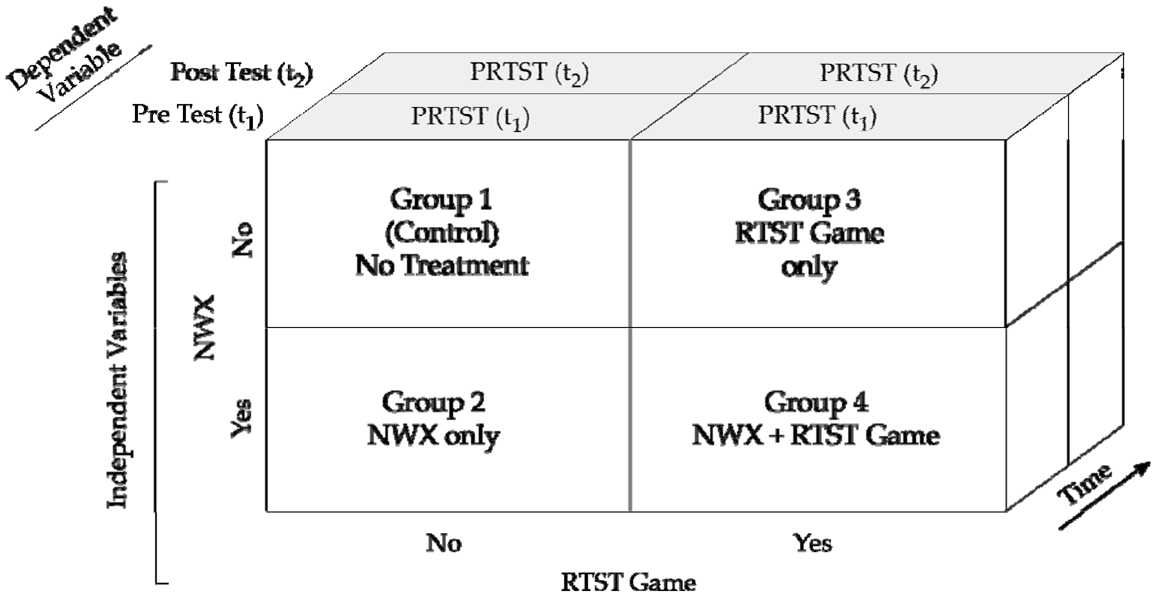

Figure 1. Graphic depiction of the experimental design and statistical analysis procedure for effects of treatment conditions on the dependent variable Perceived Reaction Time and Stopping Time Test (PRTST test)

CHAPTER IV

RESULTS

The results are presented in four parts. First, the general demographic characteristics of the students in the study are described. Second, the statistical tests of hypotheses for the Perceived Reaction Time and Stopping Time (PRTST) test are provided. Next, the user evaluation descriptive demographic data are described. Finally, the last section describes the students' performance scores on the MM NWX simulation exercise and HAZCUE test. The narrative results are intended as a summary. The accompanying tables provide more detailed information.

Characteristics of the Users

The demographic data presented in this section were collected after the users logged onto the program. Twelve students did not report their demographic information. The users' average age was 15.92 years with a standard deviation of 1.14 years (see Table 6). Sixty-four (57.7%) students were males (see Table 7). The users' average driving experience in an automobile was 0.36 years with a standard deviation of 0.58 and the average tractor driving experience was 2.61 years with a standard deviation of 3.49 (see Table 8).

Table 6

Means, Standard Deviations, and Sample Sizes for Students' age Across Groups (years) (n = 111)

	Group				
	Control	NWX	RTST	NWX + RTST	Group Mean
Mean	15.88	16.65	16.15	15.15	15.92
S. D.	1.21	0.76	0.37	1.21	1.14
n	26	31	20	34	111

Table 7

Gender Category (%) (n = 111)

	Frequency	Percent
Male	64	57.7
Female	47	42.3
Total	111	100.0

Table 8

Means, Standard Deviations, and Sample Sizes for Students' Driving Experience on Automobile and Tractor across Groups (years) (n = 111)

Group	*n*	Vehicle	Mean	SD
Control	26	Car	0.13	0.43
		Tractor	1.62	3.53
NWX	31	Car	0.77	0.62
		Tractor	5.03	3.12
RTST	20	Car	0.35	0.58
		Tractor	0.93	2.12
NWX + RTST	34	Car	0.18	0.45
		Tractor	2.16	3.37

Forty-eight (43.2%) students worked on a farm (see Table 9). The average farm size was 85.7 acres with a standard deviation of 202.13 (see Table 10). Thirty-three (29.7%) students had experience driving a tractor on the highway (see Table 11). Fifteen (13.5%) students had "close call" experiences driving on public roads (see Table 12). Thirteen of these fifteen students were driving a tractor at the time of the "close call" (see Table 13). Three (2.7%) students were involved in collisions while driving on public road (see Table 14). Two (66.7%) of them were driving a motor vehicle at the time of the collision (see Table 15). There was no report of injury for these three collisions.

Table 9

Proportion of Students' who Reported they Worked on a Farm (n = 111)

Worked on a Farm	*n*	frequency %
Yes	48	43.2
No	63	56.8

Table 10

Mean and Standard Deviation for Farm Size in Acres

	Mean	S. D.
Farm Size	85.7	202.13

Table 11

Proportion of Students who Reported Driving Tractors on Public Road (n = 111)

Drive Tractor on Public Road	*n*	frequency %
Yes	33	29.7
No	78	70.3

Table 12

Proportion of Students who Reported "Close Call" Experiences (n = 111)

"Close Call" experience	*n*	frequency %
Yes	15	13.5
No	96	86.5

Table 13

Type of Vehicle involved in students' "Close Calls"

	n	frequency %
Motor Vehicle	2	13.3
Tractor	13	86.7

Table 14

Proportion of Students Involved in Collisions on Public Roads (n = 111)

Collision	*n*	frequency %
Yes	3	2.7
No	108	97.3

Table 15

Type of Vehicle in which Student was Riding when Involved in a Collision

	n	frequency %
Motor Vehicle	2	66.7
Tractor	1	33.3

Tests for PRTST test

The research hypotheses was investigated using a 2 X 2 X 2 repeated measures ANOVA. The variables utilized in the ANOVA were receiving the MM NWX simulation or not, receiving RTST game or not, and PRTST pre- and posttest or three different speed settings (35, 45, and 55 mph). As outlined in Chapter 3, the results for the PRTST test were examined in three parts: Perceived reaction time/distance, perceived stopping time/distance, and whether or not the user could stop the simulated vehicle in time to avoid the collision with the popup objects.

Table 16 presents the results of a 2 X 2 X 2 repeated measures ANOVA (collapsed across three speed settings) for differences in time (pre-test to posttest) for perceived reaction time/distance controlling for the effect of students' receiving the MM NWX simulation (Yes or No) and students' receiving the RTST game (Yes or No). The data in Table 16 were used to determine if there was a statistically significant improvement in mean perceived reaction time/distance from pre-test to posttest as a result of treatments (MM NWX simulation, RTST game, or both). In addition, the degree to which the MM NWX simulation, RTST game, and which speed setting interacted with each other and the observed pre- and posttest perceived reaction time/distance PRTST scores were examined.

Table 17 is similar to Table 16. The difference is that it is used to examining statistical differences for the treatments (MM NWX simulation, RTST game, or both), and three speed settings (35, 45 and 55 mph) for perceived stopping time/distance. Table 18 present the results of a 2 X 2 X 2 repeated measures ANOVA (collapsed across pre and posttest) for differences in speed settings (35, 45, and 55 mph) for proportion of students answering "yes" that they could stop in time to avoid a collision with the simulated car.

Table 19 presents the differences between participants effect of MM NWX simulation, RTST game, or the combination of the two on the repeated measures ANOVA for perceived reaction time/distance for differences in the participants' pre-test and posttest.

Table 20 is similar to Table 19 except that it presents the effect on perceived stopping time/distance. Table 21 lists the between participants effect of MM NWX simulation, RTST game, or the combination of the two on the repeated measures ANOVE for the proportion to "yes" responses to the question asking students if they could stop in time to avoid a collision of the simulated car with the popup objects for three different speed settings.

Table 16

Means, Standard Deviations and Sample Sizes for the Perceived Reaction Time/Distance across Treatment Condition from Pre- to Posttest

Group	*n*	Perceived Reaction Time/Distance			
		Pre-test		posttest	
		Mean	SD	Mean	SD
Control	26	268.20 (67.85)	19.52	225.93 (57.15)	19.96
NWX	31	212.35 (53.72)	18.11	184.73 (46.73)	18.53
RTST	20	210.40 (53.23)	23.17	156.56 (39.61)	23.70
NWX + RTST	34	206.63 (52.27)	18.64	161.67 (40.90)	19.06

Values in parentheses are distances in feet.

Table 17

Means, Standard Deviations and Sample Sizes for the Perceived Stopping Time/Distance across Treatment Condition and from Pre- to Posttest

Group	*n*	Perceived Stopping Time/Distance			
		Pre-test		posttest	
		Mean	SD	Mean	SD
Control	26	340.70 (86.19)	24.29	313.85 (79.40)	23.77
NWX	31	323.28 (81.78)	22.54	377.76 (95.57)	22.05
RTST	20	318.86 (80.67)	28.84	340.76 (86.21)	28.21
NWX + RTST	34	351.12 (88.83)	23.20	367.00 (92.84)	22.69

Values in parentheses are distances in feet.

Table 18

Means, Standard Deviations and Sample Sizes for the Proportion of "Yes" Responses to "Can you stop the car before striking the object?" across Treatment Condition and three Different Speed Settings

		Proportion of "Yes" Responses to "Can you stop the car before striking the object?"					
		35 mph		45 mph		55 mph	
Group	*n*	Proportion	SD	Proportion	SD	Proportion	SD
Control	26	.68	.06	.77	.04	.82	.04
NWX	31	.76	.05	.91	.04	.93	.03
RTST	20	.66	.07	.73	.05	.81	.04
NWX + RTST	34	.57	.05	.68	.04	.85	.04

Table 19

Test for Effects Pooled Across Treatment Groups for Perceived Reaction Time/Distance

Treatment	*F* value	*p*
NWX	1.87	.17
RTST	4.97	.03†
NWX + RTST	1.98	.16

†Significant at alpha = .05

Table 20

Test for Effects Pooled Across Treatment Groups for Perceived Stopping Time/Distance

Treatment	*F* value	*p*
NWX	1.38	.24
RTST	0.06	.80
NWX + RTST	0.02	.89

Table 21

Test for Effects Pooled Across Treatment Groups for Proportion of "Yes" Responses to "Can you stop the car before striking the object?"

Treatment	*F* value	*p*
NWX	0.90	.35
RTST	5.46	.02†
NWX + RTST	3.24	.08

†Significant at alpha = .05

Perceived Reaction Time/Distance

A 3 X 2 X 2 X 2 repeated measures ANOVA on the dependent variable of Speed did not yield significant results. Therefore a 2 (received MM NWX simulation or not) X 2 (received RTST game or not) X 2 (pre-, posttest) repeated measures was performed (collapsed across three speed settings). Tables 16 and 19 present the results of a mixed 2 X 2 X 2 ANOVA to determine whether there were effects of treatments and time differences (pre-, posttest) on perceived reaction time/distance. The results yielded a significant difference pre- to post [$F(1, 238) = 17.49$, $p < .01$] mean perceived reaction time/distance decrease from pre-test to posttest. In addition, there is a significant difference for participants who received the RTST game treatment, $F(1, 119) = 4.97$, $p = .03$. For groups that received the RTST game as treatment, their mean perceived reaction time/distance are smaller than for those students who did not receive the RTST game. The three-way interaction of time (pre-, posttest) for perceived reaction time/distance is depicted in Figure 2.

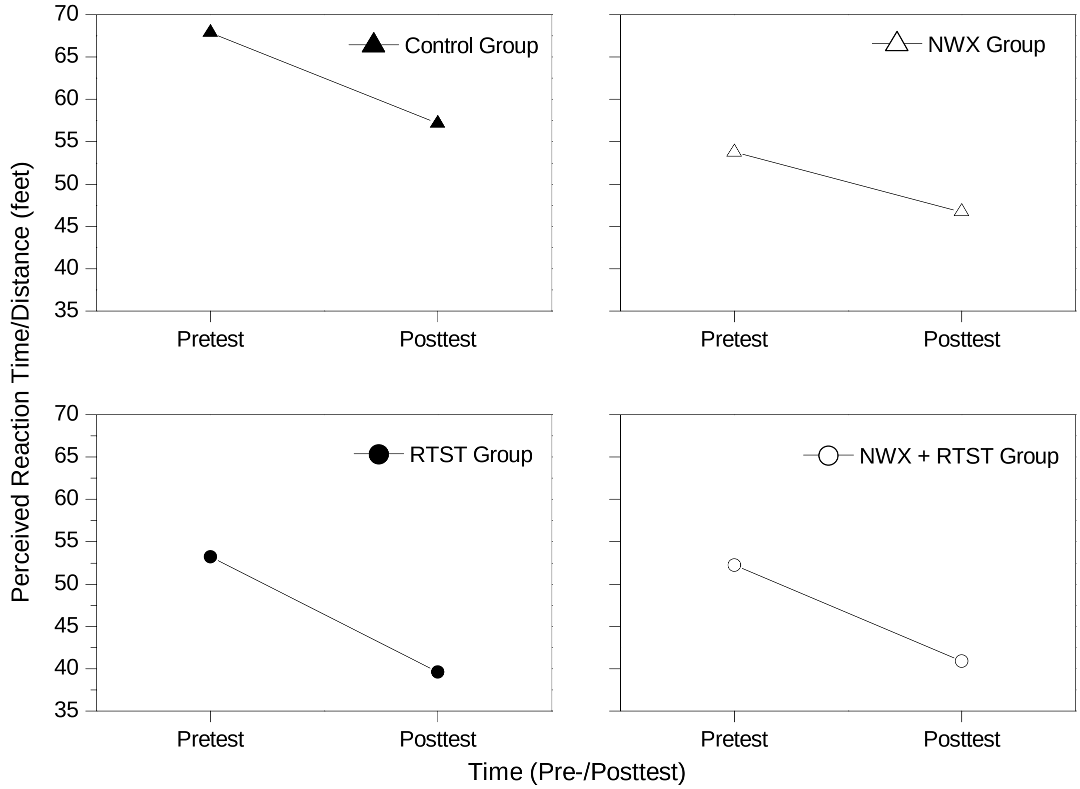

Figure 2. Graph of three-way interaction (pre-test to posttest) for perceived reaction time/distance

Perceived Stopping Time/Distance

A 3 X 2 X 2 X 2 repeated measures ANOVA on the dependent variable of Speed did not yield significant results. Tables 17 and 20 lists the result for a 2 (received MM NWX simulation or not) X 2 (received RTST game or not) X 2 (pre-, posttest) repeated measures ANOVA that was performed (collapsed across three speed settings). The results indicated a significant interaction between time (pre-, post test), NWX, and RTST, $F(1, 119) = 4.5$, $p = .04$, for mean perceived stopping distance for the group receiving both the MM NWX simulation and RTST game in smaller pre-test estimates than posttest estimates. This indicates that after participants received both treatments (NWX and RTST) they predicted longer stopping distance. The three-way interaction of receiving the MM NWX simulation (yes/no), the RTST game (yes/no), and time (pre-, posttest) for perceived stopping time/distance is depicted in Figure 3.

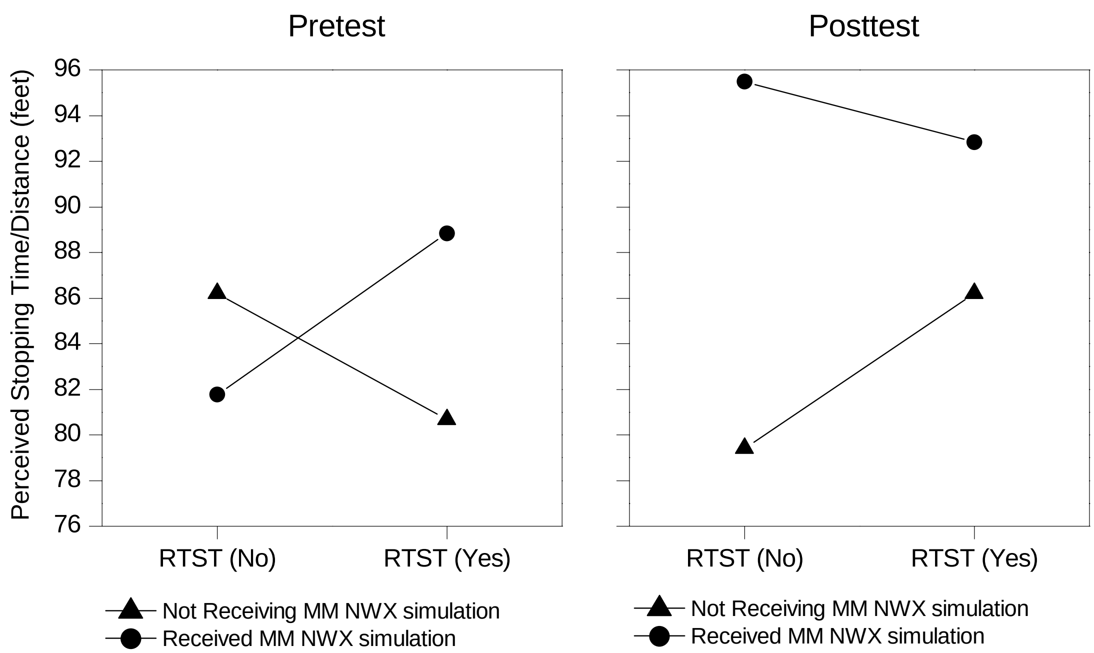

Figure 3. Graph of three-way interaction (receiving MM NWX simulation X receiving RTST game X time) for perceived stopping time/distance

Proportion "Yes" Responses to "Can you stop the car before striking the object?"

A 3 X 2 X 2 X 2 repeated measures ANOVA on the dependent variable of time did not yield significant results. Therefore a 3 (35, 45, or 55 mph) X 2 (received MM NWX simulation or not) X 2 (received RTST game or not) repeated measures analysis was performed (collapsed across pre and post test). A mixed 3 X 2 X 2 ANOVA was conducted to assess the effect of treatments on three different speed settings on the value of the proportion of "Yes" (Yes = 1) responses that indicated a student thought he or she could avoid a collision of the simulated car with objects in its path (see Tables 18 and 21).

The results yielded a significant difference for different speed settings, $F(1, 119) = 48.71$, $p <= .00$, the mean proportion of "Yes" response of the same speed increased from the 35 mph speed setting to 55 mph. However, students who received the RTST game treatment had a significantly smaller proportion of "Yes" response to the question "Can you stop the car before striking the object?" in the posttest than those who did not receive RTST game as treatment, $F(1, 119) = 5.46$, $p = .02$. The three-way interaction of receiving the RTST game (yes/no), time (pre- and posttest), and speed (35, 45, and 55 mph speed settings) is depicted in Figure 4.

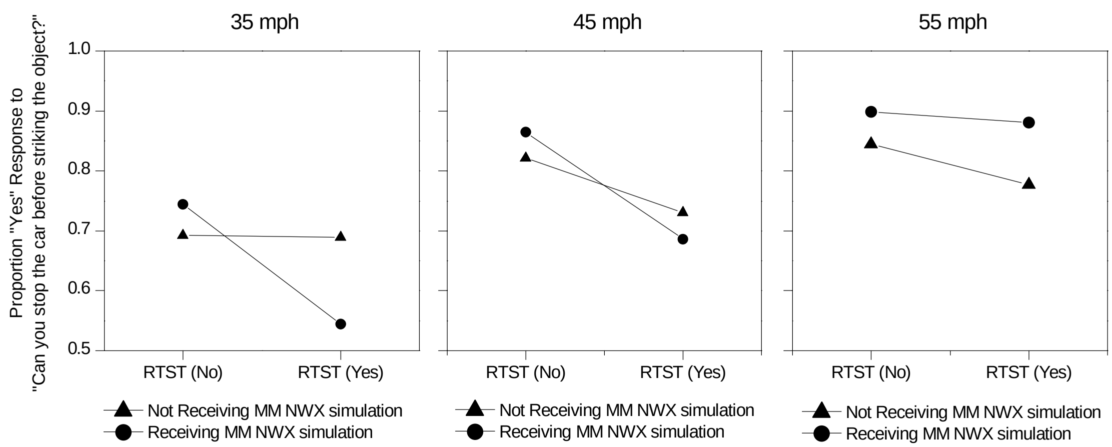

Figure 4. Graph of three-way interaction (receiving MM NWX simulation X receiving RTST game X speed) for proportion "Yes" response to "Can you stop the car before striking the object?"(collapsed across time)

Users' Judgment of the Validity, Relevance, Quality, and Utility of the Program

Each user in the treatment groups (MM NWX simulation only, RTST game only, and MM NWX simulation + RTST game) evaluated the validity, relevance, quality, and utility of the program in the last section of the program using the user evaluation questionnaire shown in Appendix H. Tables 22 through 24 present the evaluation data for the program from each of the treatment groups. Inspection of these tables reveals that the users judged the program quite favorable. Although there were differences among the different groups, the large majority of users felt that the program (a) depicted a real-life situation, (b) taught them how to prevent collisions, (c) provided useful safety information regarding ROPS and farm tractors, (d) helped them to be a more alert and cautious driver, (e) was an enjoyable activity, (f) was easy to use, (g) and easy to read. Details of the ratings of each group on each of these dimensions are found in Tables 22 through 24.

Table 25 lists the percentage of user who agreed with each evaluative statement for each treatment group. The values in Table 25 were computed by summing the percent-agreement frequency values under the Likert scale values 4 (strongly agree) and 3 (agree) presented in Tables 22 through 24. Inspection of these data reveal that the NWX group rated the program higher than the others (approximately 90% agreement for NWX group versus 70% for other treatment groups). The majority of the students agree that the exercise was not too long to complete (approximately 80% agreement). The large majority of students also agreed that they did not have chance to discuss and share their ideas with other students (approximately 50% agreement).

Table 26 through 28 lists the planned contrast comparisons between the treatment groups (NWX group vs. RTST group, NWX group vs. NWX + RTST group, and RTST group vs. NWX + RTST group) for each of the user evaluation questionnaire items. Inspection of these tables revealed that the users in NWX group judged the program significantly higher than other treatment groups on most items in the evaluation questionnaire. However, there were no significant differences for the students' rating of the program when compared with RTST group and NWX + RTST group. Observation of the four study groups also suggested that the students in the

NWX group were more engaged in the simulation. As depicted in Table 8, the mean years of driving experience, both car and tractor, for the NWX group is higher than the other three groups. In addition, one of the students from the NWX group was involved in a collision similar to the one depicted in the MM NWX simulation. These factors may account for the higher rating of user evaluation questions by the students who complete the MM NWX simulation.

Table 22

Students' Ratings of the Program's Validity, Relevance, Quality, and Utility for Groups that Completed the MM NWX Simulation (frequency %) (n = 33)

Item Content	strongly disagree 1	2	3	strongly agree 4	mean	S.D.
valid content/realistic	3.0	6.1	36.4	54.5	3.4	0.75
will help me to prevent collisions	3.0	3.0	30.3	63.6	3.5	0.71
ROPS can prevents injury	3.0	6.1	27.3	63.6	3.5	0.76
farmers should have ROPS	3.0	3.0	21.2	72.7	3.6	0.70
farmers should always wear seat belts	3.0	6.1	21.2	69.7	3.6	0.75
helped me to be a more alert and cautious	3.0	0.0	39.4	57.6	3.5	0.67
exercise took too long to complete	39.4	60.6	0.0	0.0	1.6	0.50
I liked doing the exercise	2.9	8.6	42.9	45.7	3.3	0.76
the exercise directions were clear	2.8	5.6	52.8	38.9	3.3	0.70
the drawings were easy to understand	2.8	0.0	41.7	55.6	3.5	0.65
the animated sequence was helpful	2.8	0.0	38.9	58.3	3.5	0.65
the feedback was accurate and helpful	0.0	2.8	38.9	58.3	3.6	0.56
the story is easy to read	2.8	0.0	33.3	63.9	3.6	0.65
I had chance to discuss and share my ideas.	8.3	44.4	30.6	16.7	2.6	0.88
I know what to do to prevent collisions	2.8	2.8	41.7	52.8	3.4	0.69
I will be more careful when driving in farm country	2.8	0.0	41.7	55.6	3.5	0.65

Table 23

Students' Ratings of the Program's Validity, Relevance, Quality, and Utility for Groups that Completed the RTST Game (frequency %) (n = 22)

Item Content	strongly disagree 1	2	3	strongly agree 4	mean	S.D.
valid content/realistic	0.0	18.2	40.9	40.9	3.2	0.75
will help me to prevent collisions	13.6	40.9	31.8	13.6	2.5	0.91
helped me to be a more alert and cautious	9.1	22.7	54.5	13.6	2.7	0.83
exercise took too long to complete	9.1	63.6	18.2	9.1	2.3	0.77
I liked doing the exercise	9.1	40.9	36.4	13.6	2.5	0.86
the exercise directions were clear	0.0	27.3	45.5	27.3	3.0	0.76
the drawings were easy to understand	0.0	22.7	31.8	45.5	3.2	0.81
the animated sequence was helpful	9.1	13.6	50.0	27.3	3.0	0.90
the feedback was accurate and helpful	4.5	27.3	50.0	18.2	2.8	0.80
I had chance to discuss and share my ideas.	22.7	36.4	27.3	13.6	2.3	0.99
I know what to do to prevent collisions	9.1	22.7	59.1	9.1	2.7	0.78
I will be more careful when driving in farm country	13.6	18.2	45.5	22.7	2.8	0.97

Table 24

Students' Ratings of the Program's Validity, Relevance, Quality, and Utility for Groups that Completed the MM NWX Simulation and the RTST Game (frequency %) (n = 34)

Item Content	strongly disagree 1	2	3	strongly agree 4	mean	S.D.
valid content/realistic	20.6	11.8	23.5	44.1	2.9	1.19
will help me to prevent collisions	11.8	23.5	32.4	32.4	2.9	1.02
ROPS can prevents injury	8.8	11.8	26.5	52.9	3.2	0.99
farmers should have ROPS	8.8	8.8	29.4	52.9	3.3	0.96
farmers should always wear seat belts	11.8	5.9	14.7	67.6	3.4	1.04
helped me to be a more alert and cautious	8.8	20.6	35.3	35.3	3.0	0.97
exercise took too long to complete	29.4	41.2	23.5	5.9	2.1	0.89
I liked doing the exercise	8.8	26.5	35.3	29.4	2.9	0.96
the exercise directions were clear	6.7	23.3	23.3	46.7	3.1	0.99
the drawings were easy to understand	0.0	16.7	30.0	53.3	3.4	0.76
the animated sequence was helpful	6.7	16.7	23.3	53.3	3.2	0.97
the feedback was accurate and helpful	3.3	23.3	36.7	36.7	3.1	0.87
the story is easy to read	6.7	13.3	40.0	40.0	3.1	0.90
I had chance to discuss and share my ideas.	20.0	30.0	33.3	16.7	2.5	1.01
I know what to do to prevent collisions	13.3	10.0	43.3	33.3	3.0	1.00
I will be more careful when driving in farm country	6.7	13.3	33.3	46.7	3.2	0.92

Table 25

Percent of Students' Agreeing with Evaluative Statements about the Program Pooled Across the Three Groups who Completed the MM NWX Simulation and/or the RTST Game

	group		
Item Content	NWX	RTST	NWX + RTST
valid content/realistic	90.9	81.8	67.6
will me help to prevent collisions	93.9	45.5	64.7
ROPS can prevents injury	90.9	68.2	79.4
farmers should have ROPS	93.9	77.3	82.4
farmers should always wear seat belts	90.9	81.8	82.4
helped me to be a more alert and cautious	97.0	68.2	70.6
exercise took too long to complete	0.0	27.3	29.4
I liked doing the exercise	88.6	50.0	64.7
the exercise directions were clear	91.7	72.7	70.0
the drawings were easy to understand	97.2	77.3	83.3
the animated sequence was helpful	97.2	77.3	76.7
the feedback was accurate and helpful	97.2	68.2	73.3
the story is easy to read	97.2	77.3	80.0
I had chance to discuss and share my ideas.	47.2	40.9	50.0
I know what to do to prevent collisions	94.4	68.2	76.7
I will be more careful when driving in farm country	97.2	68.2	80.0

Table 26

Mean Differences for Each User Evaluation Item Between Groups who Completed only the MM NWX Simulation and only the RTST Game

Item content	Group Mean NWX	Group Mean RTST	*t*	*p*
valid content/realistic	3.4	3.2	0.758	.451
will me help to prevent collisions	3.5	2.5	4.461	.000†
ROPS can prevents injury	3.5	3.1	1.560	.122
farmers should have ROPS	3.6	3.1	2.196	.031†
farmers should always wear seat belts	3.6	3.5	0.310	.757
helped me to be a more alert and cautious	3.5	2.7	3.439	.001†
exercise took too long to complete	1.6	2.3	-3.307	.001†
I liked doing the exercise	3.3	2.5	3.281	.001†
the exercise directions were clear	3.3	3.0	1.243	.217
the drawings were easy to understand	3.5	3.2	1.372	.174
the animated sequence was helpful	3.5	3.0	2.536	.013†
the feedback was accurate and helpful	3.6	2.8	3.703	.000†
the story is easy to read	3.6	3.1	2.282	.025†
I had chance to discuss and share my ideas.	2.6	2.3	0.921	.360
I know what to do to prevent collisions	3.4	2.7	3.393	.001†
I will be more careful when driving in farm country	3.5	2.8	3.208	.002†

†Significant at alpha = .05

Table 27

Mean Differences for Each Student Evaluation Item Between Groups who Completed only the MM NWX Simulation and both the MM NWX Simulation + the RTST Game

	Group Mean			
Item content	NWX	NWX + RTST	*t*	*p*
valid content/realistic	3.4	2.9	2.221	.029†
will me help to prevent collisions	3.5	2.9	3.189	.002†
ROPS can prevents injury	3.5	3.2	1.298	.198
farmers should have ROPS	3.6	3.3	1.839	.069
farmers should always wear seat belts	3.6	3.4	0.893	.374
helped me to be a more alert and cautious	3.5	3.0	2.677	.009†
exercise took too long to complete	1.6	2.1	-2.53	.013†
I liked doing the exercise	3.3	2.9	2.225	.029†
the exercise directions were clear	3.3	3.1	0.871	.386
the drawings were easy to understand	3.5	3.4	0.735	.465
the animated sequence was helpful	3.5	3.2	1.426	.158
the feedback was accurate and helpful	3.6	3.1	2.687	.009†
the story is easy to read	3.6	3.1	2.283	.025†
I had chance to discuss and share my ideas.	2.6	2.5	0.377	.707
I know what to do to prevent collisions	3.4	3.0	2.327	.022†
I will be more careful when driving in farm country	3.5	3.2	1.448	.151

†Significant at alpha = .05

Table 28

Mean Differences for Each Student Evaluation Item between Groups who Completed only the RTST Game and both the MM NWX Simulation + the RTST Game

Item content	Group Mean RTST	NWX + RTST	*t*	*p*
valid content/realistic	3.2	2.9	1.221	.225
will me help to prevent collisions	2.5	2.9	-1.639	.105
helped me to be a more alert and cautious	2.7	3.0	-1.068	.288
exercise took too long to complete	2.3	2.1	1.067	.289
I liked doing the exercise	2.5	2.9	-1.305	.195
the exercise directions were clear	3.0	3.1	-0.432	.667
the drawings were easy to understand	3.2	3.4	-0.676	.501
the animated sequence was helpful	3.0	3.2	-1.189	.238
the feedback was accurate and helpful	2.8	3.1	-1.203	.232
I had chance to discuss and share my ideas.	2.3	2.5	-0.555	.58
I know what to do to prevent collisions	2.7	3.0	-1.222	.225
I will be more careful when driving in farm country	2.8	3.2	-1.817	.073

Students' Performance Scores

There are three sets of performance scores for the study: the MM NWX exercise performance scores, the RTST game scores, and HAZCUE scores. Table 29 lists the mean scores and standard deviation for the MM NWX simulation. Table 30 presents the mean HAZCUE tests performance score. The performance score percentage for the MM NWX simulation in NWX group is 72.69 versus 58.92 in NWX + RTST group with standard deviations of 16.31 and 18.45, respectively. A univariate ANOVA was performed to test for significance differences on the MM NWX exercise performance scores between NWX and NWX + RTST group. The results yielded a significant difference, $F(1, 69) = 10.96$, $p = .001$, NWX group performed better than NWX + RTST group on the MM NWX exercise.

Table 29

Mean, Standard Deviation, and Sample Size for MM NWX Simulation Performance Score by Treatment Group

Group	*n*	Mean	S.D.
NWX	36	72.69	16.31
NWX + RTST	34	58.92	18.45

Table 30

Means, Standard Deviations and Sample Size for HAZCUE Performance score by Treatment Group

Group	*n*	Mean	S.D.
Control	31	38.90	2.22
NWX	35	53.95	2.14
RTST	18	47.50	5.20
NWX + RTST	31	54.36	3.85

A univariate ANOVA was performed to test for significance differences on the HAZCUE performance score for groups that received either the MM NWX simulation or the RTST game. Inspection of the results reveals that groups that received MM NWX simulation performed significantly better on recognizing collision hazards than the control group and RTST group that did not complete the MM NWX simulation exercise,

$F(1, 115) = 11.17$, $p = .00$. The HAZCUE performance score for each group is depicted in Figure 5.

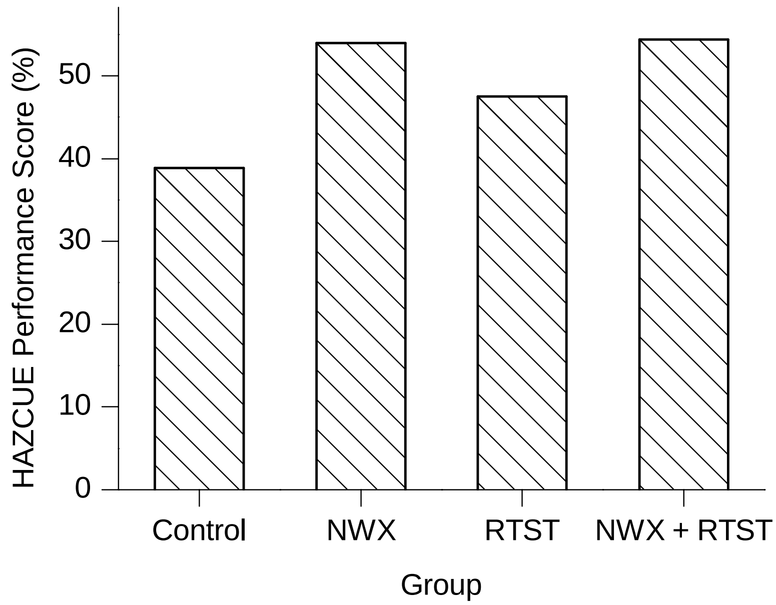

Figure 5. Graph of HAZCUE performance score for each group

Mean Differences comparisons between the treatment groups (NWX group vs. RTST group, NWX group vs. NWX + RTST group, and RTST group vs. NWX + RTST group) for the HAZCUE test were performed. Inspection of the results revealed significant differences in favor of groups that received the MM NWX simulation as treatment (e.g., NWX group vs. control group and NWX + RTST group vs. control group). Mean HAZCUE test performance score for NWX group (Mean = 53.95) was greater than control group (Mean = 38.90). Mean HAZCUE test performance score for NWX + RTST group (Mean = 54.36) is greater than control group (Mean = 38.90).

The performance score for the RTST game consisted of three parts: the number of times the simulated car hit the object, the number of times the simulated car avoided hitting the object, and the average reaction time. Table 31 lists the mean, standard deviation, and the sample size for the number of times the simulated car in the RTST game hit an object. Table 32 presents the mean, standard deviation, and the sample size for the number of times the simulated car in the RTST game avoided an object. Table 33 presents the mean, standard deviation, and the sample size for reaction time in the RTST game. A series of one-way ANOVA were performed to examine if there were significant differences between groups (RTST group and NWX + RTST group) on the number of times the simulated car hit an object, the number of times the simulated car avoided an object, and the reaction time. Inspection of these results ($Mean_{NWX + RTST}$ (5.07) > $Mean_{RTST}$ (2.63)) revealed that there was a significant difference between the RTST group and the NWX + RTST group for the simulated car avoiding an object for the speed setting of 35 mph, $F(1, 43) = 4.17$, $p = 0.047$. (See Table 32). Inspection of the results also suggests that the reaction time remains the same regardless of changes in speed (approximately 0.34 second).

Observation of the RTST game suggested the students loved to play this game. Some of the students tried to avoid an object in the RTST game by hitting the space bar constantly once the simulated car started moving. Prior to the activity, they were told that the program would not responded to the premature braking action (hitting the space bar), but they persisted anyway.

Table 31

Means and Standard Deviations for Number of Times the Simulated Car hit an Object in the RTST Game for Three Speed Setting

Speed Setting	Group	*n*	Mean	S. D.
35 mph	RTST	16	2.13	2.90
	NWX + RTST	28	2.18	1.87
45 mph	RTST	10	5.30	3.56
	NWX + RTST	25	6.64	4.22
55 mph	RTST	14	4.36	2.37
	NWX + RTST	24	7.63	6.46

Table 32

Means and Standard Deviations for Number of Times the Simulated Car Avoided an Object in the RTST Game in Three Speed Setting

Speed Setting	Group	*n*	Mean	S. D.
35 mph	RTST	16	2.63	2.31
	NWX + RTST	28	5.07	4.45
45 mph	RTST	10	0.10	0.32
	NWX + RTST	25	0.20	0.65
55 mph	RTST	14	0.00	0.00
	NWX + RTST	24	0.04	0.20

Table 33

Means and Standard Deviations for Reaction Time (seconds) in the RTST Game for Three Speeds Setting

Speed Setting	Group	*n*	Mean	S. D.
35 mph	RTST	16	0.46	.47
	NWX + RTST	28	0.34	.18
45 mph	RTST	10	0.34	.27
	NWX + RTST	25	0.32	.15
55 mph	RTST	14	0.25	.12
	NWX + RTST	24	0.34	.25

Exploratory Data Analysis

As it was originally planned, the study did not examine the effects of gender, farming experience, driving experience, and "close call" collision experience. Thus, a series of post-hoc analyses were conducted to examine the effects of these variables on students' performance on the HAZCUE test and PRTST measures.

No significant effects for gender, farming experience, driving experience, or "close call" collision experiences were observed for students' performance scores on either the HAZCUE test or the PRTST measure.

Summary

Limited support was found for research hypothesis 1 that the RTST Group and NWX + RTST Group participants that received the RTST game would perform significantly better on the PRTST posttest than (Control Group and NWX Group) that did not receive the RTST game. Of the three questions in PRTST test, groups who received the RTST game has a significantly lower proportion of "Yes" response to question "Can you stop the car before striking the object?" For perceived stopping time/distance, the only significant result was that the NWX + RTST group predicted a significantly longer stopping distance from pre-test to posttest.

Research hypothesis 2 stated that NWX + RTST Group participants that received both the RTST game and the NWX simulation would score significantly higher on the HAZCUE test than NWX and RTST Groups that received only one (i.e. the NWX simulation or the RTST game respectively), and also better than the Control Group participants on the HAZCUE test. This hypothesis was supported by the significant differences in the HAZCUE performance score. The NWX group and NWX + RTST group had significantly better results on HAZCUE test then groups that did not receive the MM NWX simulation.

Limited support for research hypothesis 3 was observed. This hypothesis stated that the RTST Group students who received only the RTST game would perform significant better on PRTST test item than NWX Group students who received only the NWX simulation, and also better than the Control Group students. Of the three questions in PRTST test, the RTST group had a significant lower "yes" response to "Can you stop the car before striking the object?"

Limited support was found for research hypothesis 4. Control group participants that received neither RTST game nor NWX simulation performed worse than all the treatment groups (NWX, RTST, and NWX + RTST) on both the HAZCUE and PRTST tests. Results approached significance on HAZCUE performance score for groups that received MM NWX simulation (NWX group and NWX + RTST group).

CHAPTER V

DISCUSSION

This study involved two educational interventions. The first was a multimedia narrative simulation exercise “No Way to Meet a Neighbor” (MM NWX) that depicted a highway farm tractor and motor vehicle collision. The second was a computer animated Reaction Time and Stopping Time game (RTST) where students attempted to stop a simulated motor vehicle before it struck objects that popped into its path. The purpose of the study was to (a) determine the effect of the multimedia NWX simulation exercise on students’ defensive driving strategies, (b) determine the effect of the RTST game on students’ accurate estimates of reaction and stopping time distances, and (c) determine the combined effects of both the NWX simulation and the RTST game. Two tests measured the effects of the two instructional interventions on student performance. The first test referred to as the HAZCUE test measured students’ ability to recognize cues of potential collision hazards and selection of defensive driving alternatives to avoid collisions. The second test was the computer administered Perceived Reaction Time and Stopping Time test (PRTST). It measured students’ perception of whether they could stop to avoid a collision at different vehicle speeds as well as their reaction time/distance and stopping time/distance to avoid a collision.

Four hypotheses were investigated. Each hypothesis examined the effects of the RTST game and the MM NWX simulation, either alone or in combination, on students’ learned defensive driving skills as measured by the PRTST posttest or the HAZCUE test. The study results indicated that both the RTST game and the NWX simulation offered some benefit to students; all four hypotheses were supported to some degree. The first hypothesis proposed that students who received the RTST game either alone or with the NWX exercise would score better than students not receiving the RTST as measured by the PRTST posttest. Statistically significant results were obtained on two indicators: accurate response (fewer unrealistic "yes" responses) to the question, "Can you stop the car before striking the object?", and students in the group that received both MM NWX simulation and the RTST game predicted longer stopping distances/times during the posttest.

The second hypothesis proposed that students receiving both the RTST game and the MM NWX simulation would score higher on the HAZCUE test than students who received either one or the other. This hypothesis was strongly supported with students receiving both treatments performing significantly better on the HAZCUE test than those receiving only one treatment.

The third hypothesis proposed that use of the RTST game alone would significantly improve students' PRTST posttest performance compared to the group that received the MM NWX simulation as treatment. The results revealed that the groups that received the RTST game scored significantly more accurately than groups that received the MM NWX simulation on the PRTST question "Can you stop the car before striking the object ?"

Finally, the fourth hypothesis examined the effect of not applying any of the treatments. It proposed that control participants receiving neither the RTST game or the MM NWX exercise would perform worse on posttest measures than participants receiving at least one of the treatments. Results revealed that there was a statically significant improvement on HAZCUE measurement for students receiving either the

MM NWX simulation alone, or combination of the MM NWX simulation and the RTST game than control group students who did not.

Findings

Groups that received the MM NWX simulation that focused on hazard recognition and defensive driving strategies, performed better on a test of those skills (the HAZCUE test) than groups that did not complete the MM NWX simulation. Groups exposed to the RTST game had significantly fewer "yes" responses to the question, "Can you stop the car before striking the object?", than groups not exposed to the RTST game on the posttest. These findings indicate that as expected, that the RTST game, aimed at improving students' ability to lower "yes" responses to the PRTST posttest question - "Can you stop the car before striking the object?", did work. Likewise, the MM NWX simulation, aimed at improving students' recognition of cues of potential collision hazards and selection of defensive driving alternatives improved students' score on the HAZCUE posttest.

However, there were no pre- and posttest between groups significant differences in students' estimates of the time/distance the simulated automobiles would travel during the reaction time/distance needed to "hit the brakes" or the stopping time/distance once the brakes were applied. Thus while the RTST game did make students aware that they were less likely to be able to stop a simulated vehicle before it collided with an object that suddenly appeared in its pathway, the game did not change students' estimates of reaction time/distance and stopping time/distance. Observations made during data collection revealed that students were all hurrying to get to the next trial to see if they could avoid a collision. They therefore paid little attention to the reaction time feedback information provided by the game after each collision occurred. For each trial, after the collision occurred, two ghost images were displayed on the monitor to show the relationship between increasing speed of the vehicle and reaction time/distance and vehicle speed and stopping time/distance. Once the brakes were applied, speed increases the reaction time/distance and stopping time/distance. Students were instructed that there would be additional information about reaction time/distance and stopping time/distance after the collision, the two ghost car images for reaction time/distance and stopping time/distance that were displayed. However, students tended to ignore this information because they were eager to try again to stop the simulated vehicle. As a result, the students did not learn the relationship between vehicle speed and reaction time/distance and vehicle speed and stopping time/distance from the RTST game. This may explain why there was no significant improvement in predicting reaction time/distance and stopping time/distance after students played the RTST game.

In addition, contrary to expectations, the mean proportion of "Yes" responses to question, "Can you stop the car before striking the object?" in the PRTST pre- to posttest increased as speed increased. This outcome may be because of misconceptions about the concept of speed. As described by McCloskey (1983) "people develop on the basis of their everyday experience remarkable well-articulated naive theories of motion. These theories provide not only descriptions of, but also causal explanations for, the behavior of moving objects" (p. 321). Most of the students in this study were just getting their licenses or learning how to drive. Most students in the study thought they could stop the vehicle as soon as they stepped on the brake. Most believed that they could stop in time to avoid a collision, no matter what the speed of the simulated vehicle.

Groups that completed the MM NWX simulation treatment performed better on the HAZCUE test, probably because the simulation focused on recognizing and anticipating circumstances that can lead to collisions between farm machinery and automobiles. The purpose of the RTST game was to demonstrate the concept of reaction time/distance and stopping time/distance after the vehicle brakes are applied. Therefore, experiencing the RTST game should not have, and did not, result in students improved performance scores on the HAZCUE test.

Limitations and Recommendations

A number of limitations influenced this study and the data collected. Each limitation and recommendations for its remedy are briefly presented.

This study was limited its sample size because of the time and budget constraints. In addition, because the study involved collecting data from four senior classes in four different rural schools, it was realized at the beginning of this study that the amount of data available for collection would be limited to the availability of the students. This was because often school activities during the senior year, (KERA performance test, a SAT exam, photo taking for the yearbook, etc.) resulted in a reduction of students who completed the program.

A second limitation of the study involved the low completion rates for groups exposed to MM NWX simulation. A problem in the MM NWX simulation contributed to this problem. The program provided no indications of what questions had been answered and how many questions remained to be answered. Therefore, some students exited the MM NWX simulation session without knowing there were questions left unfinished. The program should be modified so that students know exactly where they are and how many questions remain to be completed. In addition, the program should include a safe guard mechanism to prompt students if they attempt to exit the simulation before they have completed it.

A third limitation of the study was the instrumentation. There were two major problems related to students' answering the PRTST test. First, answering a question in the PRTST test required the student to click on and drag the simulated car to a location on the screen representing reaction distance and to click on and drag the simulated car again and move it forward to represent the distance traveled after the brakes were applied. In some cases, when students were using a touch pad instead of a mouse, they clicked on the simulated car and either forgot to drag it to the estimated distance or started to drag it but released the touch pad prematurely. This provided faulty estimates. Second, due to a limitation of the program, after the students clicked and started dragging the simulated car across screen, the program lost track of the simulated car if the mouse moved too fast. This resulted in errors in recording students' predictions of both perceived reaction distances and perceived stopping distances. In the future, the program should be modified so that students use the arrow keys on the keyboard to move the simulated car forward or backward and then press enter to estimate the distance traveled.

Another limitation of the measurement instrument is the way the program was delivered. During data collection, dealing with the schools' computer network and computer systems was a major hurdle. There were data collection problems during the pilot study. These problems were addressed and the MM NWX simulation, RTST game, and PRTST program were modified to accommodate these issues. However, more problems surfaced during the actual data collection. The data collection consisted of two stages. First, the CDROM program was tested a week prior to the data collection in each school to see if the program ran properly. After the initial test, corrections were made to the program as needed to ensure proper data collection. The actual data collection started a week after the initial test. During that week interval, one of the schools changed its computer network. This made the students unable to login to the data collection server and created a threat of losing the data for that school. In the future implementation the program should be modified to be delivered through the Internet instead of by CDROM. Moving the program to the Internet would reduce the compatibility problems caused by changes and variations in schools' network configurations. To run the program, schools would need only Internet connections and computers able to run Internet browsers.

A fourth limitation of the study involved the selection of schools. Although selection was controlled for by randomly assigning schools into experimental and control groups, there remains a possible threat to external validity concerning population from which the experimental and control groups were selected, e.g., the students from the experimental and control groups may have differed in reading ability, demographics, or in other ways.

A fifth limitation of the study involved reactive arrangements, students not knowing what they were to do and why until they had completed the activities. Lesson plans and introductory materials developed for instructional condition did not explain how the activity would be beneficial to the students. Observations made during data collection suggested that most of the student did not know what they were supposed to do and what the benefits of completing the task were. In addition, after the pre-test activities, there was no follow-up information for the treatment groups explaining what could be learned from the activities they had just done. Namely, there was no explanation of the relationship between speed and response time/distance and speed and stopping time/distance for the groups receiving the RTST game. Future implementation of the materials for instructional purposes should provide an introduction session prior to the program. During the introduction, an explanation should provide to students with an explanation of the activities and their importance. In addition, after both the pre-test and instructional treatments (MM NWX simulation and/or RTST game), feedback session should be conducted and correct and incorrect actions reviewed. Students should also discuss how the scenarios depicted could happen to them and the decisions and behaviors that can prevent similar collisions in their communities.

Summary and Conclusions

As Sanders and McCormick (1993) pointed out, young inexperienced drivers tend to receive less information from the periphery of the visual field. While following a car, young drivers tend to focus on the center of the road, to the car just ahead of them, and spend less time looking at traffic signage. This places young inexperienced drivers at higher risk of collisions because they fail to attend to a wider range of cues related to defensive driving. This study looked at ways to increase students' awareness of visual cues during driving, accuracy in estimating reaction time/distance and stopping time/distance, and use of defensive driving skills to reduce farm and non-farm vehicle collisions on rural roads. This study also found that certain skills, such as awareness of the difficulty for avoiding a collision and awareness of roadway hazards could be improved with classroom teaching methods. Unfortunately, other skills, such as students' awareness of increasing stopping time/distance with increasing vehicle speed, and the ability to predict reaction time/distance, may be more difficult to address. Some of the characteristics of inexperienced teenager drivers as described by McCloskey's (1983) naive theory of motion may place high school students at higher risk of collision and make it harder for them the to comprehend distance traveled during reaction time and braking time.

Even with these limitations, the students did benefit from the program. Those who completed the MM NWX simulation became more aware of hazard cues on the roadway and more aware of the difficulty of avoiding collisions with farm equipment. In addition, although not providing the breadth of benefits that this study hoped for, the RTST game did increase students' awareness that they might not be able to stop a motor vehicle in time to avoid a collision when an object pops into a roadway. This provides encouragement for continuing research that addresses factors related to students' understanding of vehicle velocity and its effect on the ability to stop. In addition, programming changes to the MM NWX simulation and PRTST test computer program and interface including adding an introduction and improved feedback for the program and lesson plan could significantly increase the benefits received from this method of instruction.

APPENDICES

Appendix A

Letter to School Principals

Dear Sir or Madam:

I am a PhD candidate from the University of Kentucky. Drs. Henry Cole and Joan Mazur are my dissertation advisors. As Dr. Mazur mentioned in her initial phone call, I am sending this letter to provide more details about my dissertation. Shortly, we will be contacting you to schedule, at your convenience, a visit to your school to confirm plans, have any needed discussions with your technology coordinator, and answer any questions you may have.

My dissertation includes an interactive CD-ROM computer program with a series of simulations and activities about collisions between automobiles and farm equipment on rural highways. The program teaches defensive driving skills to avoid collisions and the economic and social costs of these events. The program will take approximately 90 minutes spread over a two-day period. The activities for this research have many links to the Core Content curriculum of junior and senior high school students. We will work with teachers to integrate the content of the instructional program and the data collection procedures into regular classroom instruction. I would like to collect the data in fall 2004, from mid-September to mid-October, as your scheduling permits.

The computer program begins by asking questions about your students' age, gender, and driving experience. Then short simulations and games show a car driving on a highway with objects popping into the path of the car. The student estimates how fast he or she can stop to avoid hitting the objects. Later the student plays a game where he or she uses the computer keyboard space bar as a brake to try to stop the car before it collides with an object. Then he or she is asked to work through a short story about a collision between a car and a farm tractor. During the story the student is asked questions about what he or she thinks the automobile driver can do to avoid a collision.

If the student agrees, his or her answers to these questions will be placed in a computer database. No information that can identify the student or any other student will be included in the data file. Participating in this study may teach students defensive driving skills to prevent highway collisions. The program also teaches that driving safely is part of good citizenship that contributes to community well being. Your students' participation also will help teachers and researchers learn new ways to teach critical thinking skills.

I look forward to working with you and your students. I will contact you in two weeks to schedule a meeting at your school. If you have questions, my phone number at the University of Kentucky is 859-323-1100 ext. 80470. The phone has voice mail so you can leave a message if you wish.

Sincerely,

Bor Chyi Lin

CC: Dr. Henry Cole, Dr. Joan Mazur

Appendix B

Letter to IRB for waiver of documentation of informed consent

July 10, 2004
To: Institutional Review Board
From: Borchyi Lin
Re: Waiver of Informed Consent

For a number of reasons I am requesting a waiver of documentation of informed consent for my doctoral dissertation study. First, my study is designed so that the subjects who participate will be completely anonymous. Obtaining signed consent forms would compromise this anonymity. In addition, if informed consent forms were collected from the subjects, I would have no way of knowing which students who completed the computer program as part of their classroom assignment had completed a consent form or had not done so. Thus, I have incorporated the relevant points of informed consent in the attached cover letter for each research subject. In addition, the initial screen of the program will ask the subject for his or her consent for me to use his or her performance data for my dissertation study. Subjects completing the program are high school students. They will complete the interactive computer program about defensive driving on rural highways as part of a lesson assigned by their regular classroom teacher. Consent is not required for students to complete the lesson assigned by the teacher, but consent is required for me to collect and analyze each student's performance data.

The study is designed so that the researchers or anyone else who sees the subjects' answers (demographic and performance data) cannot identify the subjects. An encryption algorithm accomplishes this. Before students log into the program they will see the initial screen that seeks their consent to have their demographic and performance data collected and analyzed by me for my dissertation study. If the student agrees, he or she will so indicate. The student will then log in with his or her name and a self-selected four-digit personal identification number (PIN). Based on the name and PIN provided by the subjects; the program then creates a unique encryption string. This encryption string can only be decrypted with two decryption keys: subjects' name and PIN (known only to the student). The unique encryption string is then used as the identifier for the subjects' whose demographic and performance data will be included on the database. This encryption method, that ensures complete student anonymity, is demonstrated in Table 1 below.

Table 1: Encryption procedure for ensuring student anonymity

User Name (by the subjects)	PIN (by the subjects)	Encrypted string (by the program)	User ID (by the program)
Henry Cole	1111	]<#;V\2%]L;1P```	1
Borchyi Lin	1234	_\G%S]7?WHSQS]D`	2

For those students who agree to have their data used, the following information is then sent to the database: age, gender, driving experiences, and game and computer simulation scores. There is no record of subject's name or identity in the data file. Subject's identity will remain anonymous.

Because the activity is part of an assigned lesson, the teachers involved will want a record of their students' performance for grading purposes. Students who do not consent to have their data used for my study may still complete the program. They (and their teachers) can see their performance scores displayed at the end of the program. However, the data from these students will not be included in the database for my dissertation study.

Sincerely,

Borchyi Lin, PhD Candidate, Educational Psychology

Note from Mr. Lin's Doctoral Dissertation Director

I have examined and discussed these procedures with Mr. Lin. His encryption method will provide a database in which each student will be completely anonymous. Give the relatively large sample size it will be impossible to identify students in terms of patterns of the limited number of demographic characteristics or by collected or by any other means.

Sincerely,

Henry P. Cole, Ed.D,

Professor, Educational Psychology

Professor, Preventive Medicine & Environmental Health

Appendix C

Letter to Students and Parents

Date ______________________

Dear Parent/Guardian:

We request that your child participate in computer program that includes a series of simulations and activities about collisions between automobiles and farm equipment on rural highways. The program teaches defensive driving skills to avoid collisions. The program will take approximately 90 minutes spread over a two-day period. The activity is being assigned as part of your child's regular class work.

The program begins by asking questions about your child's age, gender, and driving experience. Then short simulations and games show a car driving on a highway with objects popping into the path of the car. The student is asked to estimate how fast he or she can stop to avoid hitting the objects. Later the student plays a game where he or she use the computer keyboard space bar as a brake to try to stop the car before it collides with an object. Then the student is asked to work through a short story about a collision between a car and a farm tractor. During the story, and in other parts of the program, the student is asked questions about what he or she thinks the automobile driver can do to avoid a collision. If you and your child agree, his or her answers to these questions will be placed in a computer database. No information that can identify your child or any other student will be included in the data file. Participating in this study may teach your child defensive driving skills to prevent highway collisions. Your child's participation will help teachers and researchers learn new ways to teach critical thinking skills to prevent injuries.

How the Program Begins

Your child will begin the program by typing in his or her name followed by a 4-digit personal identification number (PIN). This is a number selected by your child. It can be any number he or she wants and it should be a number your child can remember. An example might be the last four digits of his or her best friend's telephone number.

Confidentiality of Your Child's Answers

This study is designed so that researchers like Dr. Cole or myself (Bor Chyi Lin) or anyone else who see your child answers to questions in the program database cannot identify your child or any other child who completes the program. When your child types in his or her name and PIN number, the program creates a unique encryption string of characters to replace your child's name and four-digit PIN. The child's name, PIN, and any other information that can identify him or her will NOT be included in the database. Thus your child's answers to the questions will be completely anonymous. The encryption method is demonstrated for two people in Table 1 below.

Table 1: Encryption procedure for ensuring student anonymity

User Name (of the student)	PIN (4-digit number selected by the student)	Encrypted string (assigned by the computer program)	User ID (assigned by the program)
Henry Cole	1111	]<#;V\2%]L;1P```	1
Borchyi Lin	1234	_\G%S]7?WHSQS]D`	2

Because the activity is part of an assigned lesson, your child's teacher will need a record of your performance. Your child and his or her teacher will see your child's performance scores displayed at the end of the program.

Why We Need Your Permission and Your Child's Permission

To evaluate the program we need to analyze the information about the students' age, gender, driving experience, and game and computer simulation scores. We need your permission to include your child's answers in the database. His or her answers will be pooled with the answers from more than 150 other students. This pooled information will allow us to evaluate the program effectiveness. Your child's name and PIN number will NOT appear in the database. Neither will any other information that could identify your child. He or she will remain completely anonymous.

Offer to Answer Questions

If you have questions about the study, you may call Mr. BorChyi Lin or Dr. Henry Cole at (859) 323-6836. If you have questions about your rights as a research subject, you should call the University of Kentucky Office of Research Integrity toll free (866) 400-9428 or (859) 257-9428.

Sincerely,

Mr. BorChyi Lin, MSCE, PhD Candidate
University of Kentucky
(859) 269-0929
bclin@uky.edu

Dr. Henry P. Cole, Professor
Doctoral Committee Chair
University of Kentucky
(859) 323-6836
hcole@uky.edu

Appendix D

Instructions for the Participants in the Four Experimental Groups

These instructions serve as advance organizers for each of the four experimental groups. Each group will receive its set of instructions as the first step in its computer administered program. Each of the four groups will complete its activities over a two-day period. Thus, instructions are provided for each group for Day 1 and for Day 2.

Day One Instructions for Each of the Four Groups

Group 1 – (Control Group)

Thank you for participating in this activity. Today you will perform two tasks.

First, you will be asked to provide some information about your age, driving experience, and farm experience.

Second, you will watch an image of car traveling across the computer screen. You will be asked a set of simple questions about how fast you can react to and stop the car when an object suddenly appears in the road in front of the car.

Group 2 – (No Way to Meet a Neighbor Simulation Exercise ONLY)

Thank you for participating in this activity. Today you will perform three tasks.

First, you will be asked to provide some information about your age, driving experience, and farm experience.

Second, you will watch an image of a car traveling across the computer screen. You will be asked a set of simple questions about how fast you can react to and stop the car when an object suddenly appears in the road in front of the car.

Third, on a computer you will complete an interactive story about problems that can occur when farm vehicles and automobiles travel on the same rural highways.

Group 3 – (Reaction Time/Stopping Time Game ONLY)

Thank you for participating in this activity. Today you will perform three tasks.

First, you will be asked to provide some information about your age, driving experience, and farm experience.

Second, you will watch an image of car traveling across the computer screen. You will be asked a set of simple questions about how fast you can react to and stop the car when an object suddenly appears in the road in front of the car.

Third, you will play a game where you can set the speed of your simulated car as it travels along a highway. Objects will pop up in the road in front of the car. Your job is to stop the car before it hits the object.

Group 4 – (No Way to Meet a Neighbor + Reaction Time/Stopping Time Game)

Thank you for participating in this activity. Today you will perform four tasks.

First, you will be asked to provide some information about your age, driving experience, and farm experience.

Second, you will watch an image of car traveling across the computer screen. You will be asked a set of simple questions about how fast you can react to and stop the car when an object suddenly appears in the road in front of the car.

Third on a computer you will complete an interactive story about problems that can occur when farm vehicles and automobiles travel on the same rural highways.

Fourth, you will play a game where you can set the speed of your simulated car as it travels along a highway. Objects will pop up in the road in front of the car. Your job is to stop the car before it hits the object.

Day Two Instructions for Each of the Four Groups

Group 1 – (Control Group)

In today's activity, you will perform two tasks.

First, you will watch an image of car traveling across the computer screen. You will be asked a set of simple questions about how fast you can react to and stop the car when an object suddenly appears in the road in front of the car.

Second, you will be asked to answer 17 questions related to safe driving on rural highways.

Group 2 – (No Way to Meet a Neighbor Simulation Exercise ONLY)

In today's activity, you will perform three tasks.

First, you will watch an image of car traveling across the computer screen. You will be asked a set of simple questions about how fast you can react to and stop the car when an object suddenly appears in the road in front of the car.

Second, you will be asked to answer 17 questions related to safe driving on rural highways. Third, you will be asked to answer a few questions about your opinion of the activities.

Group 3 – (Reaction Time/Stopping Time Game ONLY)

In today's activity, you will perform three tasks.

First, you will watch an image of car traveling across the computer screen. You will be asked a set of simple questions about how fast you can react to and stop the car when an object suddenly appears in the road in front of the car.

Second, you will be asked to answer 17 questions related to safe driving on rural highways. Third, you will be asked to answer a few questions about your opinion of the activities.

Group 4 – (No Way to Meet a Neighbor + Reaction Time/Stopping Time Game)

In today's activity, you will perform three tasks.

First, you will watch an image of car traveling across the computer screen. You will be asked a set of simple questions about how fast you can react to and stop the car when an object suddenly appears in the road in front of the car.

Second, you will be asked to answer 17 questions related to safe driving on rural highways. Third, you will be asked to answer a few questions about your opinion of the activities.

Appendix E

Initial Screen Message

Please read this message before starting the Safe Driving in Farm County program.

About The Program

The program is a series of simulations and activities about collisions between automobiles and farm equipment on rural highways. It teaches defensive driving skills to avoid collisions.

The program begins by asking questions about your age, gender, and driving experience. Then short simulations and games show a car driving on a highway with objects popping into the path of the car. You will be asked to estimate how fast you can stop to avoid hitting the objects. Later you will play a game where you use the computer keyboard space bar as a brake and try to stop the car before it collides with an object. Then you will be asked to work through a short story about a collision between a car and a farm tractor. During the story, and in other parts of the program, you will be asked questions about what you think the automobile driver can do to avoid a collision. If you agree, your answers to these questions will be placed in a computer database. No information that can identify you will be included in the data file.

How to Start

You will begin the program by typing in your name followed by a 4-digit personal identification number (PIN). This is a number you select. It can be any number you want and it should be a number you can remember. An example might be the last four digits of your best friend's telephone number.

Confidentiality of Your Answers

This study is designed so that researchers like Dr. Cole (my advisor) or myself (Bor Chyi Lin) or anyone else who see your answers to questions in the program database cannot identify you. When you type your name and PIN number in, the program will create a unique encryption string of characters to replace your name and your four-digit PIN. Your name, PIN, and any other information that can identify you will NOT be included in the database. Thus your answers to the questions will be completely anonymous.

Because the activity is part of an assigned lesson, your teacher will need a record of your performance. You and your teacher can see your performance scores displayed at the end of the program.

Why We Need Your Permission

To evaluate the program we need to analyze the information about your age, gender, driving experience, and your game and computer simulation scores. We need your permission to include your answers in the database. Your answers will be pooled with the answers from more than 150 other students. This pooled information will allow us to evaluate the program effectiveness. Your name and PIN number will NOT appear in the database. Neither will any other information that could identify you. You will remain completely anonymous.

If you are willing to have your answers included in the database please click on the AGREE button below. If you click on the I DO NOT button you may still complete the program but your answers will not be included in the data file. By agreeing to have your answers included in the database you will be helping to improve this program that teaches safe driving.

- I AGREE to have my answers added to the database.
- I DO NOT want my answers included in the database.

Appendix F

Lesson Plan

The lesson uses a CD-ROM based computer program. This program has three sessions.

First, students will watch an image of a car traveling across the computer screen. Then they will be asked a set of simple questions about how fast they think they can react and stop a car when an object suddenly appears in front of the car. Second, working at a computer the students will answer questions after having read an interactive, ongoing story exploring problems that can occur when farm vehicles and automobiles travel on the same rural highways. Third, the students will play a game where they can set the speed of a simulated car as it travels along a highway. Objects will pop up in the road in front of the car. The student's job is to stop the car before it hits the object.

Goals

1.5-1.9 Students use mathematical ideas and procedures to communicate, reason, and solve problems.

By understanding the concept of speed, the students will (TSW) be able to learn the relationship distance and time. If the car travels in a higher speed, it will take a longer distance to do a complete stop. By identifying potential hazard on the rural highway, TSW be able to become a more defensive driver.

2.9 Students understand space and dimensionality concepts and use them appropriately and accurately.

By understanding the concept of speed, TSW be able to learn the distance and time relationship. If the car travels at a higher speed, it will take a longer distance to stop.

2.10 Students understand measurement concepts and use measurements appropriately and accurately.

By understanding the concept of speed, TSW be able to learn the relationship distance and time. If the car travels in a higher speed, it will take a longer distance to do a complete stop.

5.1 Students use critical thinking skills such as analyzing, prioritizing, categorizing, evaluating, and comparing to solve a variety of problems in real-life situations.

TSW be able to understand the importance of reaction time, and able to identify road hazard conditions and take proper actions; thus, become a more defensive driver.

5.4 Students use a decision-making process to make informed decisions among options.

TSW be able to identify road hazards and take the proper precautionary actions associated with each situation.

Objectives
TSW visualize concepts of speed and deceleration to make decisions about what they should do in real driving situations. By using the simulation game in the CD-ROM, TSW be able to set the car speed and hit the space bar to stop the simulated car and better understand the relationship between time and distance.

TSW learn to recognize potential hazards on rural highways and hence become a more defensive driver. TSW complete an interactive story that assists them in recognizing hazard cues on rural highways. Being aware of potentially dangerous situations, the student becomes a more defensive driver.

Procedures

TSW complete their activities over a two-day period.

Day 1
Demographics and driving experiences questionnaire (5 minutes)
TSW be asked to provide some information about their age, driving experience, and farm experience.

Pre-Test (10 minutes)
TSW watch an image of car traveling across the computer screen. TSW be asked a set of simple questions about how fast you can react to and stop the car when an object suddenly appears in the road in front of the car.

No Way to Meet a Neighbor Exercise (30 minutes)
TSW complete an interactive story about problems that can occur when farm vehicles and automobiles travel on the same rural highways.

Reaction Time/Stopping Time Game (5 minutes)
TSW play a game where you can set the speed of your simulated car as it travels along a highway. Objects will pop up in the road in front of the car. Your job is to stop the car before it hits the object.

Day 2
Post-Test (10 minutes)
TSW watch an image of car traveling across the computer screen. TSW be asked a set of simple questions about how fast you can react to and stop the car when an object suddenly appears in the road in front of the car.

HAZCUE Test (20 minutes)
TSW be asked to answer 17 questions related to safe driving on rural highways.

User Evaluation (USRVAL) Questionnaire (15 minutes)
TSW be asked to answer a few questions about their opinion of the activities.

Evaluations
TSW write a short essay about the economic outcome of risk taking vs. defensive driving, discuss the importance of identifying potential hazard on the rural highway, and talk about their "close call" experiences they have experienced or observed.

Appendix G

Demographic and Exposure Questionnaire

1) Name of exercise __*No Way to Meet a Neighbor*__ 2) Your age ________

3) Your sex ____ M ____ F 4) Years you have had a driver's license ____________

5) Years experience tractor driving ________ 6) Do you work on a farm? ____ Yes ____ No

7) Size of farm (acres) ________ 8) Do you drive tractors on public roads? ____ Yes ____ No

9) Have you ever <u>almost had a collision</u> (a close call) between a tractor and a motor vehicle (MV) on a public highway ? ____ Yes ____ No

10) If "Yes" to item #9, were you in the motor vehicle or on the tractor? ____ MV ____ Tractor

11) Have you ever <u>been involved in a collision</u> between a tractor and a motor vehicle on a public highway ? ____ Yes ____ No

12) If "Yes" to item #11, time of day collision occurred? (hr) ________ AM ________ PM

13) If "Yes" to item #11, were you in the motor vehicle or on the tractor? ____ MV ____ Tractor

14) If "Yes," to # 11, was anyone injured? ____ Yes ____ No

15) If "Yes" to item #11, who was injured? ____ MV Occupant ____ Tractor driver or rider

Appendix H

User Evaluation Questionnaire

Think about the exercise you just finished. Click the number that tells how much you agree or disagree with the following statements.

	Statement	Strongly Disagree			Strongly Agree
19)	The situation in this exercise could happen to me.	1	2	3	4
20)	This exercise taught me how to prevent collisions like this one.	1	2	3	4
21)	During a highway crash, a ROPS and fastened seat belt can keep the tractor operator from being injured.	1	2	3	4
22)	Farmers who drive tractors on highways should have ROPS on their tractors.	1	2	3	4
23)	When driving tractors with ROPS, farmers should always wear their seat belts.	1	2	3	4
24)	This exercise will help me to be a more alert and cautious driver.	1	2	3	4
25)	The exercise took too long to complete.	1	2	3	4
26)	I liked doing the exercise.	1	2	3	4
27)	The written directions in the exercise were clear.	1	2	3	4
28)	The exercise drawings were easy to understand.	1	2	3	4
29)	The exercise animated sequence was helpful to understand the collision event.	1	2	3	4
30)	The information in the feedback was accurate and helpful.	1	2	3	4
31)	The exercise story is easy to read.	1	2	3	4
32)	I had a chance to discuss the activity and share my ideas.	1	2	3	4
33)	Because of this exercise I now know what to do to prevent collisions between farm tractors and motor vehicles.	1	2	3	4
34)	Because of this exercise I will be more careful when driving an automobile or other motor vehicle in farm country.	1	2	3	4

Appendix I

HAZCUE test

Instructions
This quiz is about collision hazards between automobiles and farm tractors. Please read each of the following items. Click on all the correct answers for each question.

You are driving along a country road on a sunny afternoon and you have the window rolled down. There are many fields and farms along this road and the air smells of freshly cut hay. Fences and trees line both sides of the road. As you round a turn in the road you see a large fully loaded hay wagon moving slowly ahead of you in the same direction. Just ahead of the hay wagon you see a driveway leading to a farm yard and barn. Answer the following questions.

1. Where is the hay wagon?
   - **Ahead of you**
   - Behind you
   - On your right
   - On your left
2. Where are the trees and fences?
   - **Ahead**
   - **On your right**
   - **On your left**
3. What may be pulling the hay wagon?
   - A car
   - **A tractor**
   - A team of horses
4. A tractor is pulling the hay wagon. A farmer is driving the tractor. Which of the following statements is true?
   - The farmer can see your car approaching in his rear view mirror.
   - The farmer can hear your car approaching the wagon from behind.
   - **The farmer cannot see your car approaching the wagon from behind.**
   - **The farmer cannot hear your car approaching the wagon from behind.**

As you approach the rear of the hay wagon you see a straight section of highway in the left lane about the length of three football fields. The highway ahead is clear and no vehicles are approaching. You also can hear a diesel engine and think this noise is from the tractor pulling the wagon. The wagon and the tractor are approaching driveway to the farm on the left. Answer the following questions.

5. Which is true?
   - It is safe to pass the hay wagon and tractor because the highway in front of the wagon is straight and clear.
   - **It is *not* safe to pass the wagon and tractor even if the highway ahead is straight and clear of traffic.**
   - It is safe to pass the wagon as long as you honk the horn because the tractor driver can hear you.
   - **It is *not* safe to pass the hay wagon and tractor even if you honk your horn.**

6. As the wagon gets close to the driveway to the farm on the left side of the road what might happen?
   - **The tractor and hay wagon might turn left into the driveway.**
   - The tractor and hay wagon might turn right into the field.
   - **The tractor and hay wagon might stop.**
   - The tractor and hay wagon might back up.

Just before the hay wagon gets close to the driveway, your car speedometer says 60 mph. When you are five car lengths behind the wagon you pull out to pass the wagon and tractor. Just then the tractor turns left across the road into the farm yard. The tractor and wagon block the whole road.

7. What can you do to avoid running into the hay wagon and tractor?
   - Step on the brakes hard.
   - Steer around the wagon and tractor on the left.
   - Steer around the wagon and tractor on the right.
   - **At this time you cannot avoid a collision.**

8. The tractor and wagon turn into the driveway and block both lanes of the road. If you immediately step on the brake as hard as you can, can you stop before hitting the tractor and wagon?
   - Yes
   - **No**

9. When you were traveling 60 mph, suppose you applied the brakes hard, but were not able to stop completely. About how fast do you think you would be traveling when your car collides with the tractor and wagon?
   - 50 mph
   - **35 mph**
   - 20 mph
   - 8 mph

10. Think about the story. What could the tractor driver have done to prevent the collision?
    - **There is nothing the tractor driver could have done.**
    - Signaled his left turn with the tractor turn signals.
    - Signaled his left turn with his left arm and hand.
    - Driven faster when he turned into the driveway.

11. What could you (the automobile driver) have done to prevent the collision?

- Speed up to get by the hay wagon and tractor before the farmer turned into the driveway.
- **Slow down and stay behind the wagon.**
- Flash the head lights and blow the horn before passing the wagon.
- Hit the brakes fast and very hard to stop before the collision.

12. In what other situations could you have a collision with farm equipment while driving through farm country?

- **When driving fast and coming over the top of a hill in the road**
- **When approaching farm machinery that is wider than one lane of the highway**
- **When it is dark and the farm machinery does not have lights or reflective markers**
- **When driving fast and coming around a curve in the road**

13. When you are driving on a country road and come up behind a large hay wagon being pulled by a tractor, about how fast will the tractor and wagon usually be traveling?

- 40 — 45 miles per hour
- 25 — 30 miles per hour
- **10 — 12 miles per hour**
- 4— 6 miles per hour

14. A large diesel tractor is pulling a fully loaded hay wagon on a country highway. The tractor driver needs to make a left turn into a driveway. What can the tractor driver do to alert drivers *behind* him that he is about to turn left?

- Signal a left turn with his left arm and hand.
- Turn on the tractor left turn signal
- **Slow down and begin a very slow and gradual left turn.**
- Look back over his shoulder to make eye contact with the car driver.

15. What time of the day and what day of the week are drivers at greatest risk of collisions with farm tractors and farm equipment on rural highways?

- Tuesday afternoon at 1:30 PM
- **Friday evening at 6:00 PM**
- Sunday morning at 10:30 AM
- Thursday evening at 11:15 PM

16. A young man who is wide awake and alert is traveling along a highway at 55 mph (81 feet per second). Suddenly a dog runs in front of his car. About how many feet will the car travel from the time the driver sees the dog before he can step on the brakes?

- **40**
- 30
- 20
- 10

17. During what time of year are collisions between motor vehicles and farm equipment *most* common in Kentucky and the central United States?

- **July**
- March
- December
- November

Appendix J

Traffic Fatalities and Vehicle Miles on Rural non-Interstate Highway (1999 to 2003)

Table J1

Fatalities and Total Vehicle Miles on rural non-interstate highway during the period from 1999 to 2003

	Fatalities			Total Vehicle Miles travel		
STATE	Rural Non-Interstate	Total	%	Rural non-Interstate	Total	%
Alabama	3166	5164	61%	115193	285620	40%
Alaska	170	458	37%	7960	23717	34%
Arizona	2025	5363	38%	50397	252687	20%
Arkansas	2171	3134	69%	73781	148566	50%
California	6633	19571	34%	224557	1561952	14%
Colorado	1564	3423	46%	56581	212382	27%
Connecticut	340	1579	22%	24020	154163	16%
Delaware	339	625	54%	17947	43316	41%
Florida	6210	15236	41%	147701	813581	18%
Georgia	3908	7823	50%	184938	529333	35%
Hawaii	257	624	41%	12246	43551	28%
Idaho	959	1370	70%	33490	70045	48%
Illinois	2568	7161	36%	104395	520235	20%
Indiana	2757	4441	62%	138970	357561	39%
Iowa	1547	2227	69%	72589	150542	48%
Kansas	1722	2473	70%	57519	141099	41%
Kentucky	3071	4322	71%	103642	234466	44%
Louisiana	2665	4629	58%	86132	210682	41%
Maine	780	965	81%	41876	72405	58%
Maryland	1186	3147	38%	59960	259699	23%
Massachusetts	434	2245	19%	28398	264606	11%
Michigan	3298	6652	50%	145948	493323	30%
Minnesota	2092	3133	67%	106678	267210	40%
Mississippi	3696	4416	84%	100571	180300	56%
Missouri	3547	5789	61%	120173	337776	36%
Montana	927	1218	76%	27935	50997	55%
Nebraska	968	1417	68%	42757	91929	47%
Nevada	558	1736	32%	19053	90606	21%
New Hampshire	412	662	62%	27676	61988	45%
New Jersey	854	3720	23%	50004	341431	15%
New Mexico	1075	2244	48%	47735	113987	42%
New York	3591	7644	47%	149819	654374	23%
North Carolina	4887	7699	63%	184186	455496	40%
North Dakota	408	512	80%	20687	36518	57%

(table continues)

Table J1. (continued)

Fatalities and Total Vehicle Miles on rural non-interstate highway during the period from 1999 to 2003

	Fatalities			Total Vehicle Miles travel		
STATE	Rural Non-Interstate	Total	%	Rural non-Interstate	Total	%
Ohio	3854	6869	56%	155166	534773	29%
Oklahoma	2220	3480	64%	84539	220907	38%
Oregon	1606	2301	70%	67398	173764	39%
Pennsylvania	4362	7792	56%	168184	518178	32%
Rhode Island	61	437	14%	3211	41140	8%
South Carolina	4035	5211	77%	104896	231695	45%
South Dakota	679	877	77%	22730	42244	54%
Tennessee	3380	6230	54%	106701	335502	32%
Texas	9209	18535	50%	295161	1091599	27%
Utah	957	1661	58%	26168	116686	22%
Vermont	324	405	80%	23802	41281	58%
Virginia	2538	4599	55%	112098	376768	30%
Washington	1749	3175	55%	63097	269500	23%
West Virginia	1467	2015	73%	51985	98076	53%
Wisconsin	2906	3958	73%	124066	289856	43%
Wyoming	479	868	55%	19408	42730	45%
U.S. Total	110611	211506	52%	4114124	13969249	29%

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- Digital laboratory for oral histology (7/96), University of Kentucky, College of Medicine
- Expert system on Computer Aided Instruction (1/93), University of Kentucky

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