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Development of a supplementary driver education tool for teenage drivers on rural roads

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ABSTRACT

Introduction: Teenagers are at greater risk than any other drivers on the highway system in the United States, especially in states like Texas with large rural road networks. Rural roads present many unique safety concerns that are traditionally unexplored in standard driver education curricula. In fact, many studies have actually indicated that driver education is very limited in use and efficacy. However, national goals for driver education envision a more comprehensive continuing education process, and computer-based education tools may be one supplementary method to address gaps in young driver training. *Methods:* The research team developed a flash-based computer education tool covering topics relating to driver behavior and rural roads and tested the efficacy of this tool in two rural-serving high schools in West Texas by comparing the results of pre- and post-intervention surveys using linear regression, analysis of variance, and logistic regression. *Results:* The results were promising, with students who used the intervention scoring higher on both a driver behavior scale and rural safety scale. All models indicated that students who took the intervention, even without being previously licensed, demonstrated greater knowledge and awareness. *Conclusions:* The models demonstrated the viability of this type of intervention tool for inclusion in a phased driver education program and for addressing the lack of rural road safety knowledge. *Practical applications:* The computer-based-training program developed in this project supports the potential efficacy of supplemental pre-licensure computer-based education tools for improving teen driver knowledge and safety awareness and fills a gap for rural road safety education.

1. Introduction

Crashes with teen drivers are a major concern in the United States. Teens are at greater risk than other age brackets for being killed in crashes, and crashes are the leading cause of deaths for teens in the United States (Thomas et al., 2012). This problem is often made even more severe in states with large rural road networks due to the hazardous and demanding natures of rural driving conditions. Rural roads commonly have unique hazards that include different geometric and access properties from urban roads (Karlaftis and Golias, 2002; Cafiso et al., 2010), increased speed limits (Theofilatos and Yannis, 2014), less cover against adverse weather (Theofilatos and Yannis, 2014), an increased association with driver alcohol use (Chen et al., 2009; Jiang et al., 2008), longer trip lengths (Chen et al., 2009), less enforcement and use of safety devices (Peek-Asa et al., 2010), underage driving in farm communities (Frisch and Plessinger, 2007), and more (National Highway Traffic Safety Administration, 1996). Texas is one of many states that faces significant burden from rural road danger due to its substantial rural network; in 2014, more fatal crashes occurred on rural roads than on urban roads, and the rate at which these crashes occurred was significantly more problematic due to the lower mileage on the rural road network (Texas Department of Transportation, 2015; Office of Highway Policy Information, 2014). The large number of fatal rural crashes is one of the reasons Texas often leads the nation in number of fatal crashes per year (National Highway Traffic Safety Administration, 2014).

An endemic issue that also contributes to the high number of traffic fatalities in Texas is the large population of young drivers (Texas Department of Transportation, 2015). Teen and beginning drivers have been consistently shown to be at greater risk for crashing than drivers in other age groups (Brijs et al., 2014; Scott-Parker et al., 2014; Thomas et al., 2012; Morrisey and Grabowski, 2006; The Association of National Stakeholders in Traffic Safety Education, 2007; Ramirez et al., 2013). There are a number of reasons for this, including a disconnection between habits and skills due to skills overassessment (Petzoldt et al.,

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2013; Lonero and Mayhew, 2010; Young Driver Research Initiative Research Team, 2007), forgetfulness of road rules due to limitations of standard education practices (Li and Tay, 2014; Scott-Parker et al., 2014; Major, 2015), and carelessness and recklessness, especially when engaging in more than one risky behavior (Brijs et al., 2014; Phillips and Sagberg, 2013; Carlos et al., 2009). Although teen driver risk tapers off over time, it is still important to address these safety concerns while drivers are young (Ouimet et al., 2014; Isler et al., 2009).

In the United States, driver education has been a common practice used to attempt to reduce the number of traffic crashes involving teens, but the efficacy of driver education has been widely debated. Few studies have shown statistically significant reductions in crashes, and those that have reported marginal gains are contentious. Numerous meta-analyses have been conducted regarding historical investigations into driver education, and these meta-analyses have typically shown that driver education itself does not adequately transfer skills or that the studies supporting driver education have been poorly constructed (Mayhew and Simpson, 1996; Ker et al., 2005; Thomas et al., 2012; Chaudhary et al., 2011; Lonero and Mayhew, 2010). The reasons that have been put forth for the inefficacy of driver education are numerous and include: lack of skills transferred into habits (Lonero and Mayhew, 2010), inexperience and immaturity (Lonero and Mayhew, 2010), lack of focus on attitudes (Lonero and Mayhew, 2010), limited time for training (The Association of National Stakeholders in Traffic Safety Education, 2007), and allowing teens to receive licenses earlier (Chaudhary et al., 2011), among others. For these reasons, driver education is simply thought to just not work.

However, it is important to bear in mind that driver education programs may vary and that driver education itself does have certain strengths, including integration with graduated driver license (GDL) programs to more thoroughly impart safe driving skills to build habits (Highway Safety Center, 2002; Morrisey and Grabowski, 2006) and reinforcement of key driving knowledge before and after licensure (American Driver and Traffic Safety Education Association Curriculum and Standards Committee, 2012; Li and Tay, 2014; Brijs et al., 2014; Lonero and Mayhew, 2010). Importantly, these strengths integrate with the vision of driver education in the United States. Government support of continued driver education is strong, although the National Highway Traffic Safety Administration (NHTSA), the Association of National Stakeholders in Traffic Safety Education (ANSTSE), the American Driver and Traffic Safety Education Association (ADTSEA), and other entities all advocate for reform of driver education. New standards have been proposed by ADSTEA (Chaudhary et al., 2011) and ANSTSE (The Association of National Stakeholders in Traffic Safety Education, 2007) to increase the requirements of driver education in all states to include a 45-h classroom program. This program will ideally include more active learning and make use of interactive tools to better convey the skills necessary to build good habits. Simulations and computer programs have been demonstrated to be effective for improving education when young drivers engage in computer-based training (CBT) because these materials are more engaging than standard education classes and documents (Highway Safety Center, 2002; Lonero and Mayhew, 2010; The Association of National Stakeholders in Traffic Safety Education, 2007; Petzoldt et al., 2013). Moreover, CBT programs allow for increased interaction and reward good behavior, enforcing good habits. Education programs designed to be similar to games have proven especially effective (Thomas et al., 2012; Li and Tay, 2014; Major, 2015). A broader vision of driver education in the United States, as envisioned by the government entities, involves driver education being used as a phased program that integrates with GDL programs to impart critical knowledge and skills to drivers before, during, and after licensure (The Association of National Stakeholders in Traffic Safety Education, 2007) in order to make it cooperative and comprehensive (Highway Safety Center, 2002; Thomas et al., 2012; Lonero and Mayhew, 2010). This type of cycle of education is critical because research has also shown that simple, one-time training programs are less effective than shorter, mass training exercises (de Crean and Vlakveld, 2013; Thomas et al., 2012). Texas specifically fails to meet these newest standards for driver education, both trailing in recommended instruction time and lacking more interactive materials (Chaudhary et al., 2011; Highway Safety Center).

In order to address the lack of appropriate training regarding rural roads and to test a potential supplementary program to be used in conjunction with standard driver education practices, the research team conducted a project on behalf of the Texas Department of Transportation wherein teen driver perceptions and behaviors were measured before and after using a CBT education tool. Students from eleventh and twelfth grade with ages ranging from 15 to 19 from two different high schools in rural communities outside of the city form the sample for this study. The intervention development is only the first phase of a series of projects investigating how to improve driver education for rural teens, and future work will focus on parental involvement and transfer of knowledge in order to provide a more dedicated, long-term education system that overcomes the shortcomings of temporary driver education. The purpose of this paper is to highlight the potential efficacy of a CBT program for pre-licensure training and to validate the use of that program with a statistical before-and-after comparison.

2. Material and methods

In order to address the known shortcoming of driver education regarding rural roads for teenagers, the research team proposed a multi-tier project to (1) gather data regarding how teens view rural roads and driving behaviors, (2) use that data to develop an interactive CBT program to address the knowledge shortcomings identified in the literature and from the data gathered from the teens, (3) test that program as an intervention, (4) gauge the efficacy of the program, and (5) modify the program and distribute it to other rural communities. The ultimate goal of this project is to freely provide an interactive online CBT program that teens in rural areas all across the United States can access to learn about rural roads and safe driving. This program fits into the vision for a more comprehensive, phased education program that provides pre- and post-licensure education and fills the gap regarding rural roads. The initial region for development of this program is Lubbock County and the surrounding counties in West Texas. A discussion of the statistical analysis methods used follows a detailed discussion of the intervention tool in this section.

2.1. Intervention tool

The intervention tool used in this project was a computer-based interactive program that used flash simulations to highlight hazardous situations or behaviors before asking questions. The tool is similar to other CBT packages, including Driver-ZED (Blank and McCord, 1998), CD-Drives (Cockerton and Isler, 2003; Isler and Cockerton, 2003), RAPT-3 (Pradhan et al., 2009), and more (Petzoldt et al., 2013; Weiß et al., 2013), yet it is sufficiently different to provide a new contribution to the growing body of literature regarding CBT. First, unlike photo-realistic programs like Driver-ZED (Blank and McCord, 1998), CD-Drives (Cockerton and Isler, 2003), and the CBT tools developed by Petzoldt et al. (2013) and Weiß et al. (2013), the education tool developed in this study uses less realistic animations. Although photorealism was avoided partially due to budget, a more general concern was accessibility. Unlike Driver-ZED and CD-Drives, the study tool is free and does not require a CD-ROM to operate; it is distributed online and therefore makes use of flash animations to capture a wider variety of scenarios and situations. Second, the study tool also differs from Blank and McCord (1998), Petzoldt et al. (2013), Weiß et al. (2013) because it uses plan-view animations in addition to within-vehicle animations to display a greater variety of hazards on rural roads, similarly to how RAPT-3 uses plan views to enhance novice driver understanding of sight obstructions (Pradhan et al., 2009). Third, the key difference between the study tool and existing CBT programs (Petzoldt et al., 2013; Weiß et al., 2013; Blank and McCord, 1998; Cockerton and Isler, 2003; Isler and Cockerton, 2003; Pradhan et al., 2009) is an almost exclusive focus on rural road safety. As mentioned, the number of annual fatal crashes on rural roads in Texas is substantial, so the goal of this project was to enhance teen driver understanding of how crashes occur on rural roads in order to promote safety awareness. Although Driver-ZED does feature scenarios that take place on rural roads, to the extent of the author's understanding, these scenarios entail more general safe driving behaviors and are not intrinsically linked to the rural roads themselves, though some topics, such as sight distance, are included in both the study tool and Driver-ZED. Moreover, it should be noted that the goal of the study tool differs from those of the other studies in that teen driver knowledge and hazard identification attitudes were being trained and assessed rather than more specific focuses, such as glance behavior (Petzoldt et al., 2013), calibration (Weiß et al., 2013), and hazard scanning (Pradhan et al., 2009). The study tool is similar to other programs, however, in that it asks multiple choice questions and provides feedback post-scenario in order to ensure a transfer of knowledge (Petzoldt et al., 2013; Isler and Cockerton, 2003).

To use the software, students used a school computer with an internet connection to follow a link to the research team's website. From this home page, students accessed each of five categories developed based on the results of the pre-test survey and the literature review. Under each category are several scenarios. Each scenario consists of a flash animation followed by a question relating to the animation. After answering the question, the program responds with whether the answer is correct or not before finally transitioning to an education slide that addresses the question and provides practical information and tips. Every student completed every scenario before taking the post-test survey. The scenarios included in the version of the software tested by students are shown below:

1. General Safety
    1.1. Rural and urban differences
    1.2. Major types of crashes on rural roads
    1.3. Rumble strips
    1.4. Highway Hypnosis
2. Geometry
    2.1. Geometry of Two-Way Frontage Roads
    2.2. Crest vertical curve
    2.3. Sag vertical curve
    2.4. Horizontal curve (day)
3. Driving Behavior
    3.1. Blind spots
    3.2. Texting while driving
    3.3. Drowsy driving
    3.4. Distracted driving
    3.5. Drunk driving
4. Weather and Environment
    4.1. Thunderstorm on rural road
    4.2. Sandstorm
    4.3. Snow and ice (vision)
    4.4. Snow and ice (stopping)
5. Animals and Other Hazards
    5.1. Work zones.

The included scenarios are based on the data gathered from the initial survey and tested students regarding specific questions given on the surveys. For example, students taking the surveys were asked if it was dangerous to drive while tired, so one scenario shows an animation that simulates the eyelids of a driver closing while engaging in the driving task to demonstrate the risk that driving while tired imposes. The scenarios were selected primarily to address key questions on which the sample students seemed to lack appropriate knowledge or behavior. For example, only 34% of students identified eating as a potentially hazardous distraction while driving, so eating was included in the distracted driving scenario to demonstrate a form of manual distraction. Other hazardous behaviors, such as speeding, were correctly identified as dangerous but to an unsatisfactory level (i.e. 69% of pre-intervention students identified speeding as a hazardous behavior), so those survey items connected to crashes on rural roads (Theofilatos and Yannis, 2014) were included as scenarios. In addition to the more behavior-oriented scenarios, scenarios related directly to rural road properties were developed based on survey responses. For example, 76% of sampled students did not identify horizontal curves in rural areas as being particularly concerning, and only 29% of the sampled students identified passing vehicles on two-lane rural roads as hazardous. Based on these findings, and on the literature review and consultation with the project sponsors, the list of 18 scenarios was developed. More scenarios were planned for later implementation to address any missing survey results as well.

Although a full review of every scenario is beyond the scope of this paper, discussion of an example scenario is warranted. One major concern for teen drivers on rural roads is highway hypnosis. Many rural highways in Texas consist of long, straight roadway sections. This fact, coupled with the propensity for teens to drive late at night, is a likely explanation for high fatal crash counts during night hours in Texas (Texas Department of Transportation, 2016). Highway hypnosis can occur when drivers operate vehicles for extended periods of time in monotonous surroundings, entering a dulled and drowsy state. Low light and lack of sleep can contribute to the issue. Scenario 1.4 demonstrates the danger of highway hypnosis to students by showing how this condition can easily take focus from the roadway and important warning signs. Fig. 1 shows a screenshot from the flash-based scenario and the question page after the animation. In it, a driver is driving down a two-lane rural highway at dusk. There is very little traffic on the road. To simulate a long driving period, the animation runs for approximately 15 s. The vehicle passes a black billboard with white text. Students must then answer the question, "What did the billboard say?" The correct answer is "Advertise Here," and students are informed if they answered correctly or incorrectly. A static screenshot of the twilit roadway then appears and provides some tips to students regarding how to avoid highway hypnosis by not becoming distracted by monotonous roadway features.

Most of the scenarios are of a similar format to Scenario 1.4 and feature an in-vehicle view to illustrate some roadway hazard. A few scenarios, namely those for crash types on rural roads, two-way frontage roads, horizontal curves, and blind spots, use plan views to show limitations in vision, run-off-the-road causes, and more. Some questions test students on their prior knowledge (rural and urban differences, crash types), but all questions are supported by informative graphics and feedback to ensure the students are learning about the hazards on rural roads. Most questions are multiple-choice answers similar to that shown in Fig. 1, but some questions ask students to check all answers that apply. Scenarios

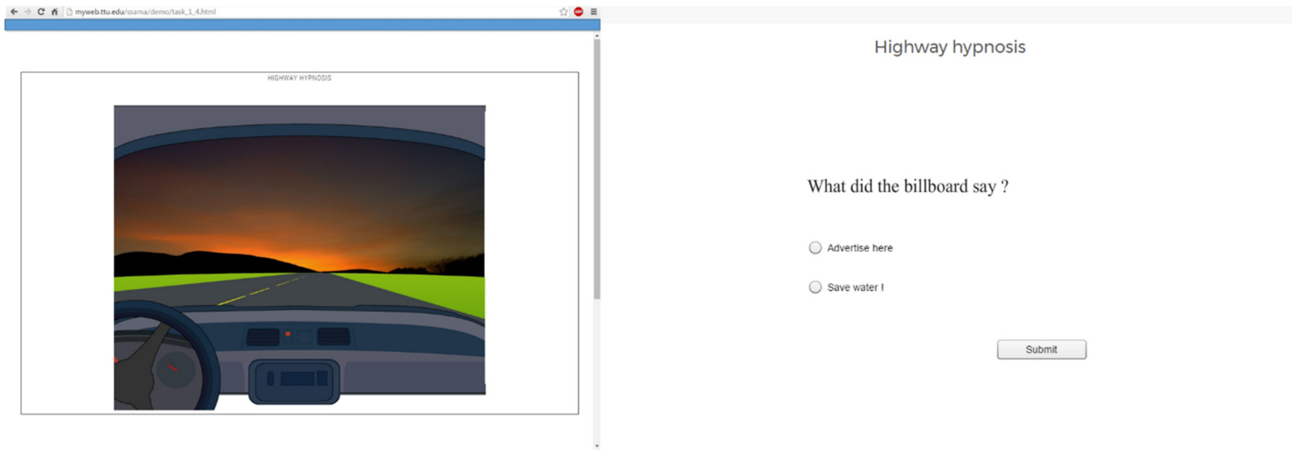

Fig. 1. A screenshot of an example scenario, in this case Highway Hypnosis, and its corresponding follow-up question to test student knowledge and awareness.

that deal with driver behavior are framed within the context of rural roads. All scenarios feature at least one question, and some scenarios (crash types, blind spots) feature multiple flash animations. Most scenarios are approximately 5–20 s long, although some are longer, especially those featuring multiple animations. Students were verbally directed to access each scenario category in order and to then work through each scenario without skipping any animations or questions. In total, progressing through all 18 scenarios requires approximately 30–60 min; missed scenarios can be re-accessed to ensure that the proper knowledge is transferred.

The intervention tool was met with very high approval from students. Students were asked for feedback on the program, and of those that responded with feedback (307), 94% reported that they found the software beneficial. A number of positive comments were left on the surveys in addition to some suggestions for improvement. It is important to note that the software is currently being modified to address suggestions for improvement and will contain additional scenarios as phase two of the research program closes.

2.2. Survey development

High schools serving rural communities outside of the city of Lubbock were chosen as testbeds for the program. Three high schools participated in the first survey deployment during the spring semester in April and May. Surveys were open for eleventh and twelfth grade students and were blindly filled out and returned in class. In total, 565 of the approximately 800 distributed surveys were collected from the students; only four were collected from the smallest school, and the remaining surveys were split at approximately 43%/57% between the two larger schools. Personal identifying information was not gathered from the students beyond asking about licensure, driver education, and driving experience. Five months later, in September, the two larger schools were used as a testbed for the intervention, and the program was tested in available class periods with eleventh and twelfth-graders aged 15–19 likely to have taken the initial survey. Students in the follow-up groups took the post-intervention survey immediately after working through the scenarios in the education program. All students in these classes completed the program and filled out surveys, resulting in 417 post-intervention responses. Unfortunately, only 106 of the 417 respondents had actually taken the initial survey, resulting in almost 19% of the first sample taking the intervention and follow-up questionnaire.

Although a shorter period between the two surveys would have been preferable for comparing results, this was infeasible due to the schedules of the two high schools and the development of the education tool. There was some concern that some students may simply have developed safer attitudes in the intervening five months, and for this reason the link between licensure and survey responses was tested. An additional limitation due to the school schedule was the deployment of the post-intervention survey immediately after the use of the education software, but the literature indicates than an immediate after-training test is not automatically problematic (Pradhan et al., 2009).

The questionnaire consisted of 52 questions initially, but the follow-up survey was reduced to 39 questions after some data were used only for the program development. The majority of questions were of binary form and asked students about their perceptions and practices regarding both driving behavior in general and rural roads. Some questions asked students to select a number of potential hazards (e.g. "Which of the following hazards might you encounter on a rural road - check all that apply?"). Students were given the option to avoid answering any questions for which they felt uncomfortable providing a response, and blank answers were marked with a letter corresponding to "skipped" for ease of comparison. Responses to the two surveys were analyzed through multiple statistical models. A select few questions were reworded slightly to ask how using the education program had changed perceptions versus a noted behavior, but the majority of questions remained unchanged.

In the present paper, most questions were binary in form rather than following the more typical Likert-type format. This is not problematic, though, because binary questions are shown to be easier for respondents to answer (Dolnicar et al., 2011) and because many studies using Likert-type questions convert the results to binary for analysis anyway (Ramirez et al., 2013; Vingilis et al., 2013). Binary responses allow for logistic regression analysis to be used, as will be discussed later in this section.

2.3. Analysis scales

It is common when analyzing the efficacy of an intervention tool to develop a scale based on the responses to survey questions to evaluate a before-and-after score for respondents (Ramirez et al., 2013; Vingilis et al., 2013). For this analysis, two scales were developed from the survey responses. The first deals primarily with teen driver behavior and contained nine items for a total score of 12 (one item contained multiple possible points). The second deals primarily with rural roads and contains 11 items with a total score of 15 (again, one question has multiple possible selections). The variables, their descriptions, and their scale are shown in Table 1. The scales were developed by awarding points for appropriate driving views and behaviors or for being able to identify risks. For example, one question asked, "Do you think speeding is dangerous?" Students who answered "yes" were awarded one point, and students who answered "no" were awarded no points. The two multi-point questions asked students to identify all unsafe behaviors (hazbeh: racing, weaving, speeding, drinking and driving; rhazards: animals, tumbleweeds, limited visibility around curves, limited visibility on hills, and inclement weather). Note that although the "hazbeh" variable has some redundancy, the hazard behaviors themselves were listed slightly differently on this item to allow students the chance to select the behavior here. It is important to note that some problematic behaviors, such as distractedly listening to music and driving with other passengers, were questioned on the surveys. However, the responses to these questions were found to be incompatible between the pre- and post-tests, so the general category multitasking was used.

2.4. Statistical analysis

SAS version 9.4 was used to perform multiple statistical analyses on the data. These analyses were carried out through multiple models to determine if the intervention tool had any effect on the scale scores. First, standard linear regression models were used to determine if the intervention tool was significant for predicting the two scale scores by considering the scale scores as the dependent variables. Then ANOVA was used to test if the intervention was effective at improving the scores independently of licensure using the two scales as the dependent variables and a new dummy variable, "tst", as the independent variable. The effects of each binary survey variable on its corresponding scale was further tested using two corresponding logistic regression models with a dummy "int" variable for whether each respondent had taken the intervention or not included as the dependent variable (Ramirez et al., 2013; Beck et al., 2009; Vingilis et al., 2013; Dolnicar et al., 2011; Jiang et al., 2008). Last, internal consistency within the model was checked through two methods. First, Cronbach's alpha was tested for each variable that composed the two scales using the CORR procedure in SAS. Then, the logistic regression models were checked for multicollinearity, a negative property that occurs when individual variables mask the effects of others, by checking variance inflation factor (VIF) and tolerance levels.

3. Results

The results of each statistical analysis indicated that the intervention was in general significant for imparting knowledge and improving students' scores. This section summarizes the results of each model and highlights significant findings.

3.1. Linear regression

Two standard linear regression models were used to determine if the intervention actually affected the scores for both the behavior scale and the rural scale. As mentioned, the "int" variable is a categorical variable for whether the student had taken the intervention or not. The dependent variables are the behavior scale scores and rural scores, respectively. Table 2 shows the predicted values with upper and lower confidence levels for each level of the independent intervention variable.

As can be seen in Table 2, students who used the intervention showed marked improvement in terms of both the behavior scale and the rural scale. Notably, the intervention seems to have had a more significant impact on the rural scale score, with students improving by nearly three points for this model. The behavior scale improvements were less substantial, though the "int" variable was significant for predicting both scales to the $p < 0.0001$ level.

3.2. ANOVA

In order to test if licensure, and its corresponding driver education, was a confounding factor on the results, ANOVA was used on the "tst" variable to determine if there were statistically significant results regarding whether students were already licensed or not. Table 3 summarizes the ANOVA results. The tst levels 1–7 correspond to students who are licensed and took both surveys, licensed but only took the post test, licensed but only took the pre-test, licensed but took no test (dummy), not licensed and took both surveys, not licensed but only took the post-test, and not licensed but only took the pre-test. Although a simpler two-way ANOVA test may have been applicable to the data, the time gap between the survey deployments seemed to warrant further distinction between those who may and may not have attained licensure in order to identify if the additional driver education that accompanied that licensure affected the survey results. The further division into pre-, post-, or both was also used to account for the fact that students who took both essentially received a repeated introduction to the topics and therefore may have scored differently than either the pre- or post- groups.

Table 1
The different variables derived from the survey questions and their corresponding point values for each of the two scales, behavioral and rural.

Behavior scale			Rural scale		
Variable name	Description	Maximum score	Variable name	Description	Maximum score
Concern	General concern for safety	1	Rural	General perception of rural safety	1
			Curves	General rural road curve safety	1
Drinking	Drinking and driving	1	Curslow	Driving slower around curves	1
			Rain	Driving in rain	1
Speeding	Speeding	1	Snow	Driving in snow	1
Tired	Driving while tired	1	Wind	Driving in windy conditions	1
Eating	Eating while driving	1	Unique	Perception of differences between rural and urban roads	1
Multitask	Distractedly multitasking	1	Passing	General safety when passing vehicles	1
Hazbeh	Various hazardous behaviors	4	Passlow	Passing slow-moving vehicles on curves	1
Cell	Cell phone use	1	Rhazards	Various rural road hazards	5
Preact	Perception-reaction abilities	1	Bridge	Bridge safety in rural areas	1

Table 2
Statistical results indicating the statistical significance of the effects of the education tool on student scores on the behavior and rural scales.

Behavior scale				Rural scale			
Int level	Predicted	Lower confidence	Upper confidence	Int level	Predicted	Lower confidence	Upper confidence
0	7.32	7.15	7.50	0	9.60	9.39	9.81
1	8.94	8.73	9.15	1	12.52	12.27	12.76

Table 3
Results from ANOVA showing the statistical differences between the different student groups (licensed/took both, licensed/only took post survey, licensed/only took pre survey, unlicensed/took both, unlicensed/only took post survey, and unlicensed/only took pre survey).

Behavior scale				Rural scale			
tst Level	REGWQ group	Mean score	N	tst Level	REGWQ group	Mean score	N
Licensed, both (1)	A	8.29	92	Licensed, both (1)	A	12.60	92
Licensed, post (2)	A	8.89	224	Licensed, post (2)	A	12.44	224
Licensed, pre (3)	B	7.26	529	Licensed, pre (3)	B	9.71	529
Unlicensed, both (5)	AB	8.29	14	Unlicensed, both (5)	A	12.15	14
Unlicensed, post (6)	A	9.24	87	Unlicensed, post (6)	A	12.70	87
Unlicensed, pre (7)	AB	8.25	36	Unlicensed, pre (7)	C	8.03	36
Model stats	Pr > F	<0.0001		Model Stats	Pr > F	<0.0001	
	Type III SS	676.23			Type III SS	2144.83	

As could be predicted from the regression model, the rural scale showed more variability than the behavior scale. However, in both models, the two highest mean scores were recorded by tst levels 6 and 1. These levels correspond to students who have no driver licenses and took only the second test and students who have driver licenses and took both tests. The fact that students who had no license and took only the second test appeared to do better on both the behavior scale and rural scale than any other students is interesting and may indicate that conventional driver education is ineffective at building good habits. However, it is important to note that tst levels 1, 2, 5, and 6 are all statistically within the same grouping, showing that there is no statistically significant difference between these levels. Still, all four of these groups took the intervention, and this seems to be the primary explanation for these higher scores. Group 3, which involved drivers who had licenses but only took the first test, performed statistically worse than those who took the intervention. Based on these results, it can be concluded that the intervention itself has a larger effect on scores than licensure.

3.3. Logistic regression

The results of the logistic regression are shown in Table 4. For both the behavior scale and rural scales, the models were testing the likelihood of a person not having taken the intervention (int = 0) versus having taken the intervention (int = 1). Therefore, the signs in the estimate column indicate the probability that a particular variable level increases or decreases the log likelihood of a student not having taken the intervention. A negative sign indicates a likelihood that the student took the intervention, and a positive sign indicates a likelihood that the student did not take the intervention. Statistical significance was considered for p-values lower than 0.05.

For the behavior scale, the only significant variables are driver license, tired driving, multitasking, hazardous behavior identification, and cell phone use. For this model, not having a driver license is more closely associated with having taken the intervention; this could indicate the potential finding hinted at in the ANOVA analysis that students who do not have licenses performed better overall due to a lack of pre-conceived notions taught by experience and

Table 4
Results from the logistic regression test to determine which variables per scale indicated a log likelihood of having not used the education tool versus having used the education tool.

Behavior scale				Rural scale			
Variable	Level	Estimate	Pr > Chisq	Variable	Level	Estimate	Pr > Chisq
Intercept	–	−0.60	0.06	Intercept	–	−1.36	<0.0001
dl	0.00	−1.59	<0.0001	dl	0.00	−1.75	<0.0001
Concern	0.00	−0.02	0.95	Rural	0.00	−0.08	0.67
Drinking	0.00	0.50	0.08	Curves	0.00	0.03	0.88
Speeding	0.00	0.03	0.89	Curslow	0.00	0.67	0.04
				Rain	0.00	0.35	0.10
Tired	0.00	0.89	0.02	Snow	0.00	−0.43	0.24
Eating	0.00	−0.27	0.19	Wind	0.00	1.17	<0.0001
				Unique	0.00	0.22	0.51
Multitask	0.00	1.91	<0.0001	Passing	0.00	2.24	<0.0001
Hazbeh	0.00	1.56	0.00	Passlow	0.00	0.19	0.55
	1.00	2.15	<0.0001	Rhazards	0.00	0.28	0.66
	2.00	3.02	<0.0001		1.00	1.72	0.00
	3.00	2.88	<0.0001		2.00	1.66	0.00
Cell	0.00	−2.51	<0.0001		3.00	1.04	0.00
Preact	0.00	0.33	0.28		4.00	0.73	0.00
				Bridge	0.00	0.19	0.34

instruction. All of the significant behavior variables aside from cell phone use indicate that not having a safe attitude or having an insufficient knowledge is more closely associated with having not taken the intervention. The phone result is troubling and could indicate a need for further instruction regarding cell phone use in the program. For the rural scale, the only significant variables were driver licensure, driving slowly around curves, driving in windy conditions, passing safety, and general rural hazard identification. The results for driver licensure are nearly identical to those for the behavior scale and seem to imply the same finding. Again, all of the significant variable levels for this model indicate that insufficient knowledge and unsafe attitudes are more closely associated with not having used the intervention. Almost all of the results for both the behavior scale and the rural scale indicate the efficacy of the intervention program.

3.4. Model validation

As mentioned, two processes were checked to test the model validation. First, the CORR procedure was used to find the Cronbach's alpha for each variable of both logistic regression models. A Cronbach's alpha value of 0.7 typically indicates a good internal level of consistency (Vingilis et al., 2013). Standardized alphas are provided for each variable, and the correlation sign shows whether removing the variable would increase or decrease the alpha. The alphas for both models are shown in Table 5.

As can be seen in the table, the behavior scale model had less consistency than the rural scale model. However, it is important to note that in both models the driver license variable actually caused more variability and decreased the internal consistency. If this variable was removed from the behavior scale model, the results would have met the 0.7 threshold. The alpha levels for the rural scale model showed good internal consistency.

The logistic regression models were also checked for multicollinearity. If a model's tolerance level per variable is greater than 0.1 and if its VIF level per variable is less than 10, the model likely has no issues with multicollinearity (Institute for Digital Research and Education, 2014). Results show that all variable tolerance levels are above 0.1 and all VIF levels below 10, so neither model presents any indication of issues with multicollinearity.

4. Discussion

4.1. Statistical findings

Overall, all of the statistical analyses seem to indicate that the intervention program had a noticeable impact on the scores for students who used the tool. Two scales were used to assess knowledge retention, and these two scales were tested as variables dependent on whether or not students had used the intervention. The linear regression models both showed that students who took the intervention performed better, although the effect was more noticeable for the rural scale. The reason for this could be that the primary focus of the education tool was on rural safety rather than driver behavior, although driver behavior was included. Therefore, it makes sense that students who used the intervention tool would be more aware of rural road safety topics. This conclusion is reinforced by the fact that many students were shocked to learn that rural roads are statistically more dangerous (in terms of fatal crashes) in Texas than urban roads. The comments left on the surveys indicate that this revelation was new and important to the students, so they may have paid more attention to the scenarios dealing more specifically with rural roads.

The ANOVA results also showed the efficacy of the intervention tool, with students who had no driver license but took the intervention tool performing better than any other students in terms of both the behavior scale and the rural scale. This finding illustrates an interesting concern related to driver education. Some researchers have hypothesized that driver education is ineffective because it may in fact inflate a student's own perception of his or her abilities without actually effectively improving those abilities; novice drivers are prone to overconfidence, and traditional driver education may exacerbate this issue (Petzoldt et al., 2013). The fact that drivers who had already been licensed typically scored lower on both scales may be indicative of the lack of efficacy for traditional driver education. Perhaps these students had already received education and training, but this education was insufficient, particularly regarding rural roads. For this reason, the intervention tool discussed in this paper may be an effective continuing education tool.

The logistic regression results confirmed the efficacy of the intervention tool as determined from the linear regression and ANOVA models. Although not every variable included in the two models was statistically significant for predicting whether a student had taken the intervention, the results for the statistically significant variables did indicate that a lack of safe driving behavior perceptions and rural safety perceptions was associated with not having used the intervention. The only variable that did not indicate a statistically significant improvement upon use of the intervention tool was cell phone use in the behavior scale. This finding likely indicates a limitation of the program itself that should be addressed. In the rural scale model, no variables statistically coincided with a loss of knowledge. Any other negative results were not statistically significant.

Table 5
Cronbach's Alpha results showing internal consistency within both scale models.

Behavior scale			Rural scale		
Variable	Correlation with total	Alpha	Variable	Correlation with total	Alpha
dl	−0.19	0.72	dl	−0.13	0.79
Concern	0.15	0.67	Rural	0.25	0.76
Drinking	0.32	0.65	Curves	0.20	0.76
Speeding	0.42	0.63	Curslow	0.40	0.74
Tired	0.30	0.65	Rain	0.46	0.74
Eating	0.37	0.64	Snow	0.38	0.75
Multitask	0.48	0.62	Wind	0.47	0.74
Hazbeh	0.57	0.60	Unique	0.39	0.75
Behscale	0.94	0.53	Passing	0.49	0.74
Int	0.27	0.65	Passlow	0.38	0.75
Cell	0.17	0.67	Rhazards	0.47	0.74
Preact	0.02	0.69	Bridge	0.17	0.77
			Rurscale	0.95	0.69
Model	–	0.67	Int	0.45	0.74
			Model	–	0.76

Interestingly, many of the significant variables produced by the logistic regression model were also mentioned in conversations following the deployment of the tool in the classrooms and in the comments on the surveys. Many students indicated that they were less familiar with passing rules and with issues like listening to loud music or talking loudly or using electronic devices to play music as dangerous multitasking activities. Students generally indicated that they learned something about these topics, and others mentioned that they found the wind and curvature scenarios beneficial. There seems to be a connection between the comments and the findings here, though other highlighted scenarios were not reflected in the models.

Another interesting result of the logistic regression model was that driver licensure had a negative association with both the behavior and rural scale scores. This reinforces the findings from ANOVA that licensed students tended to do worse on these scales. Again, this may reflect a limitation of traditional driver education. It may also be grounds for using this software primarily as a pre-licensure tool.

The measures of internal consistency showed minimal issues. No multicollinearity was present in either the behavior scale or rural scale models. Although the behavior scale model's alpha level was below the 0.7 threshold, removing the driver license variable actually improved the internal consistency and allowed it to reach an acceptable level. The rural scale model was acceptable before the removal of the driver license variable. Again, these findings seem to indicate the negative association between driver licensure and demonstrated knowledge. Overall, the many statistically significant findings from the analyses indicate the potential for this software to be used as one potential mechanism for pre-licensure education within the tiered national driver education strategy.

4.2. Limitations

This study is not without practical limitations. Although the statistical results do seem to indicate that students gained an enhanced understanding of safety, particularly on rural roads, the link between safety knowledge and driver behavior remains tenuous, and the results here do not indicate a potential reduction in crashes. This study, like that of the problem-based CBT developed by Petzoldt et al. and Weiß et al. sought merely to enhance driver knowledge and to enhance the ability of young drivers to perceive hazards (Petzoldt et al., 2013; Weiß et al., 2013). Additionally, there is a chance that the post-intervention students scored better due to having taken the follow-up survey immediately after using the education tool. However, Pradhan et al. indicate that post-training tests of knowledge may not be problematic because they still indicate a retention of knowledge (Pradhan et al., 2009). If anything, these results should be taken to indicate that repeated reviews can improve safety knowledge for students, and the software has been designed to facilitate just this type of repeated use. Finally, it should be noted that a select few of the post-intervention survey questions were reworded to reflect an after-intervention study, i.e. "How often do you text while driving?" versus "Do you think any of these situations are safe for texting while driving?" While this rewording may have been a source for error in the texting results reported in this study, most survey questions remained entirely unchanged. Because the logistic regression results were so pronounced, it is likely that these confounding effects for most questions were minimal. This study best serves to illustrate the viability of a potential CBT tool for driver education that is still in further development, and the results therefore should not be extrapolated to other groups, such as older, college-aged teens, or to indicate efficacy for crash reduction.

5. Conclusions

The findings of this study indicate that computer-based education tools may be beneficial for improving teen driver knowledge regarding rural roads. It became apparent in this study that many teens do not have adequate knowledge of safe driving behavior on rural roads, but a program like the interactive web-based tool that uses good education techniques, like active learning and problem-solving, may be an effective supplementary measure to help students build knowledge. The statistical analysis in this paper highlights the fact that high school eleventh and twelfth graders with ages ranging from 15 to 19 at the two subject schools serving rural communities who used the education intervention tool demonstrated a greater knowledge regarding safe driving behavior and rural hazards. Importantly, students who only used the intervention tool performed statistically better than even licensed drivers. This may be indicative of the fact that current driver education is insufficient, thus hinting at the need for this kind of program. These results are encouraging and fall in line with the federal vision for using education as a supplementary tool to support graduated driver licensing (Thomas et al., 2012; Highway Safety Center, 2002; American Driver and Traffic Safety Education Association Curriculum and Standards Committee, 2012; The Association of National Stakeholders in Traffic Safety Education, 2007). The tool developed and tested in this study, despite some biases, is an effective demonstration of how the gaps regarding pre-licensure driver education and rural road education can be addressed and contributes to the body of literature indicating that pre-licensure training can be effective (Beanland et al., 2013), particularly regarding hazard identification (Weiß et al., 2013). However, it is important to bear in mind that this initial study was the pilot test of the software, and further research and analysis is needed to ensure a positive impact. The research team will continue to monitor crashes and safety in the region to assess the long-term efficacy of the program and will continue to modify the program to be even more interactive and effective. The next steps of the program involve outreach and training in other rural areas and will involve parents and educators to improve the safety culture being developed around this program. The team will design an online hub for outreach, training, and success stories to continue promoting safety for rural roads. To the extent of the authors' knowledge, current CBT tools lack sufficient content regarding rural road safety, so if the limitations of this software can be addressed, this study indicates potential for another program to improve safety knowledge for novice drivers.

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