Tractor-Trailer Simulation and the Assessment of Training Scenarios for City-Driving: Skill Building in the Area of Left and Right Turn

James Whitmire II, Ron Tarr & Talleah L. Allen

Institute for Simulation and Training

Progress Building 3280 Progress Drive

Orlando, FL 32826

Abstract

A simulated inner-city training scenario was found to increase skills in the area of turning when compared with a simulated off-track training scenario. To answer this question, two groups of ten participants (5 women and 5 men) were tested using three scripted scenarios focusing on left and right turns. The first training scenario (control group) is an off-track training scenario, which consists of a large asphalt lot and the use of orange cones; the second training scenario (experimental group) is an inner-city training scenario without the presence of vehicular traffic; and the third scenario (test scenario) is an inner-city scenario with the presence of vehicular traffic. A subject matter expert, who is also a former driver and trainer, evaluated and scored all participants on four critical turns (2 left and 2 rights). The apparatus used for this study was the V-sim non-motion simulator from General Electric (GE). A 2 x 4 factorial analysis was utilized to examine conditional differences as well as gender differences. While there were no gender differences, the results for overall turns were significant, $F(1, 16) = 7.14$, $p = .017$, $\eta2 = 3.09$. The mean for the control group was ($M = 20.50$, $SD = 9.59$) with the experimental group at, ($M = 31.10$, $SD = 7.26$).

Introduction

According to Woong-Sung, Jung-Ha & Jun-Hee (2003), driving simulators are devices that immerse the operator in a realistic driving environment through feedback of visual, audio and tactile modalities. Likewise, Amico, Bruzzone & Guha (2001) suggest that possible accidents or large financial losses during the operation of complex man-machine systems can be devastating and in these circumstances simulation can prove to be invaluable. In addition, due to advances in computing technology simulation has become an efficient tool for investigation, design, research, training and logistics. Moreover, according to Pierowicz, Robin & Gawron (2001), simulators have been fruitfully engaged within the military arena and commercial airline business for over 30 years. If amply established, simulation technology may complement the training, testing, and licensing of commercial motor vehicle (CMV) drivers. Consequently, universities throughout the United States as well as the world have invested in driver simulators to carry out research and training.

The purpose of this research is to focus on simulation-based training in the area of scenario development and its potential role for improving the overall instruction of student truck drivers. In today's trucking schools, there is a shortage of equipment, which results in half of the students standing idly by while the other half practice basic maneuvers on large asphalt lots. In fact, due to high attrition rates in the trucking industry and the demand for new drivers, trucking schools are now turning to simulation as an alternative method to train tomorrow's driving force. Simulation is the only possible way to expose student drivers to as close as possible real-life driving situations without endangering the motoring public at large. Perhaps, one of the most difficult challenges for student drivers is learning how to execute left and right turns. Simply stated, it is the author's assertion that simulation can better prepare student drivers in the skill of executing left and right turns compared to traditional methods. To accomplish this task, three simulated scenarios focusing on left and right turns were scripted. The first training scenario (control group) is an off-track training scenario, which consists of a large asphalt lot and the use of orange cones. The second training scenario (experimental group) is an inner-city training scenario without the presence of vehicular traffic. The third scenario, an inner-city scenario with the presence of vehicular traffic was designed to test the control and experimental groups.

Also, does the operation of truck simulators present more difficultly for women than men? To answer these questions two groups of ten participants (10 women and 10 men) were tested. A subject matter expert, who is also a former driver and trainer, evaluated and scored all participants on four critical turns (2 left and 2 rights). A 2 x 4 factorial analysis was utilized to examine all research questions. The outcome of this study clearly suggests training in an inner-city situation (experimental group) without the presence of vehicular traffic is superior to the conventional approach (control group) of training on a large asphalt lot and better prepares a driver for training in city situations with the presence of vehicular traffic.

Scenario Development

Off-Track Training Scenario (Control Group)

For this scenario, the road data base was entitled “Warehouse” (Figure 1) and included a large building placed at the end of a large asphalt lot. A figure eight was built in this lot using 92 fixed objects (80 orange cones and 12 orange signs with black arrows). At each right or left turn the driver was directed by the arrows in which direction to turn (right or left).

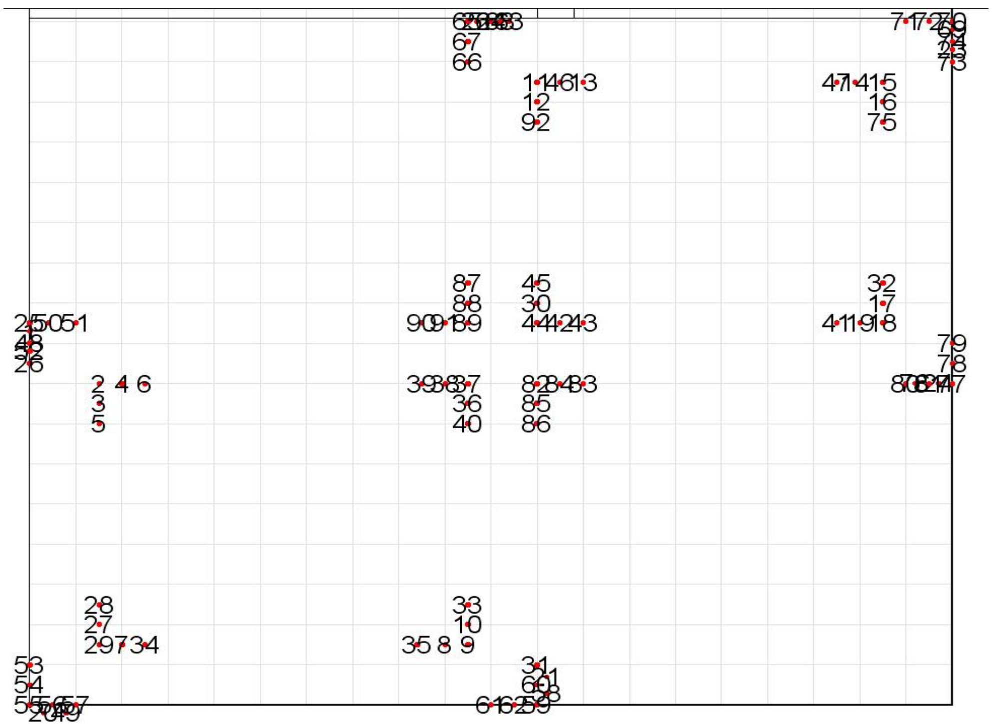

Figure 1: Off-Track Training Scenario

Inner-City-Scenario with No Traffic (Experimental Group)

The second training scenario (Figure 2) consisted of 26 vehicles, all of which are fixed objects (orange signs with black arrows). This scenario consisted of 8 rights and 5 left turns and took approximately ten minutes to complete.

Figure 2: Inner-City Training Scenario

Inner-City Scenario with Traffic (Test scenario)

The only difference between this scenario and the inner-city scenario with no traffic was the addition of 46 vehicles, which included 13 orange signs with black arrows, 10 Auto Density Route (ADR) vehicles, 22 Normal Vehicle Route (NVR) vehicles and one 4-way stop sign. All ADR vehicles had logic statements (e.g., If-Vehicle-19-Location-Not in Zone-1.0 / Then Set-Owncab-Collision-Equal to-False) included in order to reduce collision errors with the Owncab (vehicle operated by participant). All left and right turns were the same and time to complete the scenario was approximately one to two minutes longer due to traffic.

Methods

Participants

Twenty participants from the University of Central Florida and the Institute for Simulation and Technology participated in the experiment (10 males and 10 females). Their ages ranged between 22 and 57 with a mean age of 30.5 years. The participants included four undergraduate and ten graduate students with six participants listing themselves as others. The lowest computer usage was 20 hours per week while the highest was 70 hours per week. Participants were recruited at the Institute for Simulation and Training at the University of Central Florida through word of mouth. They were placed on a list and participated as they became available for testing.

Materials and Apparatus

Paper materials covered the informed consent, demographic survey, pre-simulation sickness questionnaire, post-training multiple-choice questions, post-simulation sickness questionnaires, subjective questionnaires and finally a score sheet for the grading of four critical turns throughout the test scenario. The next instrument included a collection of seven short video sessions delivered through a computer-based format on basic truck driving. These seven video clips came from Roadmaster Truck Driving School with the shortest lasting 55 seconds and the longest at 2 minutes and 34 seconds.

Perhaps the most important piece of equipment was the TranSim VS™ truck-driving simulator. This is a mid-range non-motion truck-driving simulator with a six by six-foot print developed by GE. In basic mode, it can accurately simulate the behavior of approximately 240 engines, 140 transmissions, 33 axle ratios, and 300 tire sizes, along with road conditions and various grades. Trainees and drivers learn the proper way to shift a variety of transmissions over different grades, pulling an assortment of loads—all from the safety and convenience of the classroom (GE driver development, 2003).

Procedure

The participants were brought into the simulation lab and were asked to fill out an informed consent. They were then required to fill out a demographic survey. Next, they filled out a pre-screen simulation sickness questionnaire. Afterwards, the participants watched a 13-minute and 50-second collection of 7 video clips. Video clip 1 lasted 0:55 and covered starting the engine. Video clip 2 lasted 1:08 and was entitled "Moving Off" followed by clip 3, "Off Tracking" which lasted 2:34. The fourth and fifth video clips covered right turns and lasted 3:35. Clip number 6 covered left turns and ran 1:57 and the last clip was 1:16 and addressed stopping. These clips are part of a 41 disc system owned by Roadmaster for the training of new drivers. To complete the training system by Roadmaster takes in excess of 100 hours.

Next, the participants were randomized in to one of two groups depending on the outcome of a coin toss. The two simulation training sessions consisted of an off-track scenario (control group) or an inner-city driving scenario (experimental group) without the presence of vehicular traffic. The off-track scenario consisted of an asphalt lot and several orange cones designed into a figure eight. The participants were required to practice turning in this scenario for 10 minutes. The inner-city driving scenario without vehicular traffic also lasted 10 minutes. While this scenario did not include traffic, it did include stop signs, buildings, and traffic lights.

After the participants completed the training session they were asked to take a 16-question multiple-choice test in order to establish a baseline understanding. All participants were required to score 75% or higher to be counted in the results. Next, all participants were tested on the inner-city driving scenario with the presence of vehicular traffic on four critical turns (2 right turns and 2 left turns). The test session also lasted ten minutes. The right turns were scored on signal, ease to the left before the turn, proper speed, tractor either too far or not far enough into the intersection, rear tandem tires run over the curb, rear tandem tires too far from the curb, and proper position of the truck after the turn. The left turns were scored in a similar fashion; signal, ease to the right before the turn, proper speed, tractor either too far or not far enough into the intersection, rear tandems run into the inner lane and proper position of the truck after the turn. All turns had independent characteristics; right turn 1 was a Button Hook turn, right turn 2 was a Jughandle turn, left turn 1 went from a four lane to a two lane, and left turn 2 went from a two lane road to a two lane road. All turns were scored by a subject matter expert, a former driver and trainer.

Results

The quantitative results for the 2 x 4 factorial analyses yielded the following results. There were no gender effects for combined turns as well as individual turns. However, overall conditional effects are significant. Participants trained in the inner-city training scenario without the presence of vehicular traffic (experimental group) out-performed those trained in the off-track scenario (control group) when tested in the inner-city scenario with the presence of vehicular traffic (test session). Descriptive statistics are illustrated in the table below.

Table 1: Descriptive Statistics

Turns	Condition	Mean	Std. Deviation
Right Turn 1	Inner-City	6.30	2.58
	Off-Track	4.50	1.08
Right Turn 2	Inner-City	7.60	3.06
	Off-Track	4.90	.99
Left Turn 1	Inner-City	10.10	3.25
	Off-Track	5.90	4.77
Left Turn 2	Inner-City	7.10	4.01
	Off-Track	5.20	4.34

Note: N = 10

The test session results for all turns combined were statistically significant, $F(1, 16) = 7.14$, $p = .017$, $\eta^2 = 3.09$. The overall differences in the training sessions are illustrated in the Figure 11. The mean for the control group ($M = 20.50$, $SD = 9.59$) with the experimental group at, ($M = 31.10$, $SD = 7.26$).

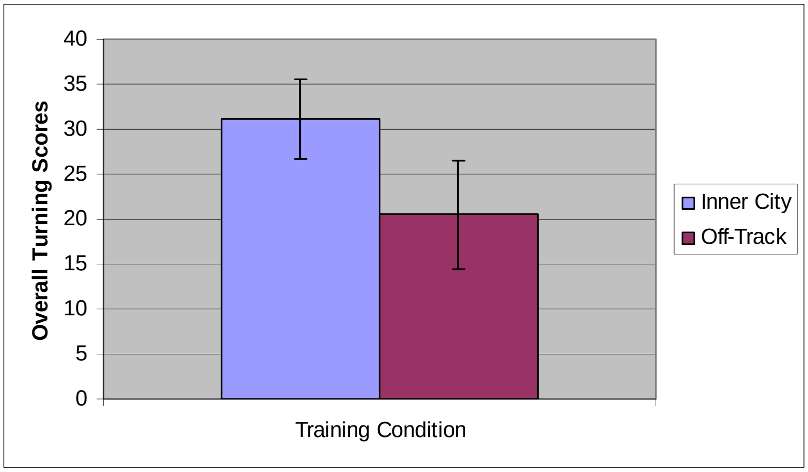

Figure 3: Overall Training Scores

The multiple-choice test (Figure 4) served as a baseline as well as a training tool. The questions were designed to measure learning captured from the instructional modules as well as the simulated training sessions. A minimum score of 75% was required on this test to be counted in the study.

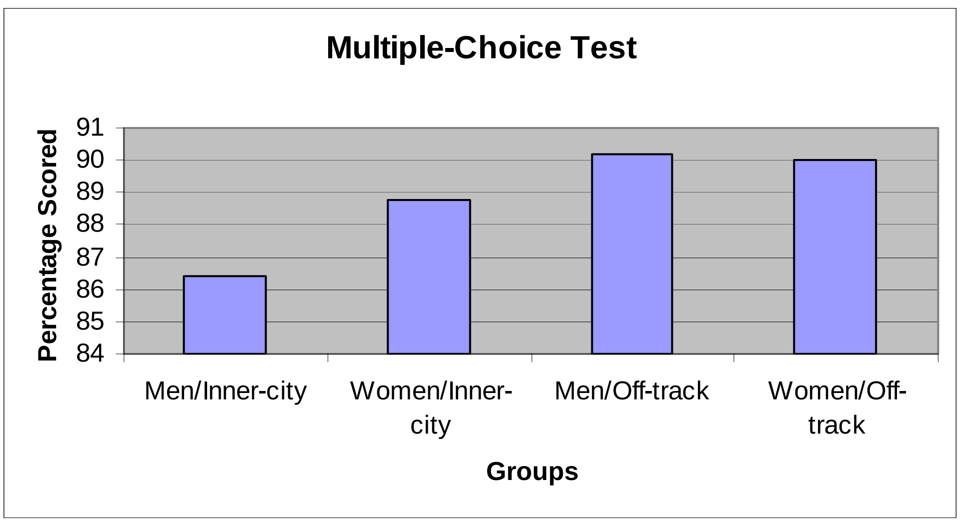

Figure 4: Multiple-Choice Test Results

Possible symptoms of non-motion simulators include nausea, disorientation, and ocular problems, such as eyestrain, blurred vision and eye fatigue. In a fixed-based simulator, the driver remains in a fixed position while the vision system senses motion. The disparity between sensory cues may result in simulation sickness (Casali, 1986). The results from the post-simulation sickness (Figure 5) questionnaire are illustrated below.

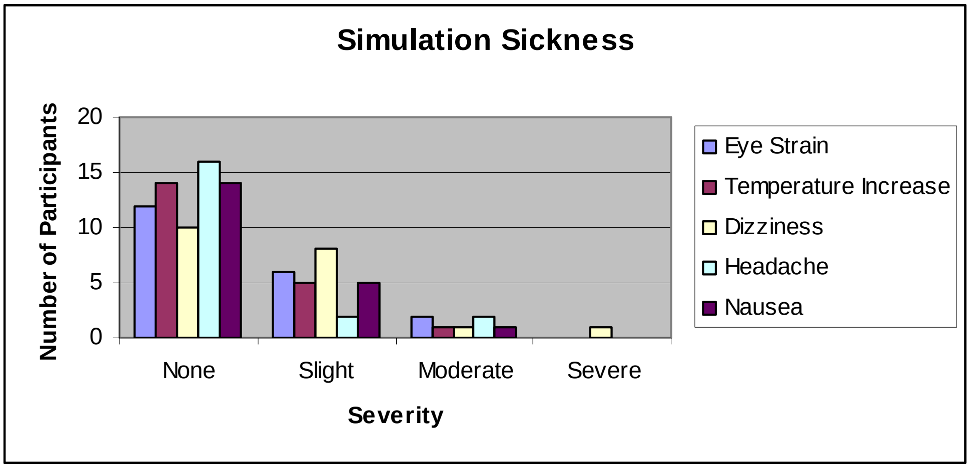

Figure 5: Simulation Sickness

Discussion and Conclusion

When drivers are trained in today's truck driving schools the conventional sequence of teaching is classroom instruction, followed by driving maneuvers on a large asphalt lot and finally driving on the public roads. Often, there is a shortage of equipment as well as instructors which leaves students standing idly by while the other students practice off-track maneuvers on asphalt lots or take turns driving while the other students ride in the sleeper compartment during road trips.

The mid-level simulator is a logical step in filling this gap and better preparing drivers to meet the challenges and demands of the road. With simulation, it is possible to script various driving situations that build skills required for the operation of these complex machines. Instead of having students standing around they could be honing their skills with the aid of simulation. In fact, without simulation, there is absolutely no way to prepare a driver for his/her first experience in the motoring public. The outcome of this study clearly suggests training in an inner-city situation without the presence of vehicular traffic is superior to the conventional approach of training on a large asphalt lot and better prepares a driver for inner-city situations with the presence of vehicular traffic.

While this study showed an impressive advantage in favor of the inner-city training scenario over the off-track scenario, there were no interactions or main effects pertaining to gender on any turn or overall. The fact that gender was not an issue in itself is noteworthy. There are abundant stereotypes surrounding the trucking profession. For instance, the scene in the popular movie "Thelma and Louise" portrays truck drivers as incompetent. Likewise, women and men alike grow up with attitudes towards driving trucks that are very different. Men often think of driving trucks as a Burt Reynolds type of profession while women are generally intimidated by the whole affair. Perhaps truck driving simulators could act as an instrumental intermediate step for bringing women into the trucking profession. It is the assertion of this author that women can operate trucks as well as men. In fact, in certain circumstances may even out-perform men. For example, women seem to be less aggressive and often cooler heads will prevail. The truck simulator gives the potential driver the opportunity to accustom him/herself with the size of the steering wheel, the clutch pedal, shifting procedures, size of the truck and the space required to successfully turn around corners. The simulator provides a safe place for the student to say to him or herself, “I can do this,” and furthermore, reduces anxiety and fear.

The limitations of this study can be examined using Kirkpatrick’s four-level approach to the evaluation of training programs. Level (1) measures satisfaction and can be demonstrated through the qualitative results of the subjective questionnaires. Ten attributes were measured on a 1 to 5 scale with 5 being the highest. The overall mean was a 3.92 which translates to a 78.4% satisfaction on all items measured. Level (2) assesses the amount of information learned. This is demonstrated by the quantitative results which illustrate an impressive advantage over the inner-city training scenario as compared to the off-track scenario. Level (3) evaluates behavior such as risk-taking, strategy, and planning as it relates to on-the-job performance and is commonly referred to as transfer of training (Kirkpatrick, 1996). The first aspect to consider when evaluating this study is the impressive outcome, especially considering the sample size, which produced an obvious transfer of training. Indeed, there was significant learning for the group that trained in the inner-city scenario as opposed to the off-track training scenario. The second factor or obvious next step is to apply this training approach in cooperation with truck driving schools where actual student drivers can participate and outcomes can be measured through surveys, interviews and statistical analysis. Level (4) measures results from the business point of view in terms of increased sales, productivity, profits and lowered turnover rates (Kirkpatrick, 1996). While this is the most difficult level to measure, both productivity and increased profits have been well documented using flight simulation within the airline industry. However, those objectives were not designed into this experiment, and therefore the impact is not known and the generalization is weak at best.

In conclusion, as simulation moves into the trucking industry the need for well-scripted scenarios as well as high-quality simulators such as the simulators provided by GE will be crucial. Hopefully, the outcome of this scenario testing is a first step in the development of a training package for truck driving schools as they bring simulation in to their instructional techniques. While this study did not evaluate student truck drivers per se, the results did demonstrate that simulation can produce learning; moreover, naive subjects can learn the skill of turning tractor-trailers when given appropriate training.

References

Amico, V., Bruzzone, A. G., & Guha, R. (2001). Critical Issues in Simulation. *SCS Proceedings, Orlando.*

Casali, J. G. (1986). Vehicular simulation-induced sickness, Volume 1: An overview. *IEOR Technical Report No. 8501. (NTSC TR 86-010).* Orlando, Fl: Naval Training Systems Center.

GE Driver Development. Retrieved December 10th, 2003 from: http://www.patrolsim.com/Products/Products.aspx

Kirkpatrick, D. (1996). Revisiting Kirkpatrick's four-level-model. *Training & Development, 1,* 54-57.

Pierowicz, J.A., Robin, J., & Gawron, V. J. (2001). Re-Assessment of Driving Simulators for the Training, Testing and Licensing of Commercial Vehicle Drivers. Retrieved August 14, 2003 from: http://ppc.uiowa.edu/driving-assessemnt/2001/Summaries/Driving%20Assessment%20Pap

Woon-Sung, L., Jung-Ha, K., & Jun-Hee, C. (2003). A Driving Simulator as a Virtual Reality Tool. *Department of Automotive Engineering, Kookmin University, Korea.*