A Study of Virtual Simulation

In a Truck Driver Training

Program

by

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A Research Paper
Submitted in Partial Fulfillment of the
Requirements for the
Master of Science Degree
in

Training and Development

Approved: 4 Semester Credits

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December 2008

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Title: ***A Study of Virtual Simulation in a Truck Driver Training Program***

Graduate Degree/ Major: MS Training and Development

Research Adviser: Renee Surdick Ed.D.

Month/Year: December 2008

Number of Pages: 60

Style Manual Used: American Psychological Association, 5th edition

ABSTRACT

In order to drive a semi-tractor in the United States the driver must obtain a commercial driver's license known as a CDL. CDL training is not federally standardized or regulated but licensing is through the Federal Motor Carrier Safety Association adopted by all states. Truck driver training does occur in both private and public entities. In the state of Wisconsin truck driver training is offered at three technical colleges and many private trucking firms hold their own training. Training in the public setting is eight to ten weeks long. One of the colleges, Chippewa Valley Technical College (CVTC) in Eau Claire, Wisconsin offers an eight week training consisting of classroom and lab. The lab takes place in a semi-tractor/trailer on the school grounds and roadways in and around the city of Eau Claire.

Chippewa Valley Technical College added virtual simulation to the truck driver training program with a donation of a Transim VS IV™ simulator in the Fall of 2007. This study will investigate the use of virtual simulation within the program focusing on cost savings, student confidence, safety, and student skill attainment.

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Acknowledgments

I can say that the encouragement of many people to include friends, fellow graduate students, instructors and family encouraged me through my graduate studies but several people were instrumental at seeing me through it all. One is Dr. Renee Surdick, my thesis advisor, ever so intuitive and research oriented in her suggestions, challenges, and encouragement that truly enabled me to research deeper and wider. Thanks to my editor, Linda Zeits, a valued friend who can now retire her red pen and Mary Volk for her assistance. Thanks to Barbara Preddy for her information compilation and Dr Dan Lofald for his encouragement and assistance in all that is statistics. Always first, just last here, my husband, Tom, who got used to the words "can't, gotta work on the paper" while I overtook the dining room table and other living spaces to conduct research and writing. Thanks to all for your support and encouragement.

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Chapter 1: Introduction

It is widely recognized that driving certain commercial motor vehicles requires special skills and knowledge. Prior to the implementation of the Commercial Driver's License (CDL) Program requirements in a number of states, anyone licensed to drive an automobile could also legally drive a tractor-trailer or a bus. Generally, many states that did have a classified licensing system, a person was not skills tested in a representative vehicle. As a result, many drivers were operating motor vehicles that they may not have been qualified to drive. In addition many drivers were able to obtain driver's licenses from more than one State and hide or spread convictions among several driving records and continue to drive (Evans, 2001).

It's the goal of this paper to investigate whether or not the method of training in a truck driving program affects skill attainment and student confidence along with the affect on program budget and safety.

The training mechanism being researched is the driving simulator utilized in the truck driving training program at Chippewa Valley Technical College in Eau Claire, Wisconsin.

Statement of Problem

What are the changes in student skill attainment, student confidence, program budget and safety record of students who participate in the truck driver training program with virtual simulation added?

Purpose of the Study

The purpose of this study is to evaluate the effective utilization and impact on student performance of a driving simulator in the eight week long Truck Driving Training (TDT) program at Chippewa Valley Technical College (CVTC). The TranSim IV L3 Simulator™ was a gift to the College in October of 2007. There was little research and only anecdotal speculation of the effectiveness of its use. It was speculated there would be immediate cost savings to the program assuming that simulation would replace drive time which appealed to the Administration at the College (W. Ihlenfeldt, personal communication February 1, 2006) on saving budget in the TDT program. Full-time instructors welcomed a new training tool but had little understanding of its impact. Part-time staff were skeptical referring to a simulator as "playing a video game" (J. Frederick, & R. Loughan, personal communication October 1, 2007), their views on the use of virtual simulation in truck driver training.

Background Impacting the Study

Simulation and virtual simulators are part of a number of educational programs at Chippewa Valley Technical College to include but not limited to:

- Law Enforcement students use a firing range to learn and perfect shooting skills, a vehicle track to practice high and low speed driving maneuvers and mannequins to practice cardio pulmonary resuscitation (CPR) in simulation
- Nurses and Paramedics hone their skills on human patient simulators from assessment of the patient to administering prescribed drugs in an emergency setting simulation (Abrahamson & Wallace, 1980)
- Fire Fighters use a burn tower to extinguish fire, search for victims in a fire scene, rappel from the rooftop and practice roped window entries
- Jailers learn defensive maneuvers and initiate baton strikes against "Red Man™" outfitted instructors in defense and arrest simulations

- Full and part-time police officers feel the effect of the FX marking cartridge ™ during felony shooting situations in firearms simulation

  (Anderson, E., Asher, J., Bruflat, M., Dickens, M., personal communication with CVTC staff, January 19, 2008) about simulation in programs at Chippewa Valley Technical College.

The cost of the Truck Driver Training Program at CVTC has come under scrutiny in the past. The program survived a major overhaul in the mid-1990s in an effort to cut costs. The staff was reduced from six to three full-time instructors. The curriculum changed from a year round entry, six month school with a one-to-one student to teacher ratio to an eight week program of twenty students configured in a four-to-one student to teacher ratio while driving in the truck. Teaching Assistants (TA's) ride in the truck as instructional staff at a reduced hourly rate compared to full-time instructors. This strategy did reduce costs to the program at the time of implementation. Today, the cost of equipment, maintenance, fuel, insurance and instruction continues to rise. Due to these factors the TDT program ranks as one of the top five expensive programs within the college. In a continuing effort to reduce costs short of completely eliminating the program, a driving simulator was introduced to the College via donation (R. Loughan, D. Severson, personal communication, June 22, 2007) CVTC staff members about program cost reduction efforts in the 1990's at CVTC specific to the truck driver training.

Assumptions of the Study

Prior to the simulator being introduced in the TDT program little research was undertaken to its' effectiveness, impact and where to include it in curriculum. To overcome the lack of research the assumptions of this study are:

- Students enrolled in the Truck Driving Training program acquire the knowledge, skills and experience essential to operate a tractor-trailer

- Novice and experienced students improve their truck driving skills with use of the simulator
- Students improve their skills test scores when combining simulation with behind the wheel driving
- Students gain confidence in truck driving through use of the simulator
- The percentage of students passing the commercial drivers license test will improve
- Student crashes during driver training will be reduced
- Maintenance and fuel costs of the program will be reduced
- Use of simulation improves truck driver training curriculum

Definition of Terms

Behind the Wheel is "operating a commercial motor vehicle behind the steering wheel in full control of said vehicle."

CDL is a "Commercial Driver's license, required by law for all operators of commercial motor vehicles, and is classified according to the vehicle weights driven."

CMVSA-Commercial Motor Vehicle Safety Act

Commercial Driver is "any person in the business of transporting products for the purpose of monetary gain, either interstate or intrastate."

Commercial Motor Vehicle is "any vehicle used in the business of transporting products."

Crash (also referred to as an accident or collision) is "an occurrence involving a commercial motor vehicle on a public road in interstate or intrastate commerce which results in: a fatality, injury to a person requiring immediate treatment away from the scene or, disabling damage to a vehicle requiring it to be towed from the scene." (FMCSR-49CFR Part 40 subsection 390.5)

DOT- Department of Transportation

Face Validity-is what you see to be real or close to actual in the simulator hardware or environment (Welles, 2008)

Construct Validity-is the training that has a similar result to a real experience (Welles, 2008)

FMCSR-Federal Motor Carrier Safety Regulations.

Intrastate-within a state's border.

Interstate-throughout the United States and Canada.

Simulation is "an imitation of some real thing, state of affairs or process."

Third Party Tester is "a person with a commercial driver's license who is certified through the WI DOT to administer the Commercial Driver License Skill Test."

Transim VS IV Simulator™ -is "a 180 degree three-panel plasma screen model with truck seat, clutch and shifter, steering wheel, accelerator, signals, lights and gauges of a semi-tractor. The 10-13 speed transmission can be selected and force-loaded steering gives the feel of real driving. Software gives real-time feedback to driving situations." (MPRI, Transim VS IV, Technology Software Publication, July 2007).

Virtual Simulator is "a high fidelity model that replicates real world equipment. A vehicle simulator provides reproduction of the characteristics of real vehicles in a virtual environment as the student is fully immersed in the process."(Turpin, Price, Welles, 2007)

Wisconsin Department of Transportation (WI DOT) governing body of commercial driver license testing in the state of Wisconsin. The WI DOT is authorized under Wisconsin State Statute 343.16.

Methodology of the Study

The study will include a literature review of relevant articles and books to include virtual simulation, simulators, truck driving, laws, curriculum based training, learning theories and self-efficacy. Crash results and skills tests comparison will be examined of non-simulator and virtual simulator users within the truck driver training program.

A survey utilizing a Likert scale will be administered to the students of one section of the truck driver training program at Chippewa Valley Technical College. This section of students received training in virtual simulation in the eight week training program.

Skill attainment measures will compare the test results in a twelve month period prior and post virtual simulation within the truck driver training program at CVTC. The use of the WI DOT Commercial Driver License Skill Test is the source of comparison. This test is administered in the last (or eighth) week of the training program by a certified Third Party Tester as required by the WI DOT.

Chapter II: Literature Review

Commercial Motor Driver's License

The Commercial Motor Vehicle Safety Act (CMVSA) of 1986 created a national Commercial Driver's License (CDL) program. The goal of the Act is to improve highway safety by ensuring that drivers of buses and large trucks are qualified to operate those vehicles and to remove unsafe and unqualified drivers from the highways (Federal Motor Carrier's Act, 2004).

The CMVSA with legislation in 1986 made it illegal to hold more than one driver's license and required States to adopt licensing and testing requirements for truck and bus drivers licensing and check a person's ability to operate the type of vehicle s/he plans on driving. Its the states responsibility to upgrade testing and licensing programs to conform with Federal standards. The Federal Highway Administration (FHWA) has developed and issued standards for testing and licensing of commercial motor vehicles (CMV) drivers. The U.S. Department of Transportation is the regulatory body that established national minimum testing and licensing standards in accordance CMVSA. States are required to test drivers seeking a CDL with knowledge and skills tests related to the type of vehicle the driver is going to operate (Federal Motor Carrier's Act, 2004).

The "how" of obtaining a CDL is not federally mandated. The CMVSA did not mandate any standardized training requirements in relation to curriculum, behind the wheel, or course length. How one obtains a commercial drivers license is the choice of the individual seeking one (Federal Motor Carrier's Act, 2008).

Safety

The Motor Carrier Safety Improvement Act of 1999 followed the Commercial Motor Vehicle Safety Act of 1986. This Act had the goals of reducing the severity and number of large-truck involved crashes through inspections, enforcement, sound research and effective commercial driver's license testing, record keeping (known as log books) and sanctions (FMCSA, 2004). Ten years after the passage of the Act, the U.S. Department of Transportation National Highway Traffic Safety Administration (NHTSA) issued traffic safety facts on large trucks.

(See Table 1)

Table 1

Involvement in Fatal and Injury Crashes and Involvement Rates for Large Trucks, 1985-1995

Year	Number of Large Trucks Involved In Fatal Crashes	Number of Large Trucks Registered	Vehicle Involvement Rate*	Vehicle Miles Traveled (millions)	Vehicle Involvement Rate **
1985	5,153	5,330,678	96.7	126,580	4.1
1986	5,097	5,249,102	97.1	130,141	3.9
1987	5,108	5,303,094	96.3	135,601	3.8
1988	5,241	5,433,560	96.5	141,397	3.7
1989	4,984	5,692,148	87.6	148,318	3.4
1990	4,776	5,854,337	81.6	149,810	3.2
1991	4,347	5,868,817	74.1	150,729	2.9
1992	4,035	5,970,925	67.6	152,803	2.6
1993	4,328	6,191,889	69.9	159,402	2.7
1994	4,644	6,303,313	73.7	170,415	2.7
1995	4,453	6,435,965	69.2	NA	--
Year	Number of Large Trucks Involved In	Number of Large Trucks	Vehicle Involvement Rate*	Vehicle Miles Traveled	Vehicle Involvement Rate **

	Injury Crashes	Registered		(millions)	
1988	96,000	5,433,560	1,764	141,397	68
1989	110,000	5,692,148	1,887	148,318	74
1990	107,000	5,854,337	1,830	149,810	72
1991	78,000	5,868,817	1,332	150,729	52
1992	95,000	5,970,925	1,586	152,803	62
1993	97,000	6,191,889	1,564	159,402	61
1994	95,000	6,303,313	1,507	170,415	56
1995	83,000	6,435,965	1,287	NA	--

*Rate per 100,000 registered vehicles
**Rate per 100 million vehicle miles traveled
NA = not available
Source: Vehicle miles traveled and registered vehicles – Federal Highway Administration National Center for Statistics & Analysis, Research & Development, 400 Seventh Street S.W., Washington, D.C. 20590

The analysis does in fact, indicate the there is a reduction of fatal crashes involving large trucks as the number of trucks registered has increased. An increase in the number of trucks registered does indicate more drivers on the roadways. Truck companies purchase trucks to be driven on roadways. A truck parked in the yard is not making money (D. Henderson personal communication, November 15, 2007) a Marten Transport safety officer on the number of drivers needed to fill the semi-trucks purchased by the company. The question of training is now at stake. In fact, the Federal Motor Carrier Safety Administration is currently gathering comment and input from the trucking industry and related consumers about establishment of standards for curriculum and drive time in order to obtain a CDL. What type of training could improve these statistics? Does more training or less training matter? Does the type of training or its' delivery mechanism matter? The findings are not published at time of this study.

Training Programs

A. Public Programs

In the State of Wisconsin the means of obtaining a CDL is either through a private trucking firm or one of the three technical colleges. Private companies have their own curriculum which they develop according to the needs of the company (CDL testing, 2008). The three technical colleges in Wisconsin (Chippewa Valley in Eau Claire, Fox Valley in Appleton and Waukesha County in Waukesha) follow a state based curriculum consisting of objectives and course outcome summaries and accomplish these goals within 8-10 weeks. Instructors in the Wisconsin Technical College System (WTCS) have requirements consisting of "a bachelor's degree or equivalent* with education or training preparing a person for the occupational area being taught. Appropriate training may include vendor, manufacturer, in-service or other structured on-the-job training in the occupation. (*Educational equivalency: Occupational experience combined with education and training preparing a person for the occupation totaling 7 years or 14,000 hours shall be equivalent to a bachelor's degree. Each academic credit or equivalent credit shall be equal to 110 hours of occupational experience). At the discretion of the district, additional criteria may be required beyond the minimum certification requirements" (Wisconsin Technical College System, 2002). Chippewa Valley Technical College (CVTC) in Eau Claire, WI is one of the colleges that offers an 8-week truck driver training program (CVTC catalog, 20007). In the fall of 2007 the college added a virtual driving simulator to their curriculum, a unique program feature (J. Hegge personal communication, December, 2007) on the use of a virtual simulator in truck driver training at Chippewa Valley Technical College.

B. Private

There are a number of private trucking companies that have training programs throughout the United States, Canada and across the world. Each private company employs a philosophy in training that best fits their company. Many split time between classroom and behind the wheel driving. Training ranges from several days to several months possibly as an employee or as an independent paying for the school (Truck Driver Training School, 2008). Many formalized training programs follow similar curriculum guidelines with outcomes to include driver safety, inspection of CMV, knowledge of laws, paperwork, trip planning, communicating effectively with peers, customers and supervisors, security of commercial vehicle as well as obtaining a CDL. Many of the private companies will reimburse the schooling upon successful completion and hiring on to the company (Associated Training Services, 2008). Many of these companies train drivers and place them on the road as soon and safely as possible. S. Schmitt (personal communication, February 27, 2007), a Roehl Trucking representative on driving school training in private industry.

These are private individuals or companies specifically organized to train individuals in an expedited manner often promising proficiency, sometime within a weekend often referred to as "CDL mills" within the industry. A Google ™ internet search of truck driver training schools produced several pages of sites offering a variety of ways to train to obtain a CDL. Some sites offer the study of CDL from a book (Advanced Tech Course, 2008). A recent student commented on his CDL training that he referred to as a "mill." He said he met a guy with a semi-tractor trailer in a parking lot, paid him $1,000 and drove around for two days in the lot. He learned how to shift and back while driving around in a circle. He never went out on the road and thought the training was "a joke." He said he did learn to shift and back and without the driving. He didn't think he learned all he could and passed the Skills Test without ever driving on the road. He was able to obtain his CDL with the signed documentation he received from the trainer. He later read the trainer was convicted of fraud for the very training he had received (P. Kosewski, personal communication September 9, 2008) spoke of his CDL training.

C. Length of Training Programs

In a 2001 study (Evans, 2001) determined effective lengths of truck driver training programs. Evans compiled information and correlated the safety records of commercial motor vehicle drivers and the length of formalized training programs the drivers attended. The results indicate a direct correlation between length of training and driving safety records of commercial drivers (Evans, 2001). The drivers with 7-9 weeks of training had the lowest percentage of accidents. In a comparison of accident records, the study determined a driver with 7-9 weeks of training and limited driving is relatively equal to a driver with 10 years of driving experience and no formal training (Evans, 2001).

Besides the formalized training and curriculum, two private firms have also integrated simulators into their truck driving training programs. Schneider National of Green Bay, WI and Bison Transport of Manitoba, Canada, are private companies with curriculum based on federal mandates for licensing commercial motor vehicle drivers. Bison has implemented truck driving simulators since 2002 and Schneider in 2005 (Lockridge, 2006). Chippewa Valley Technical College in Eau Claire, WI has a driver simulator introduced within the training curriculum as the only college in WI currently implementing this tool.

D. Virtual Simulation Industry

Aviation

The advent of simulators with Edwin Link's "blue box" in 1929 is best known and acknowledged as a revolution in learning and training. Frustrated by the cost of learning how to fly and relegated to conventional classroom training, Link decided to create a hands-on model for learning and he began to tinker with a design while working at his father's organ company. The design became known as the "Link Trainer" or "blue box" consisting of a wooden fuselage with a blue painted cockpit mounted on organ bellows. A vacuum pump operated the bellows which gave the fuselage the necessary pitch and roll of simulated flight. He set out to create a machine that could mimic the experiences of flying without ever leaving the ground. Link sold his first simulators to an amusement park where it was displayed and used as a ride in 1934. Shortly, thereafter, the U.S. Army Air Corps purchased the "Link Trainers" which had been updated to include aviation instruments of a radio and gauges that could tell the pilot if he was flying level. A hood was added to enclose the pilot in the simulator and an instrument panel gave the real life experience of flying while still on the ground (Morie, 1996).

Today, virtual flight simulators are computer graphic enhanced with surround screens, motorized hydraulics added to give that pitch and roll feel to flying. This led to the removal of noxious fluids from training centers along with reliability of the motor and access to satellite imagery and other geodata has greatly enhanced aviation simulation (Oyler, 1999). Simulation is the primary training students receive to learn how to operate an airplane without ever leaving the ground (Flight Simulators, 2006).

a. Virtual driving simulators

The automobile and trucking industry can benefit from the efficient and low cost variable for teaching drivers both basic and complex skill sets through simulation. Virtual simulation technology provides the experience of the driving task while training behaviors including psychomotor, sensory perception, cognitive and divided attention skills (Allen, Rosenthal 1999). The Utah Department of Public Safety (UDPS) applied driving simulators in the training of state and municipal law enforcement officers since 2002. The 355 officers who have trained on virtual simulators from 2002-2005 had a greater reduction in critical errors compared to those who did not experience simulator based training (Turpin & Welles, 2006). Public entitities such as police and fire departments, public works and bus companies continue to search out driver training through simulation in an attempt to reduce accident rates and insurance premiums (Yates, 2008).

Schneider National Trucking of Green Bay, WI added virtual simulation to their in-house truck driver training curriculum in 2005 as a pilot study. Results indicated virtual simulation has added a dimension to training especially with conditions, environment and specific driving situations that can't be safely replicated using traditional training methods. The company has improved graduation rates, higher retention rates and the ability to train drivers quicker and better than traditional training programs. Results showed significant improvement in cost savings and driver development. Students learning to shift on the simulator can accomplish within an hour what use to take one up to three days of driving in the truck yard. Schneider has also experienced a better safety performance with a 21 percent reduction in preventable crashes in new drivers (Lockridge, 2006). They have added simulation usage to sustainment training which is a required training for experienced drivers within their fleet. Bison Transport of Manitoba, Canada reports an 83 percent improvement in mean time between incidents after simulator training for preventable accidents (Lockridge, 2006). The high-tech virtual simulators were introduced in 2002 and since then the nearly 800 truck fleet has an increased safe driving miles by nearly 50 percent winning them the 2005 Safety fleet award (Lockridge 2006).

The University of Utah conducted a study (Strayer, et. al. 2004) of a pilot training program at the Utah Department of Transportation developed for snowplow operators, using the Mark II™ and TranSim VS™ driving simulators. The authors stated that, in the six months following training, "the odds of getting in an accident were lower for the group of drivers who received training compared with a matched control group who did not receive it" (Stayer, et. al., 2004). They also noted a 6.2 percent improvement in fuel efficiency for drivers.

b. Medical Specialties

In 1969, a study (Abrahamson, et. al. 1969) conducted at the University of Southern California School of Medicine evaluated the use of a physical patient simulator, Sim One, in training anesthesiology residents. The study demonstrated that simulator-trained anesthesiology residents required a mean number of 9.6 endotracheal intubations to achieve a skill level high enough to perform four consecutive professionally acceptable intubations, compared to 18.6 intubations for residents not trained on the simulator to reach the same standard. The same study showed that simulator-trained residents achieved the most exacting evaluation criterion applied in 55 days of training, compared to 77 days for their non-simulator-trained counterparts -- a savings of 22 days, or over 28 percent. More recently, a randomized, double-blind study at the Yale University School of Medicine's Department of Surgery evaluated (Seymour, et. al. 2002) residents trained in laparoscopy using a virtual reality (VR) system specifically known as the Minimally Invasive Surgical Trainer. The study found that VR-trained residents performed significantly better during cholecystectomy (gall bladder removal) surgery than a control group not trained using the VR system. The study also determined VR-trained residents worked 29 percent faster than control group participants and errors were six times less likely to occur during their surgeries. Control group participants were five times more likely to injure the gall bladder or burn non-target tissue and nine times more likely to fail to make progress for a minute or longer at some point during surgery.

c. Mining simulators

Tilcon New York, a mining company in the Northeast United States saw the value of equipment set for auction at one of its mining operations and requisitioned it for safety training. The safety director set out to put in place a 3-D training aid by using equipment to train rather than auction. The equipment was used to set up a small plant complete with crusher, a portable conveyor, a front end loader, some small tools, and a tank with a pump, shipping containers, and a fenced transformer. The plant is used to train new miners at orientation. The plant is set up with 150 hazards in natural surroundings. The hazards are not contrived but typical of a mining setting. One example is that of a drill left out on a bench in the welding area. The drill has exposed wires and should be taken out of service instead of used “one more time.” The trainee is given a scoring sheet and identifies hazards throughout the plant while paired with an experienced trained instructor. Tilcon has identified the need for good, quality hands on training which they have achieved with the simulated plant. The plant is also used in refresher training with experienced miners and in accordance with known industry standards for hazard identification all in the name of safety (Metzgar, 2006).

d. Skiing simulators

Skiing simulation such as the skier's edge slope simulator adjusts to mimic various slope pitches and allows for aggressive training on the forwards position once off the slopes. Other skiing simulations are the balance boards with attaché to the floor and enable the mimic of a ski stance and the video game Ski Super G which places on in a battle with other virtual skiers on racecourses using various ski-like foot motions and hand coordination (Training Tools, 2007)

e. Electric Industry

The electric industry predicts the next five years will see the retirement of a great portion of the electric industry's current work force. The need to train workers has Georgia Tech's Global Learning Center developing a powerful computer and a dozen liquid crystal display panels to simulate key systems operated from the control room of an electric generating plant. Students learn to adjust controls and can see the effect of that maneuver from not only their spot but all over the plant. Warnings indicate dangerous conditions and three-dimensional models show the exact components being controlled and in need of repair, shutdown or redirection. The effect of decisions made by the students are immediate without the potential dangerous consequence of a wrong maneuver (Electrical simulation, 2007).

f. Digital game-based learning

As defined in Merriam-Webster, simulation is "an imitation of some real thing" and is used in many disciplines in business and industry, medical to emergency to teach and to learn. A new field of simulation is digital game-based learning (DGBL). Most simply put it "is any marriage of conventional educational content and computer games with an as good or better results in student outcomes" then traditional teaching methods can produce (Prensky, 2001). DGBL works for three reasons:

1. The first is added engagement that comes from putting the learning into a game context.
2. The second is the interactive learning process employed.
3. The third is the way the two are put together in the whole package.

Anything can be learned through game play and today's youth currently learn, play and exist in this game-based environment. They have grown up with simulation games, digital cameras, cell phones that can hold and play songs, take pictures, give directions and keep a calendar besides usage as a telephone. The application, motivation and versatility make fun out of learning and can be extremely effective in today's world. (Prensky, 2001, p.3).

A variety of occupations have used digital game based learning. Engineers saw the change in computer aided drawing through the *Monkey Wrench Conspiracy,* accountants in *Permission Marketing,* business improvement in *Time Out,* stock traders in *Darwin, Survival of the Fittest.* Some fifteen years ago, doctors learned about the drug Dobutrex through the pharmaceutical giant Eli Lilly. A digital based game was created as a leave behind for doctors to try and play with the underlying premise of introducing them to the cardiac drug Dobutrex. As a result of their prescription dosage in the game, the person either died, recovered or fell somewhere in between. Doctors played it because it was quick, fast paced and fun and Eli Lilly knew it because sales rose (Prensky, 2001, p. 240-241).

And youth of today have grown up with digital game based learning (Greenfield, 1984). The Generations X & Y and beyond are learning concepts within the computer world far faster and greater then generations before them. One of the oldest users of these games is the military. Not only did they understand the use of simulators in the 1930's, (Morie, 1996) they have spent billions of dollars on research and creating very complex, sophisticated types of simulations. And no-one has benefited more than the entertainment industry. The advent of networking in the late 1950s and 1960s laid the groundwork for the modern date Internet. Networking, the internet, military design and research has brought about simulation through games such as *Apache and*

Harpoon used both in military training and the entertainment industry. And today with dwindling military budgets, the very profitable entertainment industry has taken the lead in game based learning by contracting out with commercial game houses to supply their need for specific simulations (Prensky, 2001, p. 299).

However, there are doubters to the gaming and virtual simulation world and are not convinced that any simulation is worthwhile or even educational. Gobler (2004) says that the teaching effectiveness of simulators has not been solved. Effectiveness and efficiency of simulation tools is assumed without scrutinizing their actual effects (Fox & Sullivan, 2007). As a research tool, the gaming of simulation is questioned along with validity of testing, fidelity, the domain it fits in and a variety of methodological concerns. Gobler's references are specific to business simulations and business simulators and not high fidelity simulators.

g. Skill Attainment

Applied Simulation Technologies (AST) researched the application of a driving simulator in training of over 1,000 police officers in Utah over a three year period. The research questioned design, model, use and curriculum while integrating a driving simulator in training. In reference to curriculum and application, findings concluded that there is a necessity of integrating the hardware and software to educational design. The simulator must not be viewed as a self contained device rather as a tool to support organizational goals and design (Marrs, 2008). A high fidelity piece of hardware supported by valid simulation software and curriculum with the integration of the simulator makes for an effective training course. Using this 3-phase process over a three year period AST tested and validated curriculum and simulator integration for successful application in police training (Turpin, Price, Welles, 2007).

Driver training has been defined and measured through simulator training by the Utah Department of Public Safety in 2005. Police recruits and experienced officers (355 of them) were trained on simulators and objective performance data was collected. Critical errors can be defined, measured and reduced by those same measures. Learning occurred through failure and repetition until success was achieved (Turpin & Welles, 2006).

Schneider National Trucking has documented better training by improving graduation rates, higher driver retention rates and the ability to train drivers quicker and more efficiently. Drivers training on the driving simulator have higher pass rates on the skill qualification test since implementation of the simulator in 2005. Schneider has experienced a 21 percent reduction in accidents after simulation, an overall better safety performance by drivers and fuel cost savings during training times (Lockridge, 2006).

Bison Transport of Manitoba, Canada implemented the use of high-tech simulators in 2002 and has increased safe driving miles for its entire fleet by nearly 50 percent. Bison was the grand prize winner of the Truckload Carriers Association 2005 National Fleet Safety Award, which the company attributes to the use of high-tech simulators. Preventable crashes were reduced by 83 percent and drivers are able to train in conditions that could not be safely duplicated in the field (Lockridge, 2006).

Learning Theories

a. Bloom

The way a person learns has been studied throughout time. American psychology began to set precedence in studying learning as an academic discipline (Pajares & Urdan, 1996). Benjamin Bloom took a lead in formulating a classification of levels of intellectual behavior important in learning (Bloom & Krathwohl, 1956). This classification is known as "Bloom's taxonomy" consisting of an overlap of cognitive, affective and psychomotor domains. Bloom developed levels of learning in two of the three domains. The cognitive domain has six levels: knowledge, comprehension, application, analysis, synthesis and evaluation. The affective domain emphasizes feeling and emotion on five levels: receiving, responding, valuing, organization and characterization (Bloom, 1984). The psychomotor domain is concerned with motor skills and

Bloom did not create levels for this taxonomy. Work by Harrow did summarize the psychomotor taxonomy on six levels: reflex, fundamental movements, perceptual abilities, physical abilities, skilled movement and non-discursive communication (Harrow, 1972). By using all three domains, the educator can develop "objectives the learner should acquire from the course and attempt to develop these learner capabilities through appropriate instructional experiences." The use of Bloom's classifications for students and learning and intended educational outcomes has gained considerable acceptance in education and by the American Association for the Advancement of Science (Sullivan, 2007).

Virtual simulation in driver training can accomplish these taxonomies with proper application by the instructor. The simulator is a stand-alone machine but functions most effectively with proper software application and an instructor who understands its' use. Instructional designers who understand the taxonomies can develop scenarios that bring the student through all domains and achieve the objectives and goals set forth in curriculum (Turpin & Welles, 2006).

b. Piaget

Piaget identified stages of cognitive development known as constructivism, which state people learn best when actively constructing ideas and doing experiments (Piaget, 1987). Therefore, students, learn best when presented material is combined with activity. Students in simulator-based driver training have the opportunity to learn from the scenarios provided on the simulator's high fidelity screen and work through the challenges of the scenario while driving the simulator. The assessment tool, a component of the simulator provides a significant advantage for student and instructor alike. Recording the driving behavior of the user, this tool is able to provide feedback to the instructor as to the effective and ineffective driving skills. Virtual simulation can evaluate the students' ability to respond to hazards in a safe environment. The student can learn by doing, learn by success or mistake and then repeat the scenario again without fear associated a wrong, illegal or problematic maneuver associated with actual over the road driving (Turpin & Welles, 2006) & (D. Severson, personal communication July 21, 2008) about the ability to repeat a scenario in virtual simulation safely.

c. Bandura

The encouragement of a healthy self perception has been researched as a critical component for academic success (Pagares & Schunk, 2001). Self-efficacy was introduced by Alfred Bandura in 1963 as an expansion of social learning theory and accepted years later as "social cognitive theory." Bandura defined self-efficacy as "people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives." Self-efficacy beliefs determine how a person feels, thinks, motivates and behaves (Bandura, 1994). Children with a strong sense of self-efficacy characteristically show an increase in individual accomplishment and stronger personal well being. These individuals approach difficult tasks as a challenge to master rather than shying away from or avoiding the task. Failures or setbacks are attributed to a lack of effort or knowledge rather than external factors (Bandura, 1997). While much of Bandura's studies focused on children, adult learning had been studied in the twentieth century and research determined that adults could continue to learn (Thorndike, 1928). In early twentieth century studies focused on children but shortly after World War I there began an emergence of studies of the adult learner (Knowles, 1978).

Initially, the strongest sense of efficacy occurs when one masters an experience. Secondly, one's self-efficacy is achieved through vicarious experiences provided by social models. When an individual sees another similar to themselves succeed they, in turn increase their own belief about their competencies and success. A third way to achieve self-efficacy is through social persuasion. It may be an educator providing positive feedback during trial and error (Pajares & Urdan, 2006). Self-efficacy is also tied to motivation and avoidance. An individual, who is motivated, tends to avoid tasks associated with low self-efficacy (Pajares, 1996). Lastly, self-efficacy is somewhat dependant on an individual's physical and emotional state. An individual's mood can affect one's efficacy. A positive mood not only enhances one's own outlook on life it also increases positive self efficacy. And the reverse is also proven that and low and depressive moods can diminish self-efficacy (Bandura, 1995).

Self-efficacy in today's youth may be seen quite differently when introduced to the video game-based world where the concept of failure is quite different. The player in a video-enhanced or digital game understands that success involves some failure which doesn't diminish self-efficacy but rather builds it (Masie, 2006). The game can be played over and over again with failure or success. Small successes without total game achievement can be seen as a positive accomplishment. The player is working toward a goal and failure may be a part of the success. This was experienced in kindergarten children tested with virtual simulation and traffic safety where repeated attempts were encouraged while experiencing success or failure (Renaud & Suissa, 1989). The player can repeat the scenario learning from the previous encounter in an attempt to gain success. Players of digital games often model each other and trade secrets making the challenge fun as they try to figure out the scenario. In the digital game-based world learning by failure or by an expectation failure is seen as success (Prensky, 2006). The underlying concept of virtual simulation is that the learner moves forward after success or failure. The learner is provided feedback on performance and then allowed to try again until failure is replaced with success or what research refers to as "failing forward" (Schank, 1997). Building self-efficacy is enhanced by failing forward as long as the student can gain a little more knowledge and success (Maise, 2006). The virtual simulation student gains knowledge, experiences mastery, sees others succeed and builds their confidence. Success can be achieved through experience and repetition building confidence and success (Bandura, 1997).

d. Knowles

Adult learning theory recognizes a child moves from total dependency on others for information to that of the self-directed adult. The great teachers of ancient history, Lao Tse and Confucius in China, the Hebrew prophets, Jesus, Socrates, Plato, Aristotle, Euclid, and Cicero were chiefly teachers of adults. They made assumptions about learning such as learning is a process of discovery by the learner (Bruner, 1973). “Learning by doing” which includes success and failure is the way adults learn. The adult, no longer dependent on others for care and learning, has developed into a cognitive, hands-on learner developing skills and abilities through application. Teaching this learner is the challenge of many an instructor of adults (Knowles, 1973). Using this adult learning theory, Bloom’s taxonomies in teaching and the introduction of a driving simulator within proper curriculum may be an effective tool for the learner. How effective is the essence of this research.

Chapter III: Methodology

An investigation into the use of virtual simulation in the truck driver training program at Chippewa Valley Technical College in Eau Claire, WI was conducted in order to determine any changes since the introduction and use of a driving simulator in the Fall of 2007. The following section describes methodological issues such as subject selection, instrumentation, data analysis and limitation.

Subject Selection

Subjects for this study were students within the truck driver training program at Chippewa Valley Technical College in Eau Claire, Wisconsin during calendar year 2007 and 2008.

Instrumentation

A survey was written in order to determine if the use of virtual simulation impacted student performance. Questions were drafted based on the affect and impact of virtual simulation to student confidence and skill attainment.

Data Collection Procedures

Three surveys (see Appendix C, D, and E) were administered to the same students in the June 2008 truck driver training class at Chippewa Valley Technical College. Survey 1 had potentially eight questions with subject demographics, yes and no questions and a Likert scaled question delineated into eleven subsets. This survey was administered in the first week of the eight week truck driver training program prior to using the Transim VS IV ™ or driving a semi-truck. Survey 2 had potentially eight questions of demographic, yes and no and two, open-ended questions. The survey was administered in the fourth week of the program after the use of virtual simulation and driving a semi-tractor. Survey 3 had potentially seven questions of demographic, yes and no and a Likert scaled question delineated into eleven subsets. Survey 3 was administered in the last week, or eighth week, of the truck driver training program. The seventh question in survey 1 and survey 3 are the same for comparison purposes of pre and post use of virtual simulation and driving a semi-tractor truck. Answers were compiled and later entered onto a spreadsheet for purposes of data collection and analysis.

The implied consent form (Appendix B) was administered to each student in the class on the first day of class, prior to the administration of survey 1 and the use of virtual simulation or operating a semi-tractor truck in the training. The researcher read the implied consent form to the class and the form was distributed and results collected by the researcher. The Institutional Review Board (IRB) form (Appendix A) was approved prior to administering the survey 1. The IRB identifier was placed on each survey administered to the group.

The researcher contacted the Maintenance Department of Chippewa Valley Technical College and requested and received the fuel consumption records of the trucks used specifically in the truck driver training program during 2007 and 2008. Results compiled in Table 20.

The researcher contacted the Safety Department of Chippewa Valley Technical College and requested and received the accident reports of students from the truck driver training program from September 2006 through September of 2008. Results compiled in Table 21.

The researcher contacted the Program Assistant for the truck driver training program and requested and received the skills test results of students pre-simulation January-September 2007 and post-simulation January-September 2008. Results compiled in Table 19a-b.

Data Analysis

Data was analyzed by qualitative and quantitative descriptive statistics. A Likert scaled question was used in both survey 1 and survey 3 and eleven determinant factors were measured for statistic significance. Other survey questions with quantitative measures were coded by response and frequencies were tallied. Qualitative responses to two questions in survey 2 were limited and responses recorded.

Limitations

The survey tool was intended to measure student confidence and the effect of virtual simulation in a truck driver training program. The test sample (n=15) for survey was confined to one group of students in a truck driver training program.

Skills test results compared two different years (2007 & 2008) of students with one class year experiencing virtual simulation while the other did not. Sample size was significant (n=73) in 2007 and (n=69) in 2008.

Budget considerations were limited to fuel consumption as the most constant measure of cost. Many factors could be considered but documentation is limited to fuel for this study due to availability of records.

Safety considerations were limited to documented accident reports. While other safety factors may exist such as injuries for other reasons related to the program, such records are restricted. Reduction in accidents is an industry standard and so used by the researcher. The College is self-insured and any damages estimates were recorded through body shop estimates.

Chapter IV: Results

Survey

It was hypothesized that participant involvement with the Trans VS IV™ virtual simulator would increase participants' confidence in discrete abilities associated with operating a truck. Eleven discrete performances were identified. The Likert values ranged from 1 = very uncomfortable to 5 = very comfortable. Participants were surveyed at the beginning of the course Survey 1 (pre-measure) and at the end of the course Survey 3 (post-measure) with the same questions.

The first survey question of discrete skill performance was participants' perceptions of their ability to back a semi-truck into a loading dock. The descriptive statistics for this question are in Table 2 below:

Table 2

Descriptive Statistic for Pre versus Post – Backing the semi-truck into a loading dock

Variable	N=15	Mean	Standard Deviation	*z*-test	2- tailed
Pre 1	15	2.60	.632		
Post 1	15	3.467	.640		
Post 1-Pre 1				-2.667	.008

The mean confidence level for participants on the "backing into loading dock" question was great in the post measure (3.467) than in the pre measure (2.60). The difference between these two means was statistically significant $t(28) = -2.67, p = 008$.

The second survey question of discrete skill performance was participants' perceptions of their ability to set up for a backing maneuver. The descriptive statistics for this question are in Table 3 below:

Table 3

Descriptive Statistic for Pre versus Post – Setting up for a backing maneuver

Variable	N=15	Mean	Standard Deviation	*z*-test	2- tailed
Pre 2	15	2.8000	.67612		
Post 2	15	3.6000	.82808		
Post 2-Pre 2				-2.814	.005

The mean confidence level for participants on the "setting up for a backing maneuver" question was great in the post measure (3.60) than in the pre measure (2.80). The difference

t (28) = 2.81, p = .005.

The third survey question of discrete skill performance was participants' perceptions of driving a stick shift. The descriptive statistics for this question are in Table 4 below:

Table 4

Descriptive Statistic for Pre versus Post – Driving a stick shift

Variable	N=15	Mean	Standard Deviation	*z*-test	2- tailed
Pre 3	15	3.4667	.91548		
Post 3	15	3.8667	.91548		
Post 3-Pre 3				-.847	.397

The mean confidence level for participants on the "driving a stick shift" question was less in the post measure (3.867) than in the pre measure (3.467). The difference between these two means was not statistically significant *t* (28) = -.847, p = .397.

The fourth survey question of discrete skill performance was participants' perceptions of using a 13-gear shifter. The descriptive statistics for this question are in Table 5 below:

Table 5
Descriptive Statistic for Pre versus Post - Using a 13-gear shifter

Variable	N=15	Mean	Standard Deviation	*z*-test	2- tailed
Pre 4	15	2.7333	1.03280		
Post 4	15	3.7333	.96115		
Post 4-Pre 4				-2.284	.022

The mean confidence level for participants on the "using a 13-gear shifter" question was great in the post measure (3.733) than in the pre measure (2.733). The difference between these two means was statistically significant *t* (28) = -2.28, p = .022.

The fifth survey question of discrete skill performance was participants' perceptions of downshifting. The descriptive statistics for this question are in Table 6 below:

Table 6
Descriptive Statistic for Pre versus Post – Downshifting

Variable	N=15	Mean	Standard Deviation	*z*-test	2- tailed
Pre 5	15	3.0000	1.06904		
Post 5	15	3.8000	.77460		
Post 5-Pre 5				-2.266	.023

The mean confidence level for participants on the "downshifting" question was great in the post measure (3.800) than in the pre measure (3.000). The difference between these two means was statistically significant *t*(28) = -2.26, p = .023.

The sixth survey question of discrete skill performance was participants' perceptions of stopping at an intersection. The descriptive statistics for this question are in Table 7 below:

Table 7

Descriptive Statistic for Pre versus Post – Stopping at an intersection

Variable	N=15	Mean	Standard Deviation	*z*-test	2- tailed
Pre 6	15	3.1333	.99043		
Post 6	15	4.2000	.94112		
Post 6-Pre 6				-2.159	.031

The mean confidence level for participants on the "stopping at an intersection" question was great in the post measure (4.200) than in the pre measure (3.133). The difference between these two means was statistically significant *t* (28) = -2.159, p = .031.

The seventh survey question of discrete skill performance was participants' perceptions of setting up for a right turn. The descriptive statistics for this question are in Table 8 below:

Table 8

Descriptive Statistic for Pre versus Post – Setting up for a right turn

Variable	N=15	Mean	Standard Deviation	*z*-test	2- tailed
Pre 7	15	2.8667	.91548		
Post 7	15	4.0667	.88372		
Post 7-Pre 7				-2.571	.010

The mean confidence level for participants on the "setting up for a right turn" question was great in the post measure (4.067) than in the pre measure (2.867). The difference between these two means was statistically significant $t(28) = -2.57$, p = 010.

The eighth survey question of discrete skill performance was participants' perceptions of driving a stick shift. The descriptive statistics for this question are in Table 9 below:

Table 9

Descriptive Statistic for Pre versus Post – Setting up for a left turn

Variable	N=15	Mean	Standard Deviation	*z*-test	2- tailed
Pre 8	15	3.0000	.92582		
Post 8	15	4.1333	.83381		
Post 8-Pre 8				-2.514	.012

The mean confidence level for participants on the "setting up for a left turn" question, was great in the post measure (4.133) than in the pre measure (3.00). The difference between these two means was statistically significant $t(28) = -2.514$, p = 012.

The ninth survey question of discrete skill performance was participants' perceptions of driving a stick shift. The descriptive statistics for this question are in Table 10 below:

Table 10

Descriptive Statistic for Pre versus Post – turning at a busy intersection with a stop sign

Variable	N=15	Mean	Standard Deviation	*z*-test	2- tailed
Pre 9	15	2.7333	.88372		
Post 9	15	3.6667	.61721		
Post 9-Pre 9				-2.697	.007

The mean confidence level for participants on the "turning at a busy intersection with a stop sign" question was great in the post measure (3.667) than in the pre measure (2.733). The difference between these two means was statistically significant $t(28) =$

-2.69, p = 007.

The tenth survey question of discrete skill performance was participants' perceptions of turning at a busy intersection with a traffic light. The descriptive statistics for this question are in Table 11 below:

Table 11

Descriptive Statistic for Pre versus Post – Turning at a busy intersection with a traffic light

Variable	N=15	Mean	Standard Deviation	*z*-test	2- tailed
Pre 10	15	2.7333	.88372		
Post 10	15	3.8667	.74322		

Post 10-Pre 10				-2.910	.004

The mean confidence level for participants on the "turning at a busy intersection with a traffic light" question was great in the post measure (3.867) than in the pre measure (2.733). The difference between these two means was statistically significant *t* (28) =

-2.910, p = 004.

The eleventh survey question of discrete skill performance was participants' perceptions of changing lanes on a 4-way highway. The descriptive statistics for this question are in Table 12 below:

Table 12

Descriptive Statistic for Pre versus Post – Changing lanes on a 4-way highway

Variable	N=15	Mean	Standard Deviation	*z*-test	2- tailed
Pre 11	15	3.0667	.88372		
Post 11	15	4.2000	.67612		
Post11-Pre 11				-2.505	.012

The mean confidence level for participants on the "changing lanes on a 4-way highway" question was great in the post measure (4.20) than in the pre measure (3.067). The difference between these two means was statistically significant *t* (28) = -2.505, p = 012.

The twelfth question asked in survey 1 and survey 3 is to measure confidence in driving and the statistics are shown in Table 13 below:

Table 13

Statistics for Pre versus Post in the question-how confident are you in your abilities to professionally drive a semi-truck:

Variable	N=15	Mean	Standard Deviation	*z*-test	2- tailed
Pre 12	15	3.81	.834		
Post 12	15	3.82	.603		
Post 12-Pre 12				-.036	.000

The mean confidence level for participants on the "confidence in abilities to professionally drive a semi-truck" question was same in the post measure (3.82) than in the pre measure (3.81). The difference between these two means was not statistically significant t (28) = -.036, p = .000.

Quantitative Data Survey 1

Table 14

Survey 1 responses to the following question

Have you ever driven a semi-truck?		If yes, how many years?			
Yes	1	Years			
No	14	1-5	6-10	11-15	16+
N=15		1	0	0	0

Quantitative data was collected in survey 1 to identify the experience of participants with a driving simulator and shown in Table 15.

Table 15

Survey 1 responses to the following question

Have you ever driven a truck driving simulator?		If yes, how many times?			
Yes	0	Years			
No	15	1-5	6-10	11-15	16+
N=15		0	0	0	0

Quantitative Data Survey 2

Quantitative data was collected in survey 2 to determine the frequency of use of the shifting gear as shown in Table 16 and the backing maneuver as shown in Table 17.

Table 16

Survey 2 responses to the following question:

Did you use the shifting gear on the truck driving simulator?		"Yes" how many times?			
Yes	14	1-5	6-10	11-15	16+
No	0	0	1	1	12
No response	1				
N=15					

Table17

Survey 2 responses to the following question:

Did you use the backing maneuver on the simulator?		If yes, how many times?			
Yes	14	Years			
No	0	1-5	6-10	11-15	16+
Blank	1	6	7	1	0
N=15					

Skill test results

The Commercial Driver License Skill Test is regulated by the Wisconsin Department of Transportation (DOT) under Wisconsin State Statue 343.16. The test is a two part test consisting of MV 3542 Pre-trip Inspection (Appendix I) for documentation of skill and the MV 3543 Commercial Driver License Skill Test (Appendix J). Descriptive statistics for this cohort pre-simulation group (January – September 2007) was compared to a cohort post-simulation group (January – September 2008) as shown in Table 18a-b.

Table 18

Skills Test results

a. Descriptive statistic results for cohort no simulation versus simulation

Variable	N	Mean	Standard Deviation
No Simulation	73	17.26	6.44
Simulation	69	14.87	.5.75

b. ANOVA table for pre and post simulation curriculum

Source	*df*	ss	ms	F
Group	1	202.739	202.74	*5.414
Error	140	5241.88	37.44	
Total	141	5444.62		

Budget

Fuel consumption for the months January – September in pre-simulation (2007) and post-simulation (2008) was tabulated as shown in Table 19.

See Table 19

Table 19

Fuel consumption

N=Number of Trucks	2007 Gallons	2008 Gallons	Difference
16	9627.5	6782.7	-2844.8

The figures indicate a 30% savings in fuel consumption.

Safety

Safety considerations were determined by comparing accidents occurring pre-simulation October 2006 – September 2007with post-simulation accidents October 2007- September 2008. See Table 20 below:

Table 20

Accidents pre and post-simulation October 2006-September 2008 in truck driver training

Date	Time of Day	Event	Damage Amount	Driver
Pre-simulator				
1/29/07	2:10 p.m.	Public Roadway Sideswipe on Curve	$1,000	Female
4/21/07	9:30 p.m.	Private Lot Left Turn (2 Vehicles)	$3,815	Female
Post-simulator				
10/25/07	7:00 a.m.	Public Roadway Right Turn/Parked Car	$1,000	Male
11/13/07	2:20 p.m.	Public Roadway Right Turn Hit Stop Light	$2,600	Male

December 2007 through December 2008, no accidents have been reported which is 100% reduction in reportable accidents.

Chapter V. Discussion

The research for this study focused on the addition of virtual simulation in the Truck Driver Training program at Chippewa Valley Technical College. Changes were tracked in student confidence, student skill attainment, program budget and the safety record of students. The tracking occurred in pre and post virtual simulation years since the introduction of virtual simulation via a Trans VS IV™ simulator in the program.

Survey

Quantitative results were determined in all three surveys. Survey 1 and survey 3 shared two sets of questions in determining student confidence. A pre (survey 1) and post (survey 2) survey instrument was used to determine student confidence with the same 11 determinant questions referring to comfortableness. The results showed statistical significance pre to post simulation in ten of the eleven determinants. The confidence is significant indicating that the use of virtual simulation had a significant effect on student confidence for specific elements to driving a semi-tractor trailer truck. See Appendix F for demographics of survey group.

The one question of driving a stick shift had no statistical significance in student confidence and the use of the simulator for this specific element. This finding may be attributed to the fact that participants may very well know how to drive a stick shift from the 3, 4 or 5-speeds taught in manual-shift automobiles and trucks. The next question in the survey after the stick shift was the use of the 13-speed shifter which is a semi-truck transmission and that result was statistically significant that there was change from pre to post usage of the participant's abilities.

The last question (or the twelfth question) asked separately from the eleven specific elements was the question of how confident is the participant in the ability to professionally drive a semi-truck pre versus post simulation and there was no statistical significance. The pre test result was the same as the post test which is not significant statistically but does have significance in the student awareness of what driving professionally may mean. At the start of class the level of confidence in driving is neither “not confident” nor “very confident” (Table 13) which is the reason to take the class. At the end of the class with seven weeks of driving and practice with additional time on virtual simulation, the class is neutral in confidence of the ability to drive professionally.

Qualitative results in survey 2 had singular frequency values and some themed results. In the two questions of virtual simulation being more or least helpful there were three frequencies each for backing and shifting in both questions.

Skill test results

The Commercial Driver License Skill Test is regulated by the Wisconsin Department of Transportation (DOT) under Wisconsin State Statute 343.16 and obtained by taking a written and a driving test which is administered by a Third-Party tester. The Third-Party tester must possess a commercial driver’s license and successfully complete the Third-Party Tester (TPT) training course sponsored by the WI DOT. Once certified, the Third-Party Tester rides with the person seeking licensure in the same like vehicle. The TPT uses form MV 3542 Pre-trip Inspection (Appendix I) for documentation of set pre-driving skill and the MV 3543 Commercial Driver License Skill Test (Appendix J) for actual driving skill (Wisconsin Legislative Bureau, 2005).

The TPT observes driver abilities and skills and points are denoted on the forms if driving errors are performed. Results are tabulated and the total number determines pass or fail. A total score of 26 points or higher is a failure (J. Fredericks, personal communication, November, 2008) on how to score the Skills Test for commercial driver licensing.

There are two full-time third party testers at Chippewa Valley Technical College who test the majority of students within the truck driver training program. One part-time third party tester is also employed by Chippewa Valley Technical College and started skills testing in June of 2008 and used as needed.

One full-time instructor trained on virtual simulation through the Transim VS IV™ simulator was the consistent TPT throughout this study. The other full-time instructor experienced an illness that limited his time as a TPT in the post-simulation year and seniority limited his exposure to classes in the pre-simulation year. The post simulation classes had at least three different adjunct instructors during virtual simulation and behind the wheel training. Adjunct instructors also taught in classroom and were trained in virtual simulation by current instructors October 2007 through February 2008. Three teaching assistants (TA's) were employed during the pre and post simulation classes as instructors in the truck with the student.. The teaching assistants were heard to say the simulator was referred to as a "toy and a game". It is unknown the affect on students with such language. (D. Severson, personal communication, February, 2008).

The descriptive statistics for the skills test comparison are significant between the cohort group of those with no simulation (n = 73) versus the simulation group (n = 69). The differences between means (17.26 versus 14.87) was statistically significant ($\underline{F}$ (1,140) = 5.414 $\underline{p}$. $\leq$ .05). The post simulation group has improved in the skills tests since the addition of virtual simulation within the truck driver training program.

Survey 1 and survey 3 tracked confidence scores. Virtual simulation may be a factor in overall confidence scores but one must also take into consideration that the student has had significant behind the wheel time for seven weeks prior to the administration of survey 3.

Budget

Program costs are continuously monitored by a number of entities throughout the college. Scrutiny to cost of programs takes into consideration need and want of society, individuals and programs. The truck driver training program has sixteen tractors and twelve trailers to maintain.

A full-time maintenance technician is on staff specifically assigned to the program. A driving yard, a dual oval driving track and skid pad are all a part of the program. The program does seek an annual chauffeur training grant which allows for consideration in the payment of some maintenance costs and limited equipment purchases.

This study concentrated on the fuel costs consumed pre and post simulation specifically January-September 2007 and 2008. Sixteen same semi-tractors were used during both these years. In 2008 there was a 30% reduction in fuel usage for similar sized groups (2007 n=73, 2008 n=69) which is a significant savings when fuel, maintenance costs, wear and tear on equipment is considered.

Safety

Safety is a major concern in the truck driving industry and an important component, concern and objective among the instructors in the truck driver training program. The students learn how to inspect a semi-tractor and trailer to assess the working components for safe operation of the vehicle. The driver is taught how to enter the tractor safely by using the three point entry method upon entry into the cab of the tractor. The use of the seat belt is required in the program by driver and any passenger. The driver has stringent requirements from being drug-free and absolutely sober. All drivers are made aware of the fact that any driver related alcohol conviction(s) incurred in any vehicle also affects the commercial driver license (Wisconsin Legislative Bureau, 2005). Safety considerations include the inspection of the vehicle and all the component parts of the truck to the very person driving the vehicle. The semi-tractor trailer at 53' long and weight limits exceeding 8,000 pounds has special considerations and precautions when operating along the highways of our nation and the driver must be fully aware of this responsibility (Michigan DOT, 2007).

The safety measurement for this study is the accident rate comparison in the truck driver training program at Chippewa Valley Technical College twelve months prior to virtual simulation with the introduction of the Transim VS IV™ simulator to thirteen months after virtual simulation. Virtual simulation was brought on-line in the latter part of October 2007 in the truck driver training program. The scheduled eight-week class was already in progress when the virtual simulation was introduced. Accident reports for the months of October 2006 to September 2007 (pre-simulation) were compared with the reports from October 2007 to November 2008 (post-simulation). For clarification, an accident is classified as such if there is injury to anyone in either vehicle, property damage of $1,000 or more to any one person's property or $200 damage to government property (Wisconsin Legislative Bureau, 2005).

In all the reported pre and post simulation accidents, the trailer of the semi-tractor was involved in the damage. At 53' long the trailer is a major component of the truck and is involved in every aspect of driving and maneuvers throughout the eight-week program. Accidents are a major concern in the trucking industry in terms of safety, cost in insurance and company (or individual) liability. Companies want responsible and safe drivers who can take and deliver a load in a timely and safe manner. Several companies report the use of virtual simulation in initial training as well as sustainment training for experienced drivers has increased their safety ratings by reduction of accidents. Two of these companies include Schneider National with a reported 21% reduction in accidents in 2004 and Bison Transport with an 83% reduction in preventable accidents in 2005 (Lockridge, 2006).

The review of reported accidents for this study included the Wisconsin Department of Transportation MV4000 accident reports filed by the drivers. CVTC requires additional paperwork filed by driver and instructor and any other witnesses. The safety director collects this documentation for dissemination to the necessary agencies requiring report. (S. Bonk, personal communication October, 2007) on how to report an accident. Most significantly is the finding of the two crashes in October and November 2007. This period of time was the initial roll out of virtual simulation in the TDT program. The instructors were learning "the how" of virtual simulation in theory, application and curriculum. The class in October 2007 was the pilot group experiencing the implementation of virtual simulation in truck driver training. During this implementation period (October –December 2007) two accidents occurred which are neither pre or post simulation. However, in the subsequent eleven months (January 2008-November 2008) there have been no reported accidents amongst the 76 student drivers completing the TDT program.

Recommendations

What are the changes in student skill attainment, student confidence, budget and safety record of students who participate in the truck driver training program with virtual simulation added? This was the very problem statement seeking answers with the undertaking of this study.

Student skill attainment was measured by a cohort group pre simulation (n=73) and post simulation (n=69) and a statistical significance was not pre to post. A third party tester thought the scores were better since the introduction of the simulator and the study does verify that very thought. The tester was impressed how the virtual simulation scenarios followed closely to the skills test maneuvers in sequence (D. Severson, personal communication September, 2008) about gaining better skill test scores. A longitudinal study of continued effectiveness is a suggestion for further study.

The survey tool was an effective measure of confidence in skills testing when comparing pre versus post simulation. Eleven descriptors were used and ten were statistically significant answering the question that virtual simulation does change student confidence specifically in specific driving maneuvers such as setting up for a right turn, left turn, backing, using a 13-gear shifter, etc. Testing specificity to maneuvers may be a consideration of further study to determine if skill attained on the simulator is also or transferred to the semi-truck.

The idea that introducing a simulator will impact the budget positively was measured and the study revealed a 30% decrease in gallons of fuel used with the same trucks over the same time period pre and post simulation. A recommendation for future consideration is the study of the maintenance performed on the semi trucks in an effort to determine if there is significance in simulator use to maintenance costs.

Safety results are quite significant since introduction of virtual simulation in the truck driver training program. Pre simulation year yielded two accidents while post simulation yielded none. There were two accidents during the initial introduction of the simulator which is neither pre nor post but during. These accidents occurred within two weeks of each other during the particular eight week course but more impressive is the no accident report since simulation. The program has had a 100% reduction of reportable accidents from December 2007 to December 2008.

Future research should track the statistics in relation to skills test, accident reports and budget to include maintenance schedules and costs for trucks used within the program while virtual simulation is in place.

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Appendix A

Appendix B

Appendix C

This project has been reviewed by the UW-Stout IRB as required by the Code of Federal Regulations Title 45 Part 46

Truck Driver Survey 1
Please circle the answer that best fits your situation.

Circle One Answer

Sex Female Male

Age 16-20 21-30 31-40 41-50 51-60 61-70

	Circle One Answer			
Have you ever driven a semi-truck	Yes	No		
If you answered "yes" to above, how many years	1-5	6-10	11-15	16+
Have you ever driven a truck driving simulator?	Yes	No		
If you answered "yes" to above, how many times	1-5	6-10	11-15	16+

How comfortable are you performing each of these maneuvers in a semi truck?
Circle the number on the scale that best describes how you feel
Very uncomfortable Neither comfortable or uncomfortable Very Comfortable
1 2 3 4 5

Backing the semi-truck into a loading dock	1	2	3	4	5
Setting up for a backing maneuver	1	2	3	4	5
Driving a stick shift	1	2	3	4	5
Using a 13 gear shifter	1	2	3	4	5
Downshifting	1	2	3	4	5
Stopping at an intersection	1	2	3	4	5
Setting up for a right turn	1	2	3	4	5
Setting up for a left turn	1	2	3	4	5
Turning at a busy intersection with a stop sign	1	2	3	4	5
Turning at a busy intersection with a traffic light	1	2	3	4	5
Changing lanes on a 4-way highway	1	2	3	4	5

How confident are you in your abilities to professionally drive a semi-truck
Circle one
Not at all Confident Somewhat Confident Very Confident
1 2 3 4 5
Thank you.

Appendix D

This project has been reviewed by the UW-Stout IRB as required by the Code of Federal Regulations Title 45 Part 46

Truck Driver Survey 2
Thank you for your time and effort in filling out the following survey. Please circle the answer that best fits your situation.

	Circle One Answer					
Sex	Female	Male				
Age	16-20	21-30	31-40	41-50	51-60	61-70

	Circle One Answer			
Did you use the shifting gear on the truck driving simulator?			Yes	No
If you answered "yes" above, How many times did you shift?	1-5	6-10	11-15	16+
Did you use the backing maneuver on the simulator?			Yes	No
If you answered "yes" above, How many times did you back?	1-5	6-10	11-15	16+

What did you find the most helpful in using the simulator?

What did you find the least helpful?

Thank you.

Appendix E

This project has been reviewed by the UW-Stout IRB as required by the Code of Federal Regulations Title 45 Part 46

Truck Driver Survey 3

Please circle the answer that best fits your situation.

	Circle One Answer	
Sex	Female	Male

Age	16-20	21-30	31-40	41-50	51-60	61-70

	Circle One Answer	
Did you use the shifting gear on the truck driving simulator?	Yes	No
If you answered yes to above, Did that help you with shifting in the truck?	Yes	No
Did you use the backing maneuver on the simulator?	Yes	No
If you answered "yes" above, Did that help you with backing in the truck?	Yes	No

How comfortable are you performing each of these maneuvers in a semi truck?

Circle the number on the scale that best describes how you feel

Very uncomfortable	**Neither comfortable or uncomfortable**		**Very Comfortable**	
1	**2**	**3**	**4**	**5**

Backing the semi-truck into a loading dock	1	2	3	4	5
Setting up for a backing maneuver	1	2	3	4	5
Driving a stick shift	1	2	3	4	5
Using a 13 gear shifter	1	2	3	4	5
Downshifting	1	2	3	4	5
Stopping at an intersection	1	2	3	4	5
Setting up for a right turn	1	2	3	4	5
Setting up for a left turn	1	2	3	4	5
Turning at a busy intersection with a stop sign	1	2	3	4	5
Turning at a busy intersection with a traffic light	1	2	3	4	5
Changing lanes on a 4-way highway	1	2	3	4	5

How confident are you in your abilities to professionally drive a semi-truck

Circle one

Not at all Confident		**Somewhat Confident**	**Very Confident**	
1	**2**	**3**	**4**	**5**

Thank you.

Appendix: F

The demographic data for the study is reported below, which is the same group over three different surveys.

Demographic data of surveys 1 – 3

Survey 1 – 3					
Age	21-30	31-40	41-50	51-60	61-70
Male	4	3	3	3	1
Female	1				

Appendix G

Qualitative Data

Qualitative data was collected in survey 2 asking for response to two questions on most helpfulness and least helpfulness of the driving simulator as shown below.

Qualitative Data of survey 2 responses to the question:

What did you find most helpful in using the simulator?	n=15
Driving in bad weather	1
I don't know	1
Different situation that you can't do every day in a real truck	1
The feel of the road and the affect of the weather	1
Being aware of other drivers	1
Driving technique	1
Conditions	1
Nothing	2
Shifting	3
Backing	3

Appendix H

Qualitative responses for survey 2 are reported as shown below.

Survey 2 responses to the question in participants' own words.

What did you find the least helpful in using the simulator?	n=15
Snow simulations	1
I don't know	1
It's not quite the same as driving a truck down the road	1
Backing	1
On the road traffic	1
Found everything helpful	
Shifting	3
Nothing	4
Illegible response	1
No response	1

Appendix I

Appendix J