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Published in: Proceedings of the Human Factors and Ergonomics Society Annual Meeting
DOI: 10.1177/1071181319631528

Available online: 20 Nov 2019

Citation:
Sætren, G. B., Lindheim, C., Skogstad, M. R., Pedersen, P. A., Robertsen, R., Lødemel, S. & Haukeberg, P. J. (2019). Simulator versus traditional training: A comparative study of night driving training. Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 1669-1673. doi: 10.1177/1071181319631528

Simulator versus traditional training: A comparative study of night driving training

Gunhild Birgitte Sætren*[1], Catharina Lindheim[2], Martin Rasmussen Skogstad[2], Pål Andreas Pedersen[1], Rolf Robertsen[1], Ståle Lødemel[1], & Per Johan Haukeberg[1]

[1]*Nord University, Business School, Road Traffic Section, Norway*
[2]*NTNU Social Research, Studio Apertura, Norway*

In recent decades, simulators have become an increasingly accepted part of training in sectors like aviation, medicine, and the petroleum industry. Some countries like the Netherlands, the UK, and Finland have accepted simulators as a part of driver's education, but in Norway the use of simulators is both limited and restricted. This experimental study aimed to determine whether simulator-based training in night driving could be beneficial compared to traditional Norwegian training. Two equal-sized groups of learner drivers completed both simulator training and traditional training, and both training sessions were followed by a multiple-choice test mapping the learner drivers' theoretical knowledge on the topic. The results show that theoretical learning outcome is higher from simulator training compared to traditional training, indicating that an increased use of simulators could be beneficial in driver training.

Keywords: Driver training, learner drivers, driving simulator, theoretical learning, multiple-choice test, comparative study

INTRODUCTION

Driving simulators have become an important research tool in topics such as traffic behaviour (Meuleners & Fraser, 2015; Risto & Martens, 2014), road safety (Underwood, Crundall, & Chapman, 2011) and performance reducing factors (e.g. alcohol (Helland et al., 2013), medical conditions (Hird, Vetivelu, Saposnik & Scweiser, 2014; McKay, Rapport, Bryer & Casey, 2015), old age (Ball & Ackerman, 2011; Casutt, Theill, Martin, Keller & Jänke, 2014; Golisz, 2014; Hunt & Arbesman, 2008; Lavalliere, Simenau, Trembely, Laurendau & Teasdale, 2012)). The use of driving simulators as a training tool has in a few studies been evaluated both for learner drivers (see Martín-delosReyes et al., 2019) and for learning specific skills among licenced drivers (new technological equipment (Sportillo, Paljic, & Ojeda, 2018), fuel-efficient driving (Strayer & Drews, 2003), and improvement of speed processing and spatial attention (Roenker, Cissell, & Ball, 2003). Despite a few studies, the potential role of driving simulators as a training tool for learner drivers is not well explored. A 2019 systematic review only identified five studies on the safety impact on young novice or learner drivers using driving simulators (Martín-delosReyes et al., 2019). The results were inconsistent and the review suggested additional studies.

Simulators are considered a cost-effective way of training for safety critical scenarios in industries such as aviation, medicine, petroleum, and nuclear power (e.g. Bye et al. 2011; McGaghie, Issenberg, Petrusa & Scalese, 2010; Salas, Bowers & Rhodenizer 1998). When looking into the use of driving simulators in driver education, potential advantages could be cost effectiveness, environmentally friendly training, repeatability, accessibility to different scenarios (accident scenarios, dangerous situations, darkness, snow, difficult weather conditions, and extreme road traffic density), the possibility to make errors in a safe environment, and interaction with new technology such as advanced driver assistant systems (Sætren et al., 2018; 2019). Globally, driving simulators are far from a standard element in learning how to drive, even though some countries are increasingly adapting simulators as part of the driver education (e.g. the Netherlands, the UK, Germany, and France; Baten & Bekiaris 2003; Goepp 2017; Stiegler & Vennefrohne 2017). The purpose of this study was to compare the learning outcome between traditional and simulator training in one segment of the Norwegian driver education - night driving.

Driver education and the night driving course in Norway

The learner driver program in Norway is an extensive stepwise program consisting of 4 levels for the passenger car driver's license with a comprehensive syllabus.

- Level 1 Basic traffic course
- Level 2 Basic training (vehicle and driving skills)
- Level 3 Proficiency in traffic
- Level 4 Final training

To proceed from one level to the next, a driver instructor must verify that the learner driver is qualified. The average learning period, from novice to the issuing of the driver's license, is two years. In order to complete the driver training, one has to pass a theoretical test after level 1 (multiple choice) and a practical test after level 4. This research is based a part of the syllabus in level 1.

The night driving course is a mandatory part of the introductory basic traffic course (level 1) and consists of a classroom part and an in-car demonstration where the learner driver is being a passenger both in traffic and on a closed track. Level 1 must be completed before getting the learner's permit (except from during extended summer season when it is not dark enough outside), and hence the learners are not able to drive the car him/her self during this session. The night driving course can only be completed during November 1st to March 15th. The topics learned on this course are causes and

effects in connection with accidents in the dark, risk assessment, appropriate behaviour and use of lights when you drive, park, and how to make emergency stops in the dark (NPRA, 2018).

Until 1979 the learner driver in Norway was taught to drive in the dark by driving a car on a closed track. The intention was to understand how the car reacted and to learn central skills such as correct use of lights, but the training was optional. Night driving training became mandatory on September 15th 1979 as part of level 3 in the curriculum for the class B license (the standard license to drive a car in Norway) (NPRA, 1980). The learner driver drove the car him or herself in real-life traffic with a driver instructor in the passenger seat. The todays regulations with the mandatory basic night driving course before getting the learner's permit was introduced on September 12th 2003 (Lovdata, 2003; NPRA, 2003). This time night driving was moved from level 3 to level 1 – it was changed from being a hands-on practical training late in the learning process to become an early stage learning of theory on the topic.

In this paper, we explore potential differences in learning outcome between traditional learning methods and the use of a simulator when learning theoretical knowledge on night driving in Norway. The research question is: *Can simulators be used to improve night driver training?* In this study we used a simulator training program for night driving and tested the learning outcome from the training through participant scores on multiple-choice tests completed immediately after training.

METHOD

Experimental setup

The participants were learner drivers recruited from a driver school in Norway at the university that also educates driver instructors. They were randomly selected and divided into two groups. Group 1 started with traditional training and Group 2 begun their training in the simulator (see Figure 1).

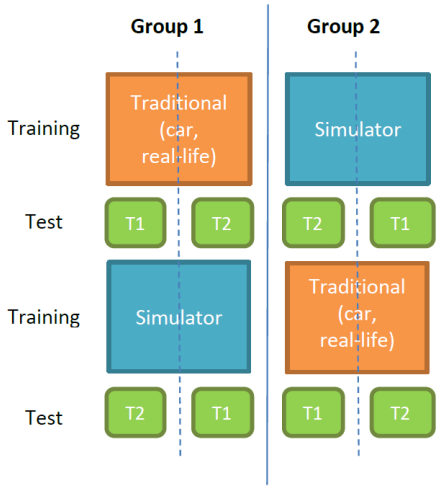

Figure 1 Research design

The two groups were again divided into two subgroups that immediately after the training session were given different tests (T1 and T2). Later all the learner drivers went through a second night driving training (simulator or in-real-life depending on the first training method) also followed by a test – the one they did not get after the first training session. This research design is illustrated in Figure 1. After completing the experiments, the participants included in this study have completed both simulator and real-time training, and taken both tests.

Traditional night driver training

The traditional night driver training was carried out outside in the dark and consisted of two sessions lasting approximately 45 minutes each. The first session was conducted in a closed course and the second session in real-life traffic directly afterwards. The learner drivers were passengers in both sessions. Before the practical sessions, the learner drivers were given a short briefing by driver instructor students on the plans for the training session. Next they got into the cars. Two driver instructor students and two learner drivers were seated in each car – the instructors in the front and the learners in the back. The drive to the training course took approximately 15 minutes. During this drive there was no mandatory program, but the driving instructors were free to use the time for teaching - reflecting on situations occurring during the drive. The first part of the training at the course was a demonstration of visibility and lights. The learner drivers got out of the cars and watched the demonstration from the side of the track. Instructors were driving a car round the track demonstrating different use of lights, while other instructors acted the role of pedestrians demonstrating the use of reflectors on clothing. Together they demonstrated the importance of correct use of lights and safety equipment. Other instructors were standing together with the learners explaining the lesson and answering questions from the driving learners. Then they got back into the cars and drove around the field while teaching use of lights, visibility, and braking distance. This completed the first session. Afterwards they drove from the field and into real-life traffic on a predefined route. Different elements related to the night driving curriculum were shown, described, and discussed among instructors and learners in the car the entire way. This second session lasted about 45 minutes before returning to the classroom for a short briefing on learnings and experiences. This completed the traditional training, and the learner drivers were then immediately provided one of the multiple-choice tests in a room next door which they all completed without help from others. Which test the got was predefined by the groups and subgroups (Figure 1).

Simulator training

The simulator training consisted of a predefined training program specially designed for Norwegian night driving, developed by driver instructor experts. The training was carried out at the driver school in the afternoons, and each

driver learner was given a specific time for their simulator training. All learners did their simulator training alone – only with a driver instructor student present in the room. The student instructors gave the learners a short instruction on how the simulator works, and provided technical assistance during the training session if necessary. The learners were given a few minutes to get familiar with the simulator before the session started. The simulator training for night driving consisted of 6 sessions, and a virtual instructor explained the theoretical concept and guided the learner drivers through the different exercises. The six sessions are: 1) Basics, 2) Meeting a vehicle, 3) Being passed, 4) Passing other vehicles, 5) Pedestrians and other hazards, 6) Roadside parking.

The learner drivers had to pass one section before they could move on to the next. All in all, the simulator training lasted about 45-60 minutes, but for learner drivers who needed more repetitions in order to complete a session, it took a bit longer. After the simulator training, the learner drivers immediately took a multiple-choice test in a room next door. Another student was observing the test situation.

Multiple-choice test

The two multiple-choice tests for night driving theory (T1 and T2) consisted of 20 questions each on the topic of night driving. They all had four different alternatives out of which only one was correct. The questions covered a broad range of topics related to the theoretical curriculum of night driving and they were based on previous questionnaires developed by Robertsen, Sætren, Haukeberg & Sivertsen (2017). In addition to the knowledge-based multiple-choice questions, we added eight questions to gather information about the learner driver and their experience: age, gender, if they have had night driving training or an introductory basic traffic course before, their experience with computer games, previous driving experience, and their preferences on how to learn night driving (simulator and traditional). In addition they were given the opportunity to comment on which form of training they preferred.

Each learner driver was given both simulator training and traditional training and answered both the T1 and T2 tests, but in different orders in order to avoid learning effects creating a bias in the data and potential effects from one test being easier than the other. It took about 15 minutes to answer each test. The order of training and testing is presented in Figure 1.

Collected data – Analysis

The main empirical data in this study were the results from the night driving theory tests completed by the participating learner drivers (T1 and T2). All test results were collected on paper and manually coded into SPSS for further analysis. Occasionally there were participants marking multiple answers to a question. If it was impossible to interpret which of the answers was the final one, the answer was registered as blank which again was interpreted as a wrong answer.

There were also some participants who, for different reasons, only participated in one training session and only took one test. These were included when calculating the correction value balancing the influence of different level of difficulty of the two tests (see Results below). When comparing learning outcomes through test results, the participants completing only one test were not included.

RESULTS

The sample consisted of 82 participants, 48 male (59 %) and 34 female (41%), with 66 participants completing both training methods (simulator training and traditional night driver training) and both tests (T1 and T2). The age range was narrow with 69 (84%) participants participating the year they turned 16, 10 (12%) the year they turned 17, and 3 (4%) participants in the 18–20 year range.

Out of a possible 20 points, T1 had an average score of 12.95 ($N = 74$, $SD = 3.34$) and T2 had an average score of 14.46 ($N = 74$, $SD = 2.90$) when all participants where included. Based on the difference in average scores, T1 was given a correction of 1.51 points to give the two tests the same average scores and thereby highlighting learning outcomes between the first and second test for the participant regardless of whether T1 or T2 was taken first.

Two results indicate that the learning outcome from the simulator training was higher: 1) The participants who started with the simulator training scored in average 1.08 points more on their first test than the ones who starting with traditional training ($N = 82$, $\Delta = 1.08$, $p = .11$). 2) Those who had simulator training between the two tests had an average increase in test score of 1.44 ($N = 33$, $SD = 3.11$), while those who had the traditional training between the tests had no increase ($N = 33$, $\Delta = -0.53$, $SD = 2.56$). The difference in increased test scores between the two groups was significant ($t(64) = 2.81$, $p < .01$) related to order of training methods (see Figure 2).

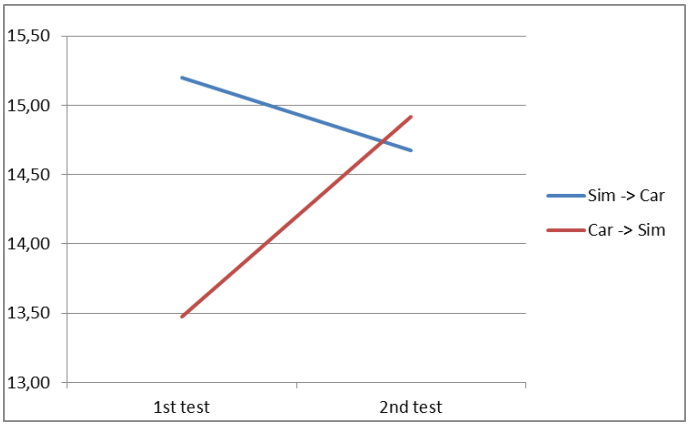

Figure 2 Test scores

DISCUSSION

We compared two different training methods for learning about night driving; a simulator training program and the traditional method where learner drivers are passengers in a car in traffic. The results indicate quite clearly that the simulator training used in this experiment provided a better learning outcome – measured in theoretical learning – compared to the traditional training method where the pupils are passengers during the instructors' learning sessions.

There are several differences between the two training methods e.g. in interaction with real surroundings, interaction and reflection with instructor, how the students are involved and participate, and rigidity in learning program.

Another aspect is the standardisation of the training content, and there are pros and cons for both training methods in this regard. A simulator has a standardised training program, and through this the learner drivers will have the same training but not necessary equal learning outcome. A driver instructor has the opportunity to vary the training approaches and adapt the teaching to the needs and preferences of the learner drivers. The context and the situations the learner drivers meet will vary, and how well the learner driver actually learns the different elements in the curriculum depend therefore strongly on the skills of the instructor. A standardised learning program makes sure that all theoretical aspects in the curriculum are covered, and the simulator software controls the learner driver's progress by not letting the learner drivers pass to the next level before the current level is acceptably completed.

In this experiment, it is important to point out that the driver instructors were driver instructor students. The driving school was established to provide the students sufficient and suitable practical experience, but this also means that the learner drivers are training in a situation which also is a training situation for the driver instructor students. This does not necessarily lead to lower-quality training, and it might even be better as a result. We observed skilled driver instructor students being 100% focused on giving the learner drivers the best training possible under close guidance of experienced teachers who are assistant professors at the university. The students were clearly conscious their teaching methods and pedagogical approach. They asked the learners questions with the intention to force reflection around the situations rather than just preaching facts and theory. Still, the situation is not completely the same as if the experiment were to be performed in a traditional driving school.

The last difference we would like to point out is on the learning context. During the simulator training, the learner drivers experienced a quiet, rather calm learning situation, indoor and alone in the room with technical assistance available if necessary. Such learning conditions could be beneficial over being outdoors in the dark, cold winter-weather (sometimes down to −20°C). Additionally, the training on the track was carried out group wise in groups of 10–20 learner drivers together. This caused additional, possible distractions such as small-talk and focus on other learners instead of the demonstrations, and thereby hinder optimal learning. Both training situations were carried out during the same hours of the day, after school hours for the learner drivers, which means between 15.00 and 21.00. Thus, we considered there to be equal conditions in terms of fatigue and tiredness.

Finally we would like to mention an advantage the simulator training clearly provides – the opportunity to conducted night driving training all year round since it is independent of sufficient outdoor darkness like the traditional night driving training is today.

Methodological implications

The empirical data were based on a relatively small group of 82 participants, of whom 66 completed the experiment. When the learning module is small, both in curriculum and in time, the measured learning outcome from this module will also be minor. In a large sample randomly divided into two groups it is unlikely that one group comes into the experiment as much more knowledgeable and skilled. In a small sample such as this one, we must be open to that the measured learning outcome was also influenced by the participants' knowledge when entering the experiment. Some of the learner drivers have more experience from traffic (both as drivers and passengers) than others, which might have provided them with some of the knowledge already. This would have reduced the initial knowledge gap and thus the possible level of increased learning outcome.

Implications and further research

Our findings indicate that simulator training in driver training is beneficial, but our area of research is limited and the findings are based on a relatively small sample. In the following years we want to repeat the experiment to see if we can reproduce our findings, and to provide a larger sample.

We also see the necessity to produce a baseline to estimate the learning outcome from the first training session.

Secondly we will explore the opportunity to do experimental research on other parts of the driver learning curriculum, including on topics related to the training of actual driving skills. If the use of driving simulators should possibly have a commercial impact, the area of use must also include training of practical skills.

Finally we would like to study different scenarios for simulators in use at Norwegian driving schools – what are the financial possibilities, what about district versus city-schools, how will this influence the way Norwegian driver instructors are educated, etc.

Further, night driving is a mandatory part of the training and is not regulated to be accepted as simulator-based training in Norway today – neither for any other mandatory topics in the driver training. In order to change this, more research on the topic is needed.

CONCLUTION

In the current study, simulator training outperformed traditional training in participants at an early stage in obtaining their driver's license. The results thus indicate that simulators might be a valuable part of driver training in the future for teaching theoretical aspects. The study only explored a smaller part of a larger curriculum (night driving training), and hence the results should not be generalised to the larger driver training program without further research.

ACKNOWLEDGEMENTS

We are very grateful to the Norwegian Research Council's FINNUT program (grant number 260524) that funded this research.

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