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Simulator training in driver education—potential gains and challenges

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ABSTRACT: Norway is currently ranked as one of the top nations in regard to road safety. However, continued efforts are applied as we stretch towards a goal of zero deaths and serious injuries in road traffic accidents. In this paper we explore if Norwegian driver education could benefit from simulator training. Possible advantages are cost effectiveness, environmentally friendly training, repeatability, accessibility to different scenarios (accident scenarios and dangerous situations, darkness and snow outside of winter, 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. However, there are challenges such as how to increase the number of simulators in Norway, and legal obstacles as current legislations require all mandatory parts of the Norwegian driver education to be conducted on the road. Our overall impression is that the driver education in Norway could have advantages in applying a more systematic approach to simulator training.

1 INTRODUCTION

The purpose of this paper is to investigate the use of simulator training in driver education in Norway, discuss the potential gains and challenges and look at the possibility of increasing the availability and use of driving simulators. In Norway, like in many other countries, the public authorities have established a formal theoretical and practical driver education (NPRA 2017), based on scientific and policy factors, where professional driving teachers employed by approved driving schools are the main responsible bodies to conduct the education. The driver learner program is an extensive and systematic module based program with a comprehensive syllabus. The program is to a large degree based on the Goals of Driver Education-matrix (GDE-matrix; Keskinen 1996 in Hatakka et al. 2002; Keskinen et al. 2010). In this program it is estimated that the average learning period, from novice to the issuing of the driver's license, is two years. The authorities recommend that training starts at the age of 16 in order to get the driver's license at the age of 18 – which is the lower limit for receiving a car driver's license in Norway. To reduce accident risks in novice drivers, elements of the driver training are carried out in real life situations where driver learners are accompanied by skilled driver instructors. Additionally, in Norway it is legal and recommended for experienced drivers (normally parents) to provide driver learners with extra practice. The only premise is that the driver learner has completed an introductory course and that the experienced driver must have held their driver's license for a minimum of five years without receiving any penalties or driver's license endorsements (FOR 2017). Such additional training is meant to increase the driver learners' experience behind the wheel prior to their exams and the license issuance. Our question is to whether driving simulators could be a training platform in Norway to increase driver learners' driving experience, and if they can complement or even substitute some of the more traditional learning methods used in today's education.

In many industries where human errors are likely to have critical outcomes, such as aviation, hospital medicine and commercial nuclear power, simulator training is frequently used as part of training. Simulator training can be cost efficient and can provide training in situations that are rarely seen (e.g. accident scenarios; Bye et al. 2011; McGaghie et al. 2010; Salas, Bowers & Rhodenizer 1998). Currently driving simulators are not the standard way of learning how to drive, however, in some European countries, such as in The Netherlands and the United Kingdom, simulator training has gained some acceptance as part of the driver education (Baten & Bekiaris 2003), and there are reports showing an increased use of simulators in Germany (Stiegler & Vennefrohne 2017) and France (Goepp 2017). There are several factors explaining why simulator training is more common in other industries where human errors are likely to have critical outcomes than in driving. In medical surgery for instance, the risk of letting unskilled personnel practice on people is considered too high, so simulation has become a natural way of acquiring skills. Doing simulator training means that there is room to learn from mistakes. The same is seen in aviation. Additionally, the costs and emissions of flying a large aircraft are so substantial that doing all the training necessary to obtain a commercial pilot license is not considered economically or environmentally beneficial. Even though developing, building and handling a simulator also result in costs, it is far less expensive than training in airplanes. In aviation, as well as industries such as commercial nuclear power, simulators can be used to train personnel to avoid serious accidents and to minimize the overall consequences if unwanted events occur.

It is our impression that all of the reasons mentioned above, concerning reduced risk through extra training, prevention of fatalities and injuries, handling accident scenarios, and reduced cost and emissions, can be used as reasons to introduce car driver training in simulators. In this paper we will attempt to clarify current usage and potential gains of simulators in driving education in Norway (section 2). This is discussed in the light of the rapid technological development in today's automobile industry, and how new technology can be included in simulators. This is followed by a discussion on the structural and practical obstacles in implementing an increase in simulator training in driver education (section 3).

2 POTENTIAL GAINS IN SIMULATOR TRAINING

It has never been common to use driving simulators as part of the driver education in Norway. Currently, only 5–10 out of 1033 driving schools, offer simulator training for driving-license category B driver training (vehicle weight less than 3500 kg), and the simulators are mainly used for learning the basic introductory elements of handling and maneuvering a car. These schools seem to lack a systematic pedagogical or educational plan in their simulator use. Additionally, The Norwegian Public Road Administrations are rather strict on what is allowed to be taught in a simulator only. Any topic that is mandatory in the education will not be approved using only a simulator (NPRA 2017), despite research indicating that for instance that the mandatory dark driving demonstrations have the same learning outcome taught in real life and in a simulator (Mikkonen 2007; Robertsen et al. 2017). A different approach is taken in Finland where dark driving sessions are approved using a simulator, so these aspects are not internationally agreed upon.

There have not been many empirical studies measuring and discussing the learning outcomes from using simulators in driving education. We only found one published study on use of simulator training in driver education in Norway (Robertsen et al. 2017). This study was regarding theoretical learning outcome when comparing traditional training and simulator based training on dark driving demonstration. Dark driving is a part of first module (basic handling of the car) in the Norwegian driving education program. This study showed no significant differences in the outcome between these two groups on theoretical knowledge of dark driving. According to some of the international empirical studies concerning driving simulators, it seems like simulator training could be useful in driving education. In a study carried out in in The Netherlands by de Winter et al. (2009), they found that better driving simulator performance increased the actual driving skills on the roads and the chance for passing the final driving test. Additionally, Crundall et al. (2010) found that commentary training in a driving simulator has beneficial effects on driving behavior in the UK. For instance, it was found to improve responsiveness to hazards on the roads. Wang et al. (2010) have pointed out that road hazard performance was significantly higher for a simulator trained group of novice drivers than others. Divekar et al. (2016) also report that novice drivers' outcome in PC-based simulator training increases the awareness and driving skills in real life operations. Additionally, a German study showed that the training period could be reduced by 21 days when using a simulator instead of traditional training with a driver instructor (Reindl, Gunther, & Wottge 2016). However, in all these empirical studies there are methodological challenges in isolating and measuring the learning outcome from simulator training, and determining the transferability from improvements in the simulator to improved driving on real roads. Another common challenge in these studies is the difficulty to measure the long term effects on the drivers' skills and behavior. Nevertheless, it seems to be an agreement in these empirical studies that especially novice drivers have a significant short term positive learning outcome from training specific elements in simulators.

Based on this earlier research, a systematic offer of simulator training in the official driving education might make it easier to learn the basic skills in handling a car and making the soon-to-be drivers trained in adjusting their road traffic behavior to the circumstances on the road. Hence, it seems likely that driving in a simulator, accompanied by other training methods, could be used to improve the various driving- and safety skills during the phase of learning to maneuver a car. Particularly, in order to reduce risks of young drivers, training with professional driving instructors combined with simulator training, seems to gradually become accepted as a useful tool in developing driving skills.

The gains of supplying adequate simulator training are also related to the possibility to train in a secure environment where the negative consequences of making mistakes are eliminated. It is also environmentally friendly, flexible, could train driver leaners in different road traffic environments any time of the year. For instance, Norway has a large road traffic density variance. This means that different mandatory training scenarios, such as urban and rural driving, are fairly easy to obtain in the cities and other densely populated areas. However, in some rural areas access to urban driving might entail a long journey. A widespread access to driving simulators could potentially reduce the number of those long journeys. Due to the long dark winter in Norway, it is particularly important to learn how to drive in the dark and handling the challenges of darkness. However due to the lack of darkness in summer, the mandatory dark driving demonstration can only be conducted from the end of October till mid-March. With a simulator of sufficient quality, dark driving demonstrations can be given all year around. Other environmental challenges are seen in other countries, such as southern France (Goepp 2017), where it is not unlikely to go through the entire driver education without facing rain. The possibility for all driver learners to experience different weather conditions and road traffic densities is a good argument for using a simulator. Additionally, simulator training has the potential to be cheaper for the driver learner, if sufficient instructions are given virtually and thereby removing the necessity of one driving instructor per driver learner.

Simulator training should also be seen in connection to the rapid technological development seen in the automobile industry. When a driver learner has finished the driving education, should he/she only be able to handle the basic technology found in every car, or should he/she have learned how to use and interact with new technology introduced in new cars to assist the driver? Staying in touch with the technological race while using a traditional training approach would entail a very frequent replacement of vehicles. Using a simulator approach might be easier as a software update could potentially provide the new technology or features to be used without replacing the simulator.

From other industries, research has shown that training for new and more automated technology is of importance in order to avoid unwanted incidents (Salas et al. 2006; Sætren and Laumann 2015). It would be beneficial to have a system for training drivers who buy new cars with new Advanced Driver Assistant Systems (ADAS) technology. Research shows that buyers have very limited knowledge of the new technology in their new cars and on how it can be used. One of the reasons could be that only 24% reported that they received instructions regarding the ADAS technology from the manufacturer when buying the car (Harms & Dekker 2017). Training in simulators could provide an important alternative for learning how to drive with ADAS technology for instance for drivers who already hold their driver license but need training for new technology.

3 CHALLENGES IN SIMULATOR TRAINING

In order to implement a broader use of simulator training in driver education there are a lot of challenges and obstacles that have to be discussed and solved. First, there are technological challenges in developing adequate hardware and software making the simulators relevant for learning to drive on the road. For instance, to what degree could and should simulators be designed to give the driver learners a "car-like" experience when training, and should the simulators be designed to make it possible to adjust for different equipped cars? A software-challenge would be to design adequate road traffic situations training the driver learners to handle and control the vehicle on the road in different road traffic settings.

One of the main challenges in simulator based training, if thought of being used for more advanced driver education, is to adjust the training to the GDE-matrix. As mentioned, the hierarchical GDE-matrix is an important base for the Norwegian driver education. The GDE-matrix originally consisted of four levels, where the first level is vehicle maneuvering, second level is mastering road traffic situation, the third level is goals and context of driving, and fourth level is goals for life and skills for living (Keskinen 1996 in Hatakka et al. 2002) and later a fifth level, social skills, was added (Keskinen et al. 2010). The skills are learned through theoretical and practical teaching in addition to individual and group work. To reach level four and five it takes time to mature, thus, the authorities recommend starting at age 16 in order to have a driver license at age 18. The main reason for this is that adequate psycho-motoric skills and physiological functions are found not to be sufficient for good and safe driver performance. For instance, when the lowest levels of the hierarchy are learned, they are applied under guidance of higher level objectives. Hence, the training of basic skills is important but the driver learner should also be able to deal with goals higher in the hierarchy such as dealing with social pressure (Hatakka et al. 2002). There is little doubt that simulator training could be of help for the lower levels in the GDE-matrix, but in order to deal with the higher levels including self-evaluation, simulator training might not be optimal. Thus, this argues that simulator training cannot completely replace the traditional driver's education, but be a supplement.

Increasing the use of simulators in Norway has specific legal challenges. The mandatory driver's education is regulated such that it must be given by professional driver instructors while the driver learners are sitting behind the wheel of an actual car. Hence, training in simulators can only be seen as an additional part of an education program and not a part of the mandatory education. That being said, learning how to drive entails a large amount of training outside of the mandatory elements allowing driving schools to use simulators a substantial amount if they want to. The main obstacle in Norway seems to be the lack of simulators. There might be several reasons for this, but it seems that in general, the driving schools do not consider it economically beneficially to offer simulator training. In addition to the investment cost of simulator, the driving schools have to handle the cost of software updates, maintenance, and training staff in simulator handling. Without simulators, the main income of a driving school is hours spent on the road with driver learners. Introducing a simulator (particularly one that is cheaper than traditional training) the school has to change its business model for selling man-hours to include selling simulator-hours. For the driving instructors this would undermine their occupation. This is further underlined with the argument for having simulators in countries such as France, where it was emphasized that a school with 5–6 instructors, one driver instructor can be replaced with a simulator (Goepp 2017). There is no shortage of driving instructors in Norway, like for instance in Germany (Stiegler & Vennefrohne 2017), thus, the Norwegian market does not provide that need for a simulator for better efficiency.

Another challenge is simulator sickness. Simulator sickness is a subset of motion sickness, leading to many experiencing nausea after only a short while in a driving simulators, influencing the usefulness of simulator training (de Winter et al. 2012). Simulator sickness is due to the perceived discrepancies between the motion expected by the participant and the motion displayed in the simulator. This has been a problem in a wide range of simulators and virtual reality applications, but it is gradually decreased as the simulations improve in terms of both responsiveness and reduced delays. Research shows that younger individuals are less prone to simulator sickness than older (Brooks et al. 2010). This could be beneficial for driver learners, but might be a hindrance for using simulators for upholding driving skills for those who have had a driving license for some time.

4 CONCLUDING REMARKS

Our impression is that the car driving education in Norway could have advantages in using simulators more systematically than what has been done until now. There are many possible advantages from introducing simulators in driving schools such as cost effectiveness, environmentally friendly training, repeatability, accessibility to different scenarios (accident scenarios and dangerous situations, darkness and snow outside of winter, 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. However, there are challenges such as how to increase the number of simulators in Norway, and legal obstacles as current legislations require all mandatory parts of the Norwegian driver education to be conducted on the road.

The experiences from other European countries and the few empirical studies that exist provide some insight into the potential for simulators to be used in driving education in Norway. However, more research should be done to find out which parts of the driving education that could be performed in a simulator, and how the simulator could set up to optimize the learning outcomes.

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